THE CASH-CDS BASIS FOR SOVEREIGN COUNTRIES: MARKET STRATEGY, PRICE DISCOVERY AND DETERMINANTS

Alessandro Carboni* and Andrea Carboni**

Abstract

We study the cash-CDS basis and its implication for market strategies and price discovery, together with the role of credit risk common factors. A positive net income is derived with a negative basis, once funding costs are considered. There exists an arbitrage opportunity for Greece in 2010, with a negative basis of more than 100 bp. Our comparison with three different basis shows that while converging markets seem adopt the same strategy, in particular for Portugal, Ireland and Greece. Results for price discovery show that the CDS market moves ahead the bond market. Finally, our empirical analysis shows that the global risk factor contributes to increase the basis, while the banking sector vulnerability proxy offers a negative contribution.

JEL Classification: G00, G10, G12, G14

Keywords: Credit Default Swaps, Asset Swap, Price Discovery, Basis, Limits To Arbitrage

** Corresponding author, University of Siena, Piazza San Francesco, 8, 53100, Siena, Italy*
Fax: +39 0577 232757
Tel.: +39 0577 232756-5105
E-mail: alecarbo@msn.com
*** University of Siena, Piazza San Francesco, 8, 53100, Siena, Italy*

1 Introduction

Credit risk indicators have received much attention during the financial crisis that began in the summer of 2007. The bail-out of Lehman Brothers (15° September 2008) has shown the importance of financial market liquidity and has demonstrated that risk management is dangerous if inappropriately used. During the crisis OTC credit derivatives came under attack because they were identified as the main contributors to the widespread turmoil, creating a new kind of dimension, namely counterparty credit risk. Hence, the need to provide more information through the creation of trade reporting for regulatory authorities, as suggested for example by (Banque de France, 2010) and (IFSL, 2009), as well as to understand what is the most informative credit risk indicator, especially during a crisis. On the other hand, it could be also interesting to go into market perspective, by analyzing both trading strategies for credit risk and their technical issues. Once arbitrage opportunities exist, they could be affected by some common factors, as suggested for example by (Carboni and Carboni, 2010) and (Ejsing and Lemke, 2009), among others.

Credit default swaps (CDS) are the most common type of credit derivatives. A CDS is a bilateral contract that provides protection on the par value of a specified reference asset, with the protection buyer that pays a periodic fee (spread) or a one-off premium to a protection seller, while the protection seller makes the payment when a credit event occurs. The premium is set as a percentage amount of protection bought. A CDS can be viewed as an insurance contract against a risky event on a reference entity. A simple CDS structure is shown in Figure 1.

According to (ISDA, 2003) credit events can be classified in: 1) Bankruptcy; 2) Obligation acceleration; 3) Obligation default; 4) Failure to pay; 5) Repudiation / Moratorium and 6) Restructuring.

The contract provides protection against credit events that can even occur before the end of the contract. In this case, there is the settlement payment made by the seller according to the contract settlement option.

Credit derivatives specify physical or cash settlement. In the physical settlement [1], on occurrence of a credit event, the buyer delivers the reference asset to the seller, in return for which the seller pays for the face value of the delivered asset to the buyer (Choudhry, 2006). The contract may specify a number of alternative assets (called *deliverable obligations*) that the buyer can deliver [2]. When more than one deliverable obligation is specified, the buyer will invariably deliver the cheapest asset on the list of eligible assets: this provides the concept of *cheapest-to-deliver* option, which is an embedded option afforded by the protection buyer [3]. On the other hand, in the cash settlement option, the contract specifies a predetermined payout value when a credit event occurs. Generally, the protection seller pays the buyer the difference between the nominal amount of the default swap and the final (market) value of the reference asset, determined by means of a poll of dealer banks. This last value can be viewed as the recovery value of the asset [4]. For a simple example we follow (O'Kane and Sen, 2004). Suppose that an investor sells protection on $10mm notional to a 5-year horizon on a credit risky issuer with a spread of 200 bp. The buyer pays approximately $50,000 every quarter. The payments stop if the issuer defaults prior to maturity, when the protection delivered by the seller is par minus the recovery rate. If we assume a 40% recovery rate, than the investor would lose $6mm. The CDS spread is the spread which determines the cash flows paid by the buyer of the contract. In this sense, the spread is the compensation for taking the risk of incurring in the loss given default, when a credit event occurs. In mathematical terms, the spread is the sum that makes the expected present value of the two lags the same, at the origination of the contract [5].

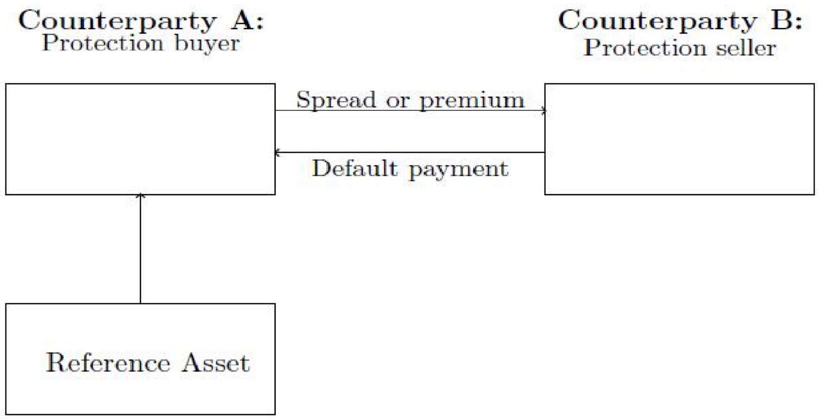
According to (O'Kane and Sen, 2004), the CDS spread is the best measure of credit risk for at least four reasons. First, the CDS contract is most pure credit risk, while the asset swap incorporates both credit and interest rate risk. Second, it is a swap contract, where the stream of cash flows ceases to exist following a credit event, compensating the buyer according to the settlement rule. Third, this is a flexible measure, so it can be possible to buy or sell CDS without restrictions. Fourth, the CDS market is relatively liquid, so CDS spreads *should* reflect the market price of risk.

Asset swaps are a common form of derivative contracts written on fixed-rate debt instruments. An asset swap is a combination of an interest rate swap and a bond, and it is used to alter the cash flow profile of the underlying security: an investor can buy for example a fixed rate bond and then hedge out (almost all of) the interest rate risk by swapping the fixed payments into floating ones. Hence, the investor takes on only the credit risk on the new security, which is equivalent to buy a floating rate note issued by the same entity [6]. For assuming this credit risk, the investor earns a corresponding excess spread known as the asset swap spread.

Following (Bomfin, 2005), the typical terms of this agreement are as follows. The market calls this contract par asset swap:

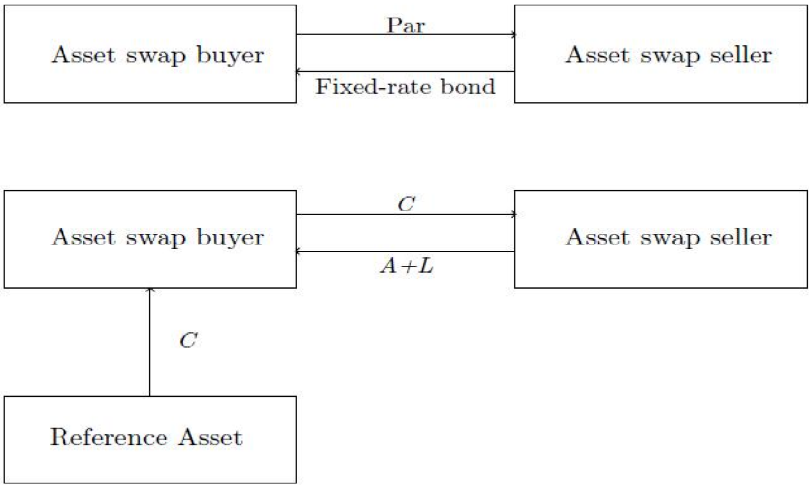
- The investor (the asset swap buyer) agrees to buy from the dealer (the asset swap seller) a fixed-rate bond issued by the reference entity, paying par for the bond, regardless of its market price.
- The investor agrees to make periodic payments equal to the coupon of the reference entity to the seller. In return, the dealer agrees to make floating rate payments (based on a fixed spread over LIBOR) and the notional principal is the same as the par value of the reference bond. In this case, the interest rate swap embedded in the contract allows the investor to receive LIBOR (L in the figure) plus a spread (A, the asset swap spread) against the payment of a fixed coupon.
- As in any other kind of swap, the spread A is set so that at the initiation, both legs have the same expected value, namely, the market value of the asset swap contract is zero. This has an important drawback. On the one hand, if the reference bond is trading below par, dealers must be compensated for selling the bond to the asset swap buyer for less than its market value. On the other, when a bond is trading above par, A must be such that the dealer's position in the swap has a sufficient positive value at the initiation of the swap. This allows a compensation for the dealer who sells the bond "at a loss".

Figure 1. Credit Default Swap



During the life of the contract, there are two possibilities. If the entity does not default, at maturity date, the investor receives the par value of the reference bond, while the interest rate swap vanishes with no exchange of notional principals. Otherwise, if default occurs during the life of the contract, the asset swap lives on, the investor loses the source of funding from the coupon, as well as the claim on the par value of the bond. He receives only the bond's recovery value upon the entity's default. An alternative option in the event of default may be the termination of the swap with an opposite sign operation.

Figure 2. Asset Swap Contract



Source: Bomfin (2005)

We have called A the asset swap spread. But what is its meaning as a credit risk indicator?

We can anticipate this useful relation:

$$(1) \quad A = \frac{P^{LIBOR} - P^{FULL}}{PV01}$$

where P^{LIBOR} is the value of the bond's cash flows discounted at LIBOR, P^{FULL} is bond's market price, while PV01 is the LIBOR discounted value of 1 bp coupon stream.

If the asset defaults immediately after the initiation of the swap, the investor (who has paid 100 for the asset swap) has an asset which can be sold at its recovery value R in the market, and an interest rate swap that is worth 100 - P, with P the full price of the bond. Hence, the investor's loss is (100 - R) - (100 - P) = $P - R$, namely the difference between the bond full price and its recovered value. If the price of the asset swap is par, then the loss on immediate default is 100 - R, similar to a default swap.

If we hold the credit quality of the asset constant and increase its price, by using for example a higher coupon, the loss on default is greater and the asset swap spread should increase. On the other hand, let us assume to allow credit quality to change, fixing both the LIBOR curve and the coupon. In this case, bond price falls only because of an increase in the issuer's credit risk and vice-versa. Therefore, an increase in the bond price P^{FULL} in (1) reduces the asset swap spread and vice-versa. That is why asset swap spread can be viewed as a measure of credit quality.

The rest of the paper is organized as follows: Section 2 deals with technical frameworks for the pricing of CDS and asset swap spread, also providing the definition of the no-arbitrage relation; Section 3 offers a description of the trading strategy for the negative basis; Section 4 presents an econometric analysis between CDS and asset swap spread, in terms of price discovery, on the one hand, while a study of the main determinant of the basis, on the other. Finally, Section 5 concludes. An appendix with data description, time series graphs and tables is provided at the end.

2 Theoretical Framework

2.1 Credit Default Swap Spread

Like any other swap, a CDS consists of two lags, one related to the expected value of the premiums paid by the protection buyer and the other related to the expected value of payments in the case a credit event occurs. When a credit event occurs, the payoff of a CDS at time t is usually the face value of the reference obligation minus its market value, as we have already described above. When the recovery rate is not zero, (Hull and White, henceforth HW, 2000) stated that the best assumption about the claim made by the bondholders in the event of default is that this claim equals the face value of the bond plus accrued interest [7]. Therefore, the payoff from a typical CDS is:

$$(2)\quad L - RL\left[1+A(t)\right] = L\left[1-R-A(t)R\right],$$

where L is the notional principal, R is the recovery rate and $A(t)$ is the accrued interest on the reference obligation at time t calculated as a percent of the face value. (HW, 2000) evaluate a single name CDS by assuming that default events, Treasury interest rates and recovery rates are mutually independent and by also assuming that there is no counterparty default risk [8]. They provide a two stages procedure. In the first, they calculate the risk-neutral probability of default at future times from the yield on bond issued by the same reference entity, while in the second, they evaluate the expected present value of both lags in the CDS.

As in (Choudhry, 2006) and (HW, 2000), we introduce some notation:

- T: Life of the CDS
- $q(t)$: Risk-neutral default probability density at time t
- $\hat{R}$: Expected recovery rate of the reference obligation in the risk-neutral world
- $u(t)$: Present value of payments at the rate of $1 per year on payment dates between time zero and time t
- $e(t)$: Present value of an accrual payment at time t for the period (t - t^*), where t^* is the payment date immediately preceding time t
- $v(t)$: Present value of $1 received at time t
- w: Total payments per year made by the protection buyer
- s: Value of w that causes the CDS to have a value of zero (CDS spread)
- π: The risk-neutral probability of no credit event during the life of the swap
- $A(t)$: Accrued interest on the reference obligation at time t as a percent of the face value.

The value of π is one minus the probability that a credit event will occur by time T. It can be calculated from the risk-neutral default probability density $q(t)$:

$$(3)\quad \pi = 1 - \int_0^T q(t)dt.$$

Before going on to CDS pricing, it is useful to provide some definitions for the risk neutral probability density $q(t)$. (HW, 2000) define $q(t)\Delta t$ as the probability of default between time t and $t+\Delta t$ as seen at time zero. On the other hand, the hazard rate $h(t)$ is the default probability between time t and $t+\Delta t$ as seen at time t, assuming no default between time zero and time t. The two variables are related according to this relation:

$$(4)\quad q(t) = h(t)e^{-\int_0^t h(\tau)d\tau}.$$

Contrarily to (Duffie and Singleton, 1997), (Jarrow and Turnbull, 1995) and (Lando, 1998) who use the hazard rate, (HW, 2000) use the default probability density to express their relations.

They assume $q(t)$ constant and equal to q_i during period (t_{i-1}, t_i) and set:

$$(5)\quad \beta_{ij} = \int_{t_{i-1}}^{t_i} v(t)\left[F_j(t) - \hat{R}C_j(t)\right]dt,$$

where $v(t)$ is the present value of $1 received at time t with certainty, $F_j(t)$ is the forward price of the j-th bond for a forward contract maturing at time t, assuming that the bond is default free; $\hat{R}$ is the expected recovery rate for holders of the j-th bond in the event of default at time t and $C_j(t)$ is the claim made by the holders of the j-th bond, if there is default at time t. (HW, 2000) extract q_j by inverting the total present value of the losses on the j-th bond:

$$(6)\quad G_j - B_j = \sum_{i=1}^{j} q_i\beta_{ij},$$

obtaining:

$$(7)\quad q_i = \frac{G_j - B_j - \sum_{i=1}^{j-1} q_i\beta_{ij}}{\beta_{jj}},$$

where B_j is the price of the bond today, G_j is the price of the j-th bond today if there is no probability of default and β is a parameter to be estimated [9].

Coming back to pricing, if a credit event occurs prior to maturity, for example at time ($t < T$), the present value of the payments is $w[u(t) + e(t)]$, while if there is no default during the life of the contract, the present value is $wu(T)$. Hence, the expected present value of the payments (i.e. premium leg) becomes:

$$(8)\quad w\int_0^T q(t)\left[u(t)+e(t)\right]dt + w\pi u(T).$$

Considering the assumptions above, the risk-neutral expected payoff from the CDS becomes:

$$(9)\quad 1-\left[1+A(t)\right]\hat{R} = 1-\hat{R}-A(t)\hat{R},$$

while the present value of the expected payoff from the CDS (i.e. protection leg) is:

$$(10)\quad \int_0^T\left[1-\hat{R}-A(t)\hat{R}\right]q(t)v(t)dt.$$

The value of the CDS is the difference between the present value of the protection and the premium leg. We have:

$$(11)\quad \int_0^T\left[1-\hat{R}-A(t)\hat{R}\right]q(t)v(t)dt-w\int_0^T q(t)\left[u(t)+e(t)\right]dt-w\pi u(T)$$

The CDS spread s is the value of the premium w that allows both legs to be equal, namely allows the difference in (11) to become zero:

$$(12)\quad s=\frac{\int_0^T\left[1-\hat{R}-A(t)\hat{R}\right]q(t)v(t)dt}{\int_0^T q(t)\left[u(t)+e(t)\right]dt+\pi u(T)}$$

If an investor forms a portfolio of a credit default swap and a T-year par yield bond issued by the same reference entity, he can replicate the T-year Treasury par yield, in the absence of arbitrage opportunity. According to (Choudhry, 2006), this difference is called cash-CDS basis.

In this case, if y is the yield to maturity (YTM) on corporate bond, and x the YTM on Treasury bond, we have:

$$(13)\quad y-s=x$$

Obviously, if y - s is significantly greater than x, it is profitable to buy the T-year par yield bond issued by the reference entity, buy the default swap and sell the T-year Treasury par yield. This is the negative basis strategy suggested by (Choudhry, 2006): an investor aims to earn a risk free return by buying and selling identical credit risk across different markets. On the other hand, if y - s is significantly less than x, it is profitable to short the T-year par yield bond, short the credit default swap and long the T-year Treasury par yield.

2.2 Asset Swap Spread

As we have already mentioned, an asset swap (AP) is a "package" involving a fixed-rate bond (B) and an interest rate swap (IRS): the first is bought by the investor from the dealer for par, while through the second the investor can swap fixed for floating cash flows. Following (Bomfin, 2005), from investor's perspective, the market value of the asset swap is:

$$(14)\quad V^{AP}(0,N)=\left[V^B(0,N)-P\right]+V^{IRS}(0,N)$$

where P is the face value of the bond and $V^Y(\cdot)$ is the market value of Y, with $Y=AP$, B or IRS. The value of the AP at inception can be decomposed in two parts. The first (in squared parentheses) illustrates that even if the buyer pays for par, the market value of the bond could be different, so he can incur either in a loss or a profit if the bond were to be resold in the open market. The second term is the market value of the embedded IRS, which may have either positive or negative market value. Considering that the market value of the bond is given to both the investor and the dealer (as well as LIBOR and bond's coupon), the main issue of negotiation would be the IRS component, namely the spread A over the LIBOR that will be a part of the floating payment made to the investor (Bomfin, 2005). The value of the spread is obtained by imposing the market value of the AP equals to zero at inception.

The market value of the bond is:

$$(15)\quad V^B(0,N)=\left[\sum_{i=1}^{N}\left(D(0,i)\delta_i\overline{C}\right)+D(0,N)\right]P,$$

with $V^B(0, N)$ the market value at time 0 of a fixed-rate bond maturing at time N, $\overline{C}$ the fixed coupon, $D(0,i)$ the discount factor, P the face value, while δ_i is the accrual factor (for example 0.5 if the bond pays coupons semiannually).

To define the market value of the interest rate swap $V^{IRS}(0, N)$, we can consider that the buyer pays fixed and receives floating: this is equivalent to say that the buyer sells a fixed-rate bond and buys a floating-rate one. These considerations allow us to price both fixed and floating legs.

Hence, the fixed leg is equal to:

$$(16)\quad V^{XL}(0,N)=\left[\sum_{i=1}^{N}\left(D^*(0,i)\delta_i\overline{C}\right)\right]P,$$

with the same coupon, notional principal and payment dates as the underlying bond. (Bomfin, 2005) states that, in this relation, there is not an exchange of notional amounts and that $D^*(0, i)$ is a different discount factor, reflecting the credit quality of the counterparties in the swap.

On the other hand, the floating leg is:

$$(17)\quad V^{LL}(0,N)=\left[\sum_{i=1}^{N}\left(D^*(0,i)\delta_i\left(F^*(0,i-1,i)+A\right)\right)\right]P,$$

where A is the spread over LIBOR and $F^*(0, i-1, i)$ is forward LIBOR as seen at time zero, for a deposit to be made at time $i-1$ with maturity at time i. Finally, the market value of the IRS for the investor is:

$$(18)\quad V^{IRS}(0,N)=V^{LL}(0,N)-V^{XL}(0,N)$$

Rewriting (17) as:

$$(19)\quad V^{LL}(0,N)=\left[\sum_{i=1}^{N}\left(D^*(0,i)\delta_i\left(F^*(0,i-1,i)\right)+A\sum_{i=1}^{N}\left(\delta_i D^*(0,i)\right)\right)\right]P,$$

adding and subtracting $D^*(0, N)P$ and rearranging (19), (Bomfin, 2005) arrives to:

$$(20)\quad V^{LL}(0,N)=\left[1+A\sum_{i=1}^{N}\left(\delta_i D^*(0,i)\right)-D^*(0,N)\right]P.$$

Finally, the value of the asset swap spread is obtained by solving the price equation for A, after substituting the relations above:

$$(21)\quad 0=V^B(0,N)+A\sum_{i=1}^{N}\left(\delta_i D^*(0,i)\right)P-V^{XL}(0,N)-D^*(0,N)P.$$

The last two terms represent the present discounted value of the cash flows from the bond underlying the AP, with discount factors constructed on LIBOR. Denoting this quantity V^{B*}, we rewrite equation (21) as:

$$(22)\quad 0=V^B(0,N)-V^{B*}(0,N)+A\sum_{i=1}^{N}\left(\delta_i D^*(0,i)\right)P,$$

by which the asset swap spread is derived easily as [10]:

$$(23)\quad \widehat{A}=\frac{V^{B*}(0,N)-V^B(0,N)}{\sum_{i=1}^{N}\left(\delta_i D^*(0,i)\right)P}.$$

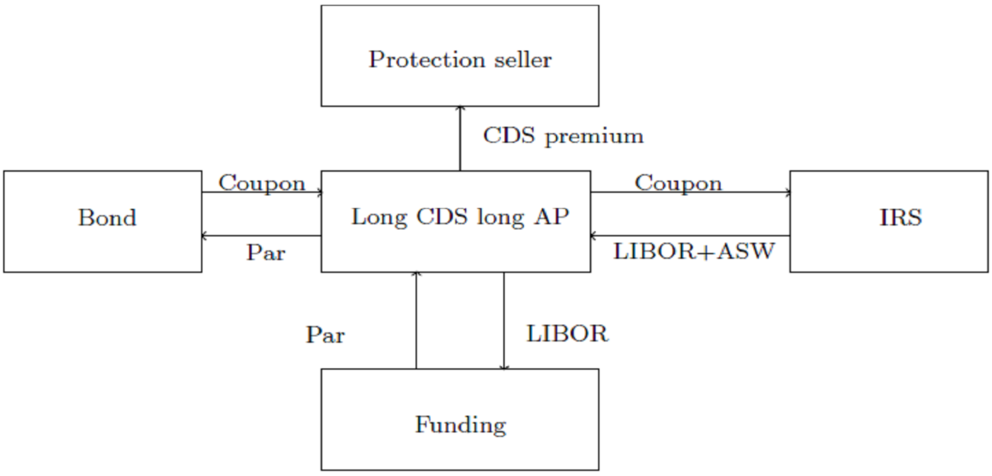
The par asset swap spread becomes positive for $V^{B*} > V^B$, assuming that the discount factors on the reference entity are lower than the same evaluated on the LIBOR curve: this means that the entity has a lower credit quality than that embedded in LIBOR, obtaining a positive spread. Opposite considerations are true for a negative spread.

2.3 No-Arbitrage Relation

Pricing considerations lead us to the definition of the theoretical no-arbitrage relationships between credit default swaps and asset swaps. Following (De Wit, 2006) and (O'Kane and McAdie, 2001), we can demonstrate that for an investor who funds himself at LIBOR, a combined position of buying protection in a CDS and entering into an asset swap is fully hedged in any state of the world.

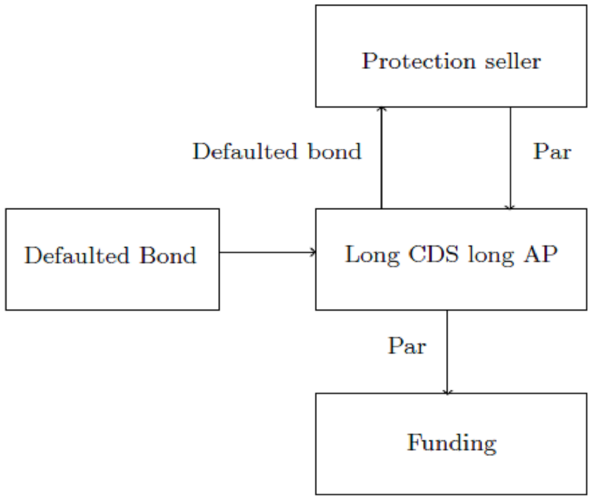
In both figures, the strategy leads to a credit risk-free position: the CDS premium should match the asset swap spread, assuming that both instruments have the same remaining maturity.

Figure 3. No default situation



Source : (De Wit, 2006)

Figure 4. Default situation.



Source : (De Wit, 2006)

The natural market strategy is to buy the cash bond, swap it in the asset swap market and buy protection using CDS. The investor receives floating coupons and pays the CDS premium. If the difference between the two premiums is not zero, as in practice, there is an arbitrage opportunity. Specifically, when the CDS spread is greater than the spread on the asset swap, we have a positive basis with the credit derivative that trades higher than the asset swap. When the basis is negative, the credit derivative trades tighter than the asset swap.

As for the CDS-cash basis, if the difference between CDS spread and the asset swap spread is not zero, the arbitrageur can trade across the cash and the synthetic market realizing a profit. In particular, when the basis is positive, he sells the cash and sells protection on that bond, while if the basis is negative he makes an opposite strategy. As suggested by (Choudhry, 2006), the CDS-bond basis is usually positive, due to the net impact of factors driving the basis, while negative basis lasts for brief periods [11].

An important feature to remember is that the asset swap contract is a par asset swap. Therefore, there is a need for the cash bond to be priced at or very near par (see both figures above). However, most corporate bonds trade significantly away from par, with the consequences that: i) the asset swap price is an inaccurate measure of credit risk and ii) the CDS-asset swap measure is an unreliable basis. This is true because when the underlying bond of the asset swap is above par, the swap price will overestimate the level of credit risk, while if the bond is below par, the asset swap will underestimate the credit risk.

3 Market Strategy for Negative Basis Trade

The no-arbitrage relation described above does not consider funding costs related to both the asset swap and the CDS contracts. According to (J.P.Morgan, 2009) *"Before the 2008-2009 liquidity crisis a buyer of a CDS protection on a single name would make regular payments of the CDS full running spread to the protection seller. However, over the last year it has become common practice for CDS protection to be bought with an upfront payment, followed by a standard fixed coupon. Buyers of protection are also required to give a proportion of the notional, known as the margin, to the dealer to act as collateral"*. When the difference between CDS and asset swap is negative, as shown in figure (2) for Greece, an investor can buy a CDS, repo the bond in order to reduce the funding costs and enter into a par asset swap, realizing a profit. We consider the funding costs of the bond and the CDS and finally compute the income for this strategy.

3.1 Asset Swap Funding

The par asset swap requires that the bond have to be priced at par. However this price can be split into two components: the bond dirty price *P* and the remaining *100-P*. We assume that investor funds every two components. The bond dirty price is financed through a secured repo. The repo counterparty will lend to the investor at a reduced rate of LIBOR *(L)* plus the repo rate *(R)*, but will also hold the bonds as collateral. Typically the counterparty will only lend the investor a proportion of the bond dirty price, while the unfunded part is the haircut *h*. Therefore, the funding for repo is:

$$(24)\quad Funding_{repo} = (1-h)(L+R)P/100$$

The haircut must be funded at LIBOR plus and unsecured funding rate (*F*):

$$(25)\quad Funding_{haircut} = (h)(L+F)P/100$$

The remaining *100-P* is financed at the same rate as the haircut:

$$(26)\quad Funding_{ap} = (L+F)(1-P/100)$$

To sum up, the total funding cost for entering an asset swap is:

$$(27)\quad Funding = \left[(1-h)(L+R)P/100\right] + \left[(h)(L+F)P/100\right] + \left[(L+F)(1-P/100)\right]$$

3.2 CDS Funding

The investor who wants to buy protection through a CDS contract has to pay an upfront followed by a standard fixed coupon. Moreover, he has to post a margin for the notional at risk (i.e. the total notional minus any upfront) [12]. We assume that both the upfront U and the margin m are financed at LIBOR plus the unsecured funding rate. We also assume that the accrued interest is zero.
The upfront funding cost is:

$$(28)\quad Funding_{upfront} = U(L+F)$$

The margin funding cost is:

$$(29)\quad Funding_{mar} = m(1-U)(L+F) - m(1-U)L = m(1-U)F$$

By combining the funding for the CDS upfront and for the CDS margin we obtain the total funding cost for the CDS:

$$(30)\quad Funding_{cds} = U(L+F) + m(1-U)F$$

Comparing equations (27) and (30) it is evident that CDS funding costs are smaller than asset swap funding costs, because both the CDS margin and upfront are fractions of the notional.

3.3 Total Funding Costs and Income

We can now compute the total funding costs and the consequent net income for a negative basis trade. We assume that the investor uses equal notionals on bond and CDS. The income from a negative basis trade is the income from the asset swap minus the CDS coupon:

$$(31)\quad Income_{basis} = L + S_{asw} - C$$

The total funding cost for the strategy is:

$$(32)\quad Funding_{tot} = \left[L + F - (1-h)(F-R)P/100\right] + \left[U(L+F) + m(1-U)F\right]$$

The net income from the negative basis strategy is:

$$Income_{net} = Income_{basis} - Funding_{tot} = (33)\quad S_{asw} - C - F - m(1-U)F - U(L+F) + (1-h)(F-R)P/100.$$

This equation is obtained by canceling out the LIBOR on the notional amount. Note that the LIBOR dependency is very small because it is paid on the CDS upfront, which itself is a fraction of the notional.

3.4 An Example for Greece

Figure (3) shows the dynamics of the 5 year cash-CDS basis together with 6 possible cases of net annual income from the negative basis strategy. In order to evaluate the presence of arbitrage opportunities, we use equation (33) by considering these chosen values:

1) upfront=0.1, haircut=0.1, spread=125bp, margin=0.1 and bond price=80
2) upfront=0.1, haircut=0.1, spread=125bp, margin=0.1 and bond price=99
3) upfront=0.1, haircut=0.1, spread=125bp, margin=0.1 and bond price=102.5
4) upfront=0.1, haircut=0.1, spread=200bp, margin=0.1 and bond price=80
5) upfront=0.3, haircut=0.3, spread=125bp, margin=0.3 and bond price=80
6) upfront=0.1, haircut=0.05, spread=125bp, margin=0.3 and bond price=80.

A positive income is obtained in 5 out of 6 cases: during the end of April up to 7 May 2010 the maximum net income obtained is 91.70 bp. This confirms the assumption by Choudhry that negative basis lasts for brief periods. Even if the basis is negative since the end of February, it is not sufficient to create a net income: in our example net income from the strategy requires at least 100 bp of negative basis [13]. However, our results deserve caution because data on both CDS premia and asset swap spread are mean values of all contracts on the same entity provided by Datastream [14].

4 Lead-Lag Analysis

An interesting analysis with both CDS and asset swap spread could be the study of the lead-lag relations. As suggested by the empirical literature (Blanco et al., 2004), (Zhu, 2004) and (Coudert and Gex, 2010), among others, the short-run relation between CDS and bond spread are bivariate. Hence, the Granger causality test does not give a direct answer to the causality relation. We care about this problem and we concentrate only on the long-run relation by using a Vector error correction model (VECM). For our empirical analysis we use 5 year CDS spread and the mean between asset swap spread with 3-5 and 5-7 year maturities. Our sample spans from the Lehman Brothers bailout to the end September 2010, with a weekly frequency. For interbank rates we use 3m interbank rate (Libor or Euribor) and the 3m Eurepo rate general collateral. All data are gathered from Datastream.

We construct the cointegrating vector with three different relations: i) CDS and asset swap spread; ii) CDS, asset swap spread and 3m Libor or 3m Euribor; iii) CDS, asset swap spread, and the difference between 3m Euribor and 3m Eurepo general collateral. For i) and ii) we run the VECM and study the price discovery process, while for iii) we estimate the cointegrating vector and compare the different basis.

Relations i) and ii) require the estimation of the following VECMs:

$$\Delta p_{CDS,t} = \lambda_1\left(p_{CDS,t-1} - \alpha_0 - \alpha_1 p_{AP,t-1}\right) + \sum_{j=1}^{p}\beta_{1,j}\Delta p_{CDS,t-j} + \sum_{j=1}^{p}\delta_{1,j}\Delta p_{AP,t-j} + \varepsilon_{1t}$$

$$(34)\quad \Delta p_{AP,t} = \lambda_2\left(p_{CDS,t-1} - \alpha_0 - \alpha_1 p_{AP,t-1}\right) + \sum_{j=1}^{p}\beta_{2,j}\Delta p_{CDS,t-j} + \sum_{j=1}^{p}\delta_{2,j}\Delta p_{AP,t-j} + \varepsilon_{2t}$$

and

$$\Delta p_{CDS,t} = \lambda_1\left(p_{CDS,t-1} - \alpha_0 - \alpha_1 p_{AP,t-1} - \alpha_2 Rate_{t-1}\right) + \sum_{j=1}^{p}\beta_{1,j}\Delta p_{CDS,t-j} + \sum_{j=1}^{p}\delta_{1,j}\Delta p_{AP,t-j} + \sum_{j=1}^{p}\gamma_{1,j}\Delta Rate_{t-j} + \varepsilon_{1t}$$

$$\Delta p_{AP,t} = \lambda_2\left(p_{CDS,t-1} - \alpha_0 - \alpha_1 p_{AP,t-1} - \alpha_2 Rate_{t-1}\right) + \sum_{j=1}^{p}\beta_{2,j}\Delta p_{CDS,t-j} + \sum_{j=1}^{p}\delta_{2,j}\Delta p_{AP,t-j} + \sum_{j=1}^{p}\gamma_{2,j}\Delta Rate_{t-j} + \varepsilon_{2t}$$

$$(35)\Delta Rate_t = \lambda_3\left(p_{CDS,t-1} - \alpha_0 - \alpha_1 p_{AP,t-1} - \alpha_2 Rate_{t-1}\right) + \sum_{j=1}^{p}\beta_{3,j}\Delta p_{CDS,t-j} + \sum_{j=1}^{p}\delta_{3,j}\Delta p_{AP,t-j} + \sum_{j=1}^{p}\gamma_{3,j}\Delta Rate_{t-j} + \varepsilon_{3t}$$

where Rate is the 3m Libor or 3m Euribor. Results from the Johansen lambda trace test in Tables (2) and (3) suggest that in 10 out of 20 countries cointegration holds for i), while in 19 out of 20 countries for ii). Hence, the inclusion of a liquidity proxy in the traditional cointegrating relation seems restore the long-run relationship. In Table (5) we report the estimated cointegrating vectors from the Johansen methodology and the Dynamic ordinary least squares (DOLS) by (Stock and Watson, 1993). We can see that only for Greece and Portugal the coefficients seem in line with the traditional definition of the basis. However, Portugal denotes a constant which is significantly different from zero. When the funding costs proxy (3m Libor or Euribor and Repo) is considered, we can see that it is significantly different from zero, while Euribor and Repo have different signs.

The price discovery analysis for the traditional cointegrating vector is shown in Table (6). When cointegration holds, results seem confirm that on average the CDS market is the leader in terms of price discovery, with respect to the bond market. However, there are cases where the relation is unclear. Estimated results from equation (35) are indicated in Table (7). Even in this case the CDS market is the leader in terms of price discovery, even if there are cases where the bond seems move ahead of the CDS market.

An interesting comparison would be realized by computing the basis with the estimated cointegrating vector for CDS and asset swap spread, together with 3m Euribor and Eurepo general collateral. For some countries we note a convergence in the three different basis, particularly evident for Greece, Ireland and Portugal. For the first one, the period involved is from February 2010 when the basis starts to become negative; moreover, there is a quasi equivalence during end of April - beginning of May and during our last period. For Ireland there is a similar pattern: the equivalence is more pronounced during the end of April, but also during end of September with an extraordinary convergence among our different basis. Portugal is only involved for the end of April, beginning of May. This pattern could enforce the presence of negative basis strategy in the credit risk market and this can be confirmed by the case of Greece in Graph (3).

A final exercise is dedicated to the determinants of the cash-CDS basis with the presence of funding costs. Following the spirit of (Carboni and Carboni,2010) and (ECB, 2010), among others, credit risk during financial turmoil is explained by three common factors. The first is reasonably approximated by the iTraxx Europe which could be considered as a global risk factor: an increase in the iTraxx Europe should create an increase in the basis. The second is the VSTOXX which measures the markets' risk aversion: an increase in the risk aversion should increase the basis. The third is the ratio of the Eurostoxx equity index for banks over the overall Eurostoxx equity index in order to deal with banking sector prospects: when this ratio falls, the market is assessing more vulnerabilities to the banking sector, then to the rest of the economy; hence the greater the ratio, the lower the basis.

By using weekly data spanning from January 2009 to September 2010, for the European countries in our sample, we estimate the following equation through OLS:

$$(36)\quad \Delta Basis = \alpha + \beta_1 \Delta iTraxx\ \ Europe + \beta_2 \Delta VSTOXX + \beta_3 \Delta Ratio + \varepsilon \quad .$$

Results from Table (8) suggest that assumptions for our proxies hold. The global risk factor seems increase the basis, the markets' risk aversion factor is a positive determinant, except for Italy, while the perception of the riskiness of the banking sector is a negative determinant, except for Norway. An interesting case is Ireland with a coefficient for the bank ratio triple with respect to other countries. However, the presence of residual autocorrelation does not allow us to conclude in a clear-cut way.

5 Conclusions

This paper explores the cash-CDS basis for sovereign entities during post Lehman Brothers bailout. After a technical description of both CDS and asset swap contract as credit risk indicators, pricing considerations lead to the definition of the no-arbitrage relation. Moreover, we explain how to realize a positive net income, after taking into account funding costs for both the asset swap and the CDS. The example of Greece during 2010 helps explaining that income from negative-basis- strategy exists. Our study confirms a positive net income with a negative basis of at least 100 bp. Through the use of the lead-lag analysis, data show that the CDS market is the leader in terms of price discovery of credit risk, even if some countries do not present clear results. The empirical evidence for the cash-CDS basis compared to its fitted versions, once funding costs are considered, demonstrates that when different basis converge, market seems adopt basis strategy. This is true in particular for Portugal, Ireland and Greece when the basis is negative. Finally, we investigate whether common risk factors are useful determinants for cash-CDS basis. Our empirical analysis shows that the global risk factor iTraxx Europe contributes to enlarge the basis, the markets risk aversion does not offer a direct contribution, while the banking sector vulnerability proxy offers a negative contribution, in particular for Ireland.

References

1. Banque de France (2010), Financial Stability Review, July
2. Blanco, R., Brennan, S. and Marsh, I.W. (2004), “An empirical analysis of the dynamic relationship between investment-grade bonds and credit default swaps”, Banco de Espana, Documento de Trabajo, No. 0401.
3. Bomfin, A.N. (2005), Understanding Credit Derivatives and Related Instruments, Elsevier Academic Press.
4. Carboni, A. and Carboni, A. (2010), “A note on banks and sovereign CDS premia dynamics: market reactions and determinants”, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1962805.
5. Chrouhy, M. (2006), The Credit Default Swap Basis, Bloomberg Professional.
6. Coudert, V. and Gex, M. (2010), “Credit default swap and bond markets: which leads the other?”, Banque de France, Financial Stability Review, Derivatives, No. 14.
7. Credit Suisse (2007), “Credit derivatives handbook”, Fixed Income Research.
8. Credit Suisse (2010), “Sovereign CDS primer”, Fixed Income Research.
9. De Wit, J. (2006), “Exploring the CDS-bond basis”, National Bank of Belgium, Working Paper, No. 104.
10. Duffie, D. (1999), “Credit swap valuation”, Financial Analyst's Journal, Vol.55, No. 1, pp. 73 - 87.
11. Duffie, D. and Singleton, K.J. (1997), “An econometric model of the term structure of interest-Rate swap yields”, The Journal of Finance, Vol.52, No.4, pp. 1287-1321.
12. Ejsing, J.W and Lemke, W. (2009), “The Janus-Headed salvation, sovereign and bank credit risk premia during 2008-2009”, ECB Working Paper, No. 1127.
13. Eichergreen, B., Mody, A., Nedeljkovic, M. and Sarno, L. (2009), “How the subprime crisis went global: evidence from bank credit default swap spreads”, NBER Working Paper, No. 14904
14. European Central Bank (2010), “Monitoring working group: determinants of government bond spread dynamics”, Prepared by Banca d' Italia, Banque de France, Banka Slovenije and Ceska narodni banka}, August.
15. Gonzalo, J. and Granger, C.W.J. (1995), “Estimation of Common Long-Memory Components in Cointegrated Systems”, Journal of Business and Economic Statistics, ERS-2002-23-F\&A.
16. Hamilton J.D. (1994), Time Series Analysis, Princeton University Press.
17. Hasbrouck, J. (1995), “One security, many markets: determining the contributions to price discovery”, Journal of Finance, Vol. 50, No. 4, pp. 1175-1199.
18. Hull, J. and White, A. (2000), “Valuing credit default swaps I: no counterparty default risk”, Journal of Derivatives, Vol. 8, No. 1, pp. 29-40.

19. Hull, J. and White, A. (2001), "Valuing credit default swaps II: modeling default correlations", Journal of Derivatives,, Vol. 8, No. 3, pp. 12-22.
20. IFLS (2009), Derivatives 2009, June.
21. ISDA (2003), Credit Derivatives Definitions.
22. Jarrow, R.A. and Turnbull, S.M. (1995), "Pricing derivatives on financial Securities subject to credit risk", The Journal of Finance, Vol. 50, No.1, pp. 53-85.
23. J.P. Morgan (2009), "The Bond-CDS funding basis", Europe Credit Derivatives Research, 25 September 2009.
24. Lando, D. (1998), "On Cox process and credit risky securities", Review of Derivatives Research, No. 2, pp. 99-120.
25. Longstaff, F.A., Pan, J., Pedersen, L.H. and Singleton, K.J. (2007), "How sovereign is sovereign credit risk?", NBER Working Paper, No. 13658.
26. Mody, A. (2009), "From Bear Stearns to Anglo Irish: how eurozone sovereign spreads related to financial sector vulnerability", IMF Working Paper, May, No. 09/108.
27. O'Kane, D. (2001), "Credit derivatives explained, market, products and regulation", Structured Credit Research, Lehman Brothers.
28. O'Kane, D. and McAdie, R. (2001), "Explaining the basis: cash versus default swaps", Structured Credit Research, Lehman Brothers Fixed Income Research.
29. O'Kane, D. and Sen, S. (2004), "Credit spreads explained", Quantitative Research Quarterly, Lehman Brothers Fixed Income Quantitative Research.
30. Sgherri, S. and Zoli, E. (2009), "Euro area sovereign risk during the crisis", IMF Working Paper, October, No. 09/222.
31. Stock, J. H. and Watson, M. W. (1993), "A simple estimator of cointegrating vectors in higher-order integrated systems", Econometrica, Vol. 61, No. 4, pp. 783-–820.
32. Zhu, H. (2004), "An empirical comparison of credit spreads between the bond market and the credit default swap market", BIS Working Paper, No. 160.

Notes:

1. There is a third type of settlement, called digital, where the seller pays a fixed percentage (decided at the issue of the contract) on the notional.
2. See ISDA (2003) for specific contractual issues.
3. See (Bomfin, 2005), (Choudhry, 2006) and (Jankowitsch et al., 2007) for a more specific reference.
4. Intuitively, for 1 of notional value, the seller pays the loss given default LGD = (1 - RR), where RR is the market or simply the recovery rate of the reference asset.
5. We will come back to the theoretical relation in the next section.
6. See (O'Kane, 2001).
7. In other studies, like for example (Duffie and Singleton, 1997), the value of this claim equals the value of the bond immediately prior to default, while (Jarrow and Turnbull, 1995) stated that it is equal to the value of the bond in the no-default case.
8. However, in (HW, 2001) they formulate pricing relations overcoming this assumption.
9. See (HW, 2000).
10. In equation (1) we have expressed this notation from dealer's position. Moreover, PLIBOR and Pfull correspond respectively to VB*(0, N) and VB(0, N).
11. Even if one could expect the basis to be negative due to financing costs associated with the cash bond position.
12. This margin protects the seller in case of default of the protection buyer. The seller will return the margin at default of the CDS reference entity, at maturity or in case of unwind. In our case the investor receives LIBOR on the posted margin.
13. The maximum income is realized together with a negative basis of 167 bp, that falls to 5 bp the day of the rescue package announcement for Greece on 10 May 2010. See J.P. Morgan (2009) for a definition of the breakeven basis.
14. Full description of the data is provided in the Appendix.

Appendix

A. Data Description

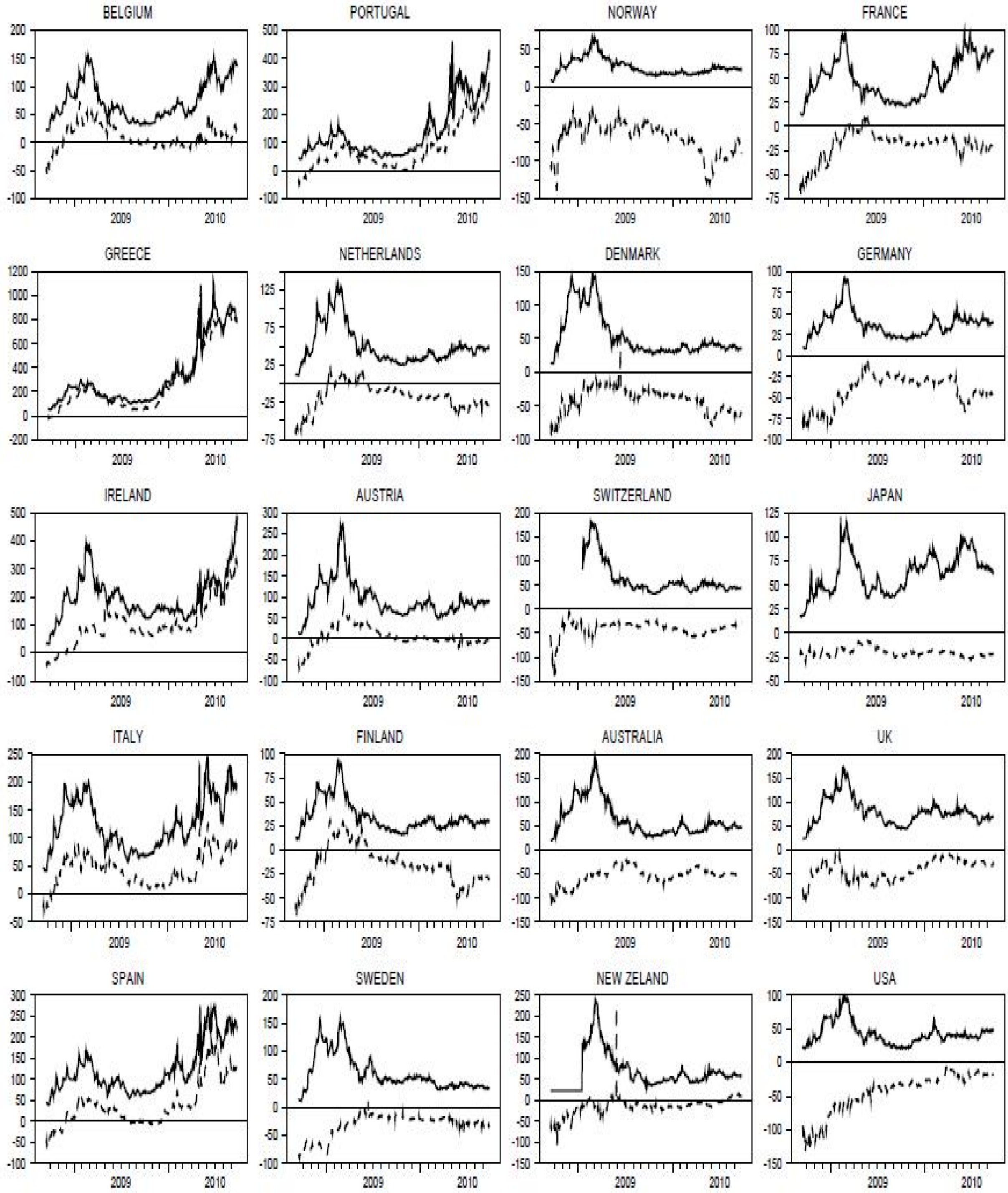
Table 1. CDS premia and asset swap spread

CDS Premia		**Asset swap spread**	
Name	**Code**	**Name**	**Code**
AUSTRALIA SEN 5YR CDS	AUGVTS5(SM)	Australian Government 3-5 Yrs	G2T0(ML:ASWPS)
AUSTRIA SEN 5YR CDS	OEGVTS5(SM)	Australian Government 5-7 Yrs	G3T0(ML:ASWPS)
BELGIUM KINGDOM SEN 5YR CDS	BGGVTS5(SM)	Austrian Governments 3-5 Yrs	G2H0(ML:ASWPS)
DENMARK SEN 5YR CDS	DNGVTS5(SM)	Austrian Governments 5-7 Yrs	G3H0(ML:ASWPS)
FINLAND SEN 5YR CDS	FINLDS5(SM)	Belgian Governments 3-5 Yrs	G2G0(ML:ASWPS)
FRANCE SEN 5YR CDS	FRGVTS5(SM)	Belgian Governments 5-7 Yrs	G3G0(ML:ASWPS)
GERMANY SEN 5YR CDS	BDGVTS5(SM)	Danish Governments 3-5 Yrs	G2M0(ML:ASWPS)
GREECE SEN 5YR CDS	GRGVTS5(SM)	Danish Governments 5-7 Yrs	G3M0(ML:ASWPS)
IRELAND (REP.OF) SEN 5YR CDS	IRGVTS5(SM)	Dutch Governments 3-5 Yrs	G2N0(ML:ASWPS)
ITALY SEN 5YR CDS	ITGVTS5(SM)	Dutch Governments 5-7 Yrs	G3N0(ML:ASWPS)
JAPAN SEN 5YR CDS	JPGVTS5(SM)	Finnish Governments 3-5 Yrs	G2K0(ML:ASWPS)
NETHERLANDS SEN 5YR CDS	NLGVTS5(SM)	Finnish Governments 5-7 Yrs	G3K0(ML:ASWPS)
NEW ZEALAND SEN 5YR CDS	NZGVTS5(SM)	French Governments 3-5 Yrs	G2F0(ML:ASWPS)
PORTUGAL SEN 5YR CDS	PTGVTS5(SM)	French Governments 5-7 Yrs	G3F0(ML:ASWPS)
SPAIN SEN 5YR CDS	ESGVTS5(SM)	German Federal Governments 3-5 Yrs	G2D0(ML:ASWPS)
SWEDEN SEN 5YR CDS	SDGVTS5(SM)	German Federal Governments 5-7 Yrs	G3D0(ML:ASWPS)
UNITED KINGDOM SEN 5YR CDS	UKGVTS5(SM)	Greek Governments 3-5 Yrs	G2GR(ML:ASWPS)
USA - TREASURIES SEN 5YR CDS	USGVTS5(SM)	Greek Governments 5-7 Yrs	G3GR(ML:ASWPS)
		Irish Governments 3-5 Yrs	G2R0(ML:ASWPS)
		Irish Governments 5-7 Yrs	G3R0(ML:ASWPS)
		Italian Governments 3-5 Yrs	G2I0(ML:ASWPS)
		Italian Governments 5-7 Yrs	G3I0(ML:ASWPS)
		Japanese Governments 3-5 Yrs	G2Y0(ML:ASWPS)
		Japanese Governments 5-7 Yrs	G3Y0(ML:ASWPS)
		New Zealand Governments 3-5 Yrs	G2Z0(ML:ASWPS)
		New Zealand Governments 5-7 Yrs	G3Z0(ML:ASWPS)
		Norwegian Governments 3-5 Yrs	G2J0(ML:ASWPS)
		Norwegian Governments 5-7 Yrs	G3J0(ML:ASWPS)
		Portuguese Governments 3-5 Yrs	G2U0(ML:ASWPS)
		Portuguese Governments 5-7 Yrs	G3U0(ML:ASWPS)
		Spanish Governments 3-5 Yrs	G2E0(ML:ASWPS)
		Spanish Governments 5-7 Yrs	G3E0(ML:ASWPS)
		Swedish Governments 3-5 Yrs	G2W0(ML:ASWPS)
		Swedish Governments 5-7 Yrs	G3W0(ML:ASWPS)
		Swiss Governments 3-5 Yrs	G2S0(ML:ASWPS)
		Swiss Governments 5-7 Yrs	G3S0(ML:ASWPS)
		U.K. Gilts 3-5 Yrs	G2L0(ML:ASWPS)
		U.K. Gilts 5-7 Yrs	G3L0(ML:ASWPS)
		U.S. Treasuries 3-5 Yrs	G2O2(ML:ASWPS)
		U.S. Treasuries 5-7 Yrs	G3O2(ML:ASWPS)

Source: CMA and Merrill Lynch. Provider Datastream. Daily data from 15 September 2008 to 27 September 2010.5 year asset swap spread are computed as mean values of asset swaps between 3 and 5 years and between 5 and 7 years.

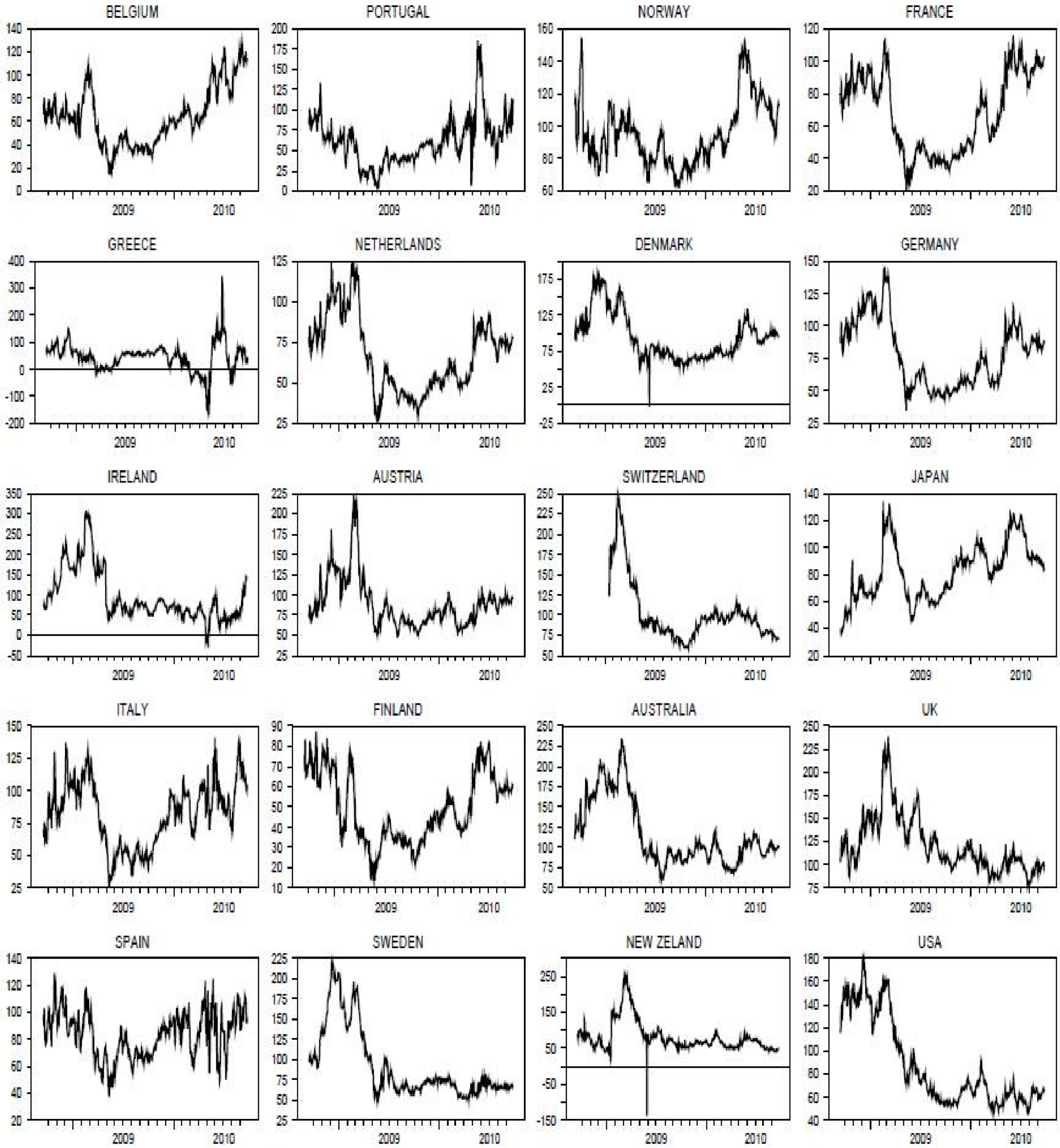
B. Graphs

Figure 1. Sovereign 5 years CDS premia (straight line) and asset swap spread (dotted line)



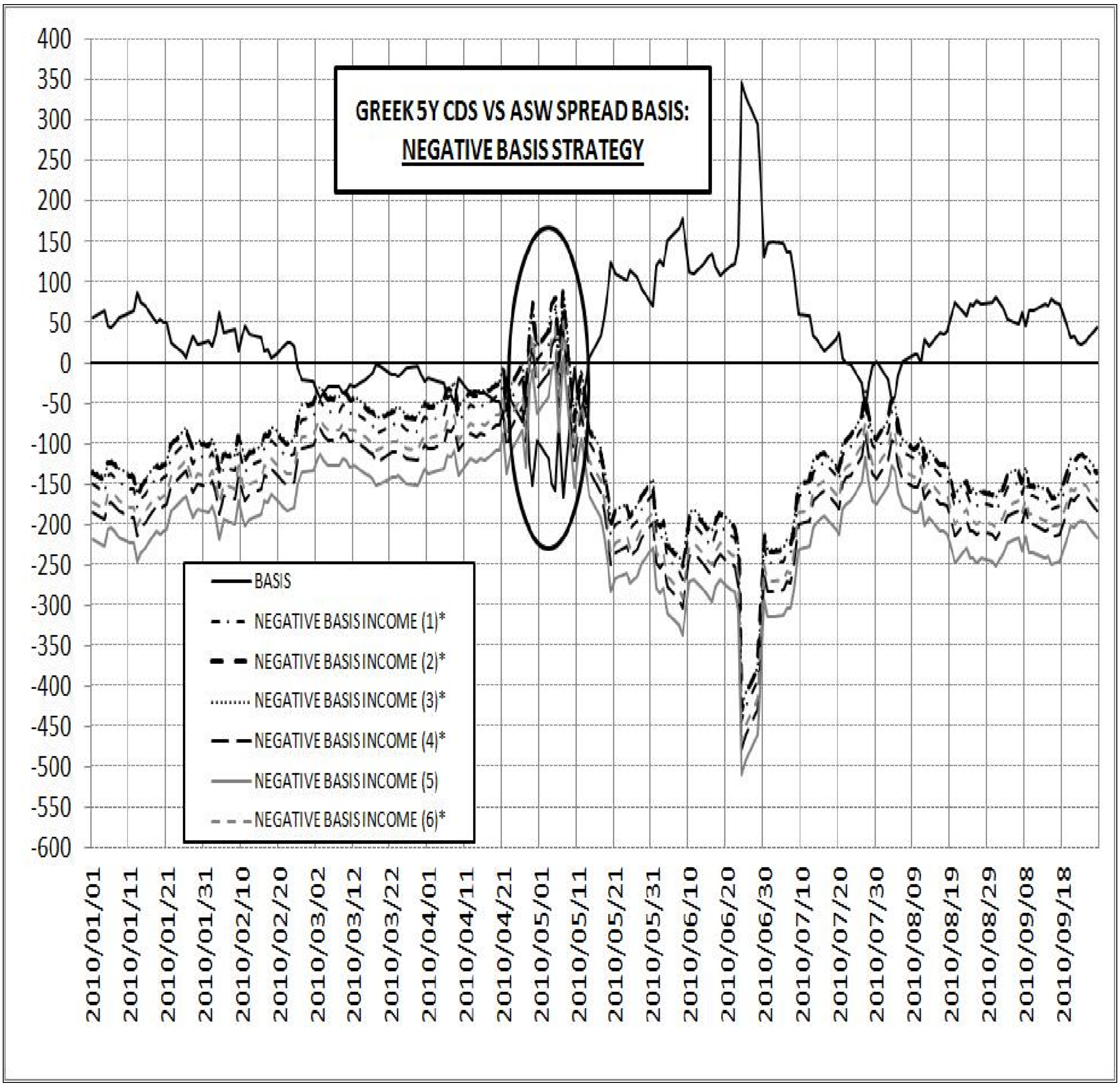
15 September 2008 - 27 September 2010

Figure 2. Sovereign Basis: 5 years CDS premia vs asset swap spread



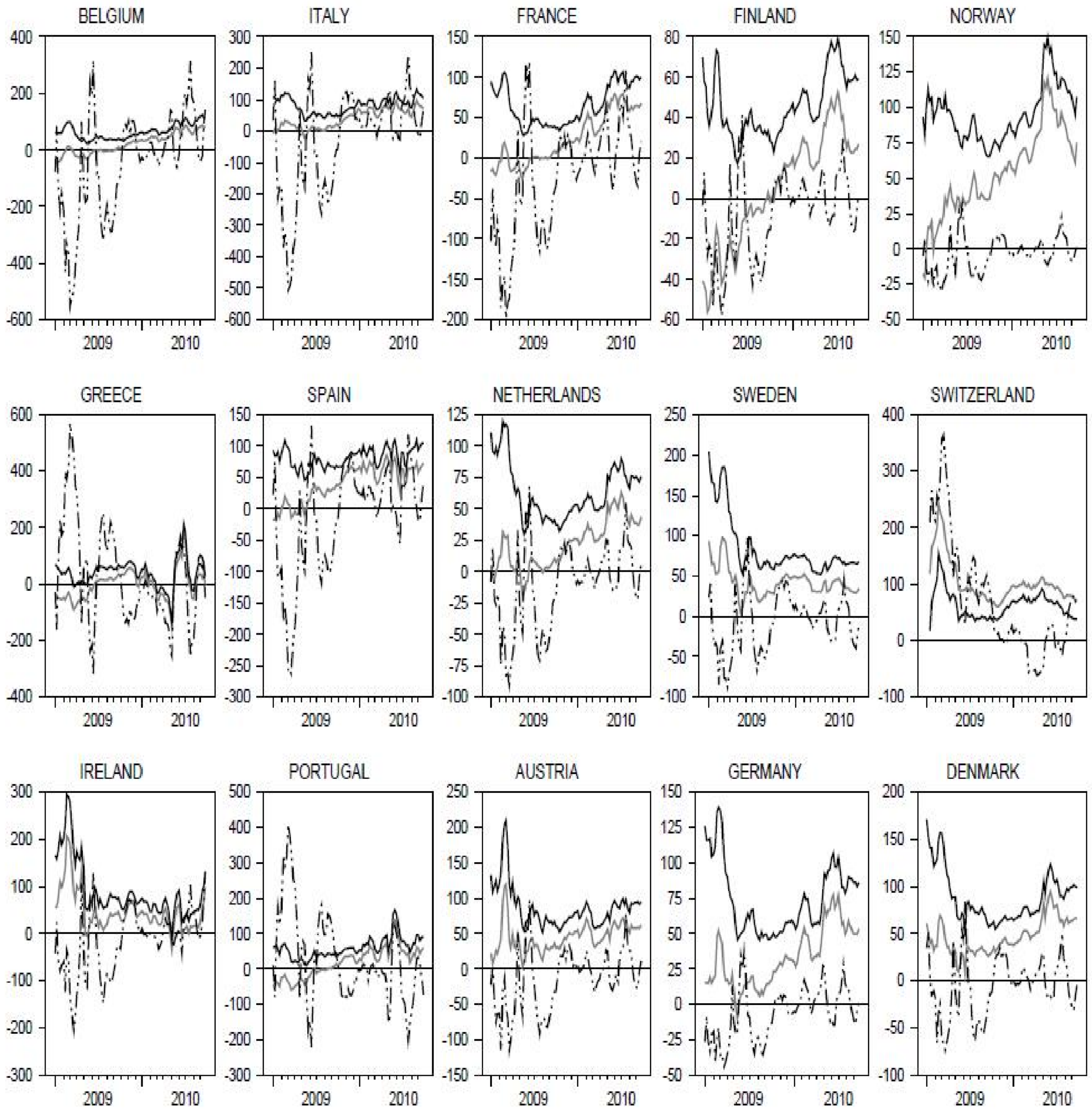
15 September 2008 - 27 September 2010.

Figure 3. Income from negative basis strategy for Greece



January - September 2010. Different parameter values. In the circle net positive income from the strategies labeled with *. See Section (3).

Figure 4. Cash-CDS basis vs fitted basis



The grey line is the basis CDS vs asset swap spread taking care of funding cost (Euribor vs Repo rate). The dotted line is the same basis with coefficients estimated from Johansen methodology with a constant. The black line is the basis CDS vs Asset swap spread. Weekly data spanned from January 2009 to September 2010.

B. Tables.

Table 2. Johansen lambda trace test without and with a constant (first and second row, respectively)

Country	none	95% crit	at most 1	95% crit
BELGIUM*	12.71	**12.28**	0.01	**4.07**
	15.50	**20.16**	2.33	**9.14**
GREECE*	13.16	**12.28**	0.72	**4.07**
	19.57	**20.16**	2.35	**9.14**
IRELAND	6.10	**12.28**	2.22	**4.07**
	9.45	**20.16**	3.02	**9.14**
ITALY	10.46	**12.28**	0.40	**4.07**
	17.59	**20.16**	6.41	**9.14**
PORTUGAL*	13.78	**12.28**	0.72	**4.07**
	21.92	**20.16**	1.61	**9.14**
SPAIN	5.32	**12.28**	0.15	**4.07**
	17.67	**20.16**	2.77	**9.14**
FRANCE*	15.80	**12.28**	0.17	**4.07**
	18.50	**20.16**	2.75	**9.14**
NETHERLANDS	12.22	**12.28**	0.73	**4.07**
	16.96	**20.16**	4.72	**9.14**
AUSTRIA*	12.74	**12.28**	1.42	**4.07**
	25.17	**20.16**	8.72	**9.14**
FINLAND	7.25	**12.28**	0.84	**4.07**
	14.75	**20.16**	6.39	**9.14**
SWEDEN*	18.42	**12.28**	2.75	**4.07**
	21.37	**20.16**	5.70	**9.14**
GERMANY*	14.33	**12.28**	0.90	**4.07**
	18.70	**20.16**	4.62	**9.14**
JAPAN	11.68	**12.28**	0.05	**4.07**
	18.31	**20.16**	5.79	**9.14**
UK*	13.25	**12.28**	0.16	**4.07**
	20.53	**20.16**	6.83	**9.14**
USA	20.80	**12.28**	3.06	**4.07**
	25.03	**20.16**	7.02	**9.14**
NORWAY	6.40	**12.28**	0.03	**4.07**
	11.95	**20.16**	5.28	**9.14**
SWITZERLAND	8.24	**12.28**	0.43	**4.07**
	14.72	**20.16**	4.87	**9.14**
AUSTRALIA*	12.02	**12.28**	2.23	**4.07**
	21.12	**20.16**	5.39	**9.14**
NEW ZELAND*	12.68	**12.28**	1.31	**4.07**
	18.45	**20.16**	7.07	**9.14**
DENMARK	8.74	**12.28**	0.86	**4.07**
	14.48	**20.16**	4.61	**9.14**

Cointegrating vectors with CDS premia and asset swap spread. * indicates cases when cointegration holds.

Table 3. Johansen lambda trace test without and with a constant (first and second row, respectively)

Country	none	95% crit	at most 1	95% crit	at most 2	95% crit
BELGIUM*	35.87	**24.21**	11.34	**12.28**	0.00	**4.07**
	40.16	**35.07**	14.99	**20.16**	2.59	**9.14**
GREECE*	42.74	**24.21**	18.28	**12.28**	0.44	**4.07**
	45.13	**35.07**	20.46	**20.16**	1.57	**9.14**
IRELAND*	44.69	**24.21**	19.77	**12.28**	1.36	**4.07**
	45.65	**35.07**	20.01	**20.16**	1.59	**9.14**
ITALY*	33.18	**24.21**	7.52	**12.28**	0.81	**4.07**
	39.89	**35.07**	13.88	**20.16**	4.76	**9.14**
PORTUGAL*	46.48	**24.21**	22.23	**12.28**	0.64	**4.07**
	51.05	**35.07**	25.28	**20.16**	1.63	**9.14**
SPAIN*	31.70	**24.21**	5.93	**12.28**	0.05	**4.07**
	47.61	**35.07**	20.09	**20.16**	1.25	**9.14**
FRANCE*	39.64	**24.21**	11.64	**12.28**	0.31	**4.07**
	42.55	**35.07**	14.33	**20.16**	2.91	**9.14**
NETHERLANDS*	35.73	**24.21**	11.36	**12.28**	0.70	**4.07**
	41.19	**35.07**	16.44	**20.16**	5.39	**9.14**
AUSTRIA*	34.44	**24.21**	9.60	**12.28**	1.95	**4.07**
	49.86	**35.07**	24.61	**20.16**	7.14	**9.14**
FINLAND*	36.25	**24.21**	10.21	**12.28**	0.41	**4.07**
	44.95	**35.07**	18.92	**20.16**	5.93	**9.14**
SWEDEN*	39.68	**24.21**	13.99	**12.28**	5.05	**4.07**
	52.34	**35.07**	24.81	**20.16**	5.21	**9.14**
GERMANY*	37.11	**24.21**	11.40	**12.28**	1.97	**4.07**
	43.51	**35.07**	17.73	**20.16**	6.94	**9.14**
JAPAN	18.16	**24.21**	5.75	**12.28**	0.61	**4.07**
	24.86	**35.07**	11.85	**20.16**	5.12	**9.14**
UK*	46.73	**24.21**	12.06	**12.28**	2.77	**4.07**
	55.97	**35.07**	20.61	**20.16**	9.20	**9.14**
USA*	42.97	**24.21**	22.14	**12.28**	3.11	**4.07**
	49.40	**35.07**	26.58	**20.16**	6.45	**9.14**
NORWAY*	44.81	**24.21**	11.62	**12.28**	0.12	**4.07**
	51.13	**35.07**	17.72	**20.16**	4.82	**9.14**
SWITZERLAND*	26.77	**24.21**	7.31	**12.28**	0.83	**4.07**
	41.90	**35.07**	20.79	**20.16**	4.67	**9.14**
AUSTRALIA*	28.49	**24.21**	8.25	**12.28**	2.10	**4.07**
	40.64	**35.07**	20.37	**20.16**	5.60	**9.14**
NEW ZELAND*	29.33	**24.21**	11.43	**12.28**	1.65	**4.07**
	35.20	**35.07**	17.27	**20.16**	4.98	**9.14**
DENMARK*	47.19	**24.21**	17.29	**12.28**	0.13	**4.07**
	52.94	**35.07**	22.92	**20.16**	4.09	**9.14**

Cointegrating vectors with CDS premia, asset swap spread and Libor or Euribor. * indicates cases when cointegration holds.

Table 4. Johansen lambda trace test without and with a constant (first and second row, respectively)

Country	none	95% crit	at most 1	95% crit	at most 2	95% crit	at most 3	95% crit
BELGIUM*	138.45	**40.10**	41.69	**24.21**	10.37	**12.28**	0.01	**4.07**
	147.68	**53.94**	50.84	**35.07**	14.95	**20.16**	2.43	**9.14**
GREECE*	130.67	**40.10**	41.29	**24.21**	18.38	**12.28**	0.49	**4.07**
	142.40	**53.94**	51.58	**35.07**	19.97	**20.16**	1.94	**9.14**
IRELAND*	151.44	**40.10**	52.14	**24.21**	19.97	**12.28**	1.73	**4.07**
	152.68	**53.94**	52.99	**35.07**	20.18	**20.16**	1.85	**9.14**
ITALY*	125.01	**40.10**	35.25	**24.21**	7.74	**12.28**	0.54	**4.07**
	135.25	**53.94**	45.48	**35.07**	13.97	**20.16**	4.07	**9.14**
PORTUGAL*	136.60	**40.10**	46.54	**24.21**	22.46	**12.28**	0.77	**4.07**
	154.71	**53.94**	63.68	**35.07**	24.53	**20.16**	2.12	**9.14**
SPAIN*	129.33	**40.10**	35.62	**24.21**	6.16	**12.28**	0.14	**4.07**
	151.33	**53.94**	57.53	**35.07**	18.46	**20.16**	1.66	**9.14**
FRANCE*	152.22	**40.10**	46.20	**24.21**	12.67	**12.28**	0.08	**4.07**
	160.90	**53.94**	54.01	**35.07**	15.03	**20.16**	2.32	**9.14**
NETHERLANDS*	151.05	**40.10**	40.32	**24.21**	10.32	**12.28**	0.59	**4.07**
	158.66	**53.94**	47.81	**35.07**	14.91	**20.16**	5.12	**9.14**
AUSTRIA*	147.23	**40.10**	41.75	**24.21**	9.72	**12.28**	1.81	**4.07**
	164.03	**53.94**	56.96	**35.07**	24.51	**20.16**	7.11	**9.14**
FINLAND*	148.86	**40.10**	40.38	**24.21**	10.00	**12.28**	0.38	**4.07**
	158.57	**53.94**	49.74	**35.07**	18.45	**20.16**	5.74	**9.14**
SWEDEN*	134.21	**40.10**	40.66	**24.21**	14.07	**12.28**	4.31	**4.07**
	150.44	**53.94**	56.69	**35.07**	27.16	**20.16**	4.54	**9.14**
GERMANY*	148.51	**40.10**	44.33	**24.21**	11.57	**12.28**	1.90	**4.07**
	156.50	**53.94**	52.05	**35.07**	17.34	**20.16**	6.69	**9.14**
NORWAY*	152.33	**40.10**	46.72	**24.21**	8.87	**12.28**	0.12	**4.07**
	157.36	**53.94**	51.69	**35.07**	13.83	**20.16**	3.81	**9.14**
SWITZERLAND*	52.99	**40.10**	25.29	**24.21**	10.18	**12.28**	0.78	**4.07**
	69.12	**53.94**	41.24	**35.07**	22.12	**20.16**	7.17	**9.14**
DENMARK*	140.15	**40.10**	45.03	**24.21**	19.04	**12.28**	0.05	**4.07**
	146.91	**53.94**	51.78	**35.07**	23.71	**20.16**	3.92	**9.14**

Cointegrating vectors with CDS premia, asset swap spread, Euribor and Repo rates. * indicates cases when cointegration holds.

Table 5. Estimated cointegrating vectors for different basis

BASIS			BASIS WITH LIBOR			BASIS WITH LIBOR AND REPO			
COUNTRY	ASW	CONST.	ASW	LIBOR	CONST.	ASW	LIBOR	REPO	CONST.
BELGIUM	-4.755***	-	0.713	-1.509***	-	1.428	-14.923***	23.293***	-
			-6.822	4.367***	-288.078	2.284	-19.647***	30.481***	31.621
	-1.306	-	-1.473***	-0.079	-				
GREECE	-1.097***	-	-0.926***	-1.199***	-	-1.083***	20.282***	-34.327***	-
			-0.938***	-1.765***	48.464	-0.981***	17.095***	-27.546***	-120.826
	-0.988***	-	-1.012***	-0.111	-				
IRELAND			0.151	-4.257***	-	-0.821***	-9.483***	14.117***	-
			-3.534	-37.271***	2575.468	-0.721***	-8.785***	13.183***	-27.177
			-0.920**	-0.096	-				
ITALY			2.202	-3.739***	-	-0.726	-18.208***	28.970***	-
			-2.885	2.064***	-128.045	-0.773	-16.276***	25.934***	-10.082
			-1.473***	-0.028	-				
PORTUGAL	-1.517***	-	-0.871***	-1.396***	-	-3.135	90.683***	-150.089***	-
	-1.245***	-38.430***	-1.315***	0.077	-30.679**	-1.371***	12.139***	-19.384***	-84.209
	-1.175***	-	-1.233***	-0.037	-				
SPAIN			0.027	-2.433	-	-0.988***	-14.563***	23.097***	-
			-1.231***	0.179***	-77.472***	-1.039***	-8.184***	13.052***	-36.465
			-1.119***	-0.008	-				
FRANCE	3.544***	-	3.068**	-0.268	-	1.625**	-5.423***	8.490***	-
			4.428**	-0.398	27.999	2.386**	-6.966***	10.768***	28.257
	-0.028	-	0.297	-0.077	-				
NETHERLAND			-0.239	-0.746***	-	0.289	-4.922***	7.435***	-
			0.952	-1.827***	97.194	0.166	-4.501***	6.816***	-6.727
			-0.768	-0.104	-				
AUSTRIA	-8.281***	-	-0.620	-1.183***	-	0.893	-10.296***	15.463***	-
	-2.133***	-77.742***	-3.380	2.649***	-259.610**	-0.117	-5.936***	8.944***	-37.297**
	-1.763***	-	-1.715***	-0.053	-				
FINLAND			-0.162	-0.438***	-	0.178	-3.326***	5.000***	-
			-0.149	-0.456***	1.665	0.052	-2.771***	4.176***	-7.855
			-0.420	-0.061	-				
SWEDEN	2.214***	-	-0.251	-0.798***	-	0.513	-5.248***	8.081***	-
	2.164***	-1.562	-2.545	1.275**	-194.999***	0.328	-4.691***	7.246***	-10.619
	0.804		0.030	0.088	-				
GERMANY	0.962	-	0.372	-0.359***	-	0.566***	-2.388***	3.675***	-
			0.566	-0.431***	12.289	0.474**	-2.228***	3.439***	-5.231
	0.271		0.443	0.035	-				
JAPAN									
UK	2.162***	-	-0.393	-1.169***	-				
	1.016***	-46.119***	-0.675	-0.622***	-57.327*				
	-0.173	-	-0.297	-0.088	-				
USA			74.407***	45.837***	-				
			-16.115***	-5.736***	-241.369**				
			0.199	-0.175	-				
NORWAY			-0.346	-0.646***	-	0.104*	-1.863***	2.805***	-
			-0.488	-0.469***	-24.890	0.073	-1.795***	2.706***	-3.103
			-0.140	-0.055	-				
SWITZERLAN			0.782***	-0.142	-	6.074***	15.380***	-20.044***	-
			1.320***	-0.560***	50.184***	3.485**	5.368***	-7.633***	55.752
			1.195**	-0.626***	-				
AUSTRALIA			0.184	-0.936***	-				
	9.575***	411.071***	0.775	-0.981***	31.113				
	0.339	-	-0.496	-0.588	-				
NEW ZELAND	10.350***	-	1.971	-1.128*	-				
			3.102	-1.315*	21.011				
	-0.760	-	-1.909***	-0.710***	-				
DENMARK			0.011	-0.492***	-	0.195	-4.426***	6.749***	-
			0.222	-0.583***	17.139	0.231	-4.515***	6.881***	2.530
			-0.414	-0.058	-				

CDS coefficients are normalized to one. */**/*** stand respectively for 10%, 5% and 1% significance values.

Table 6. Price discovery analysis

COUNTRY	λ_1	λ_2	Gonz-Grang	HAS1	HAS2	MID
BELGIUM	0.0250359990**	0.0285654077***	1	0.94343	0.48467	0.71405
	0.0144291787	0.0153871196	1	0.91754	0.40532	0.66143
GREECE	0.009799481	0.154041295*	1	0.23231	0.99891	0.61561
	0.045211540	0.142527980*	1	0.42314	0.95043	0.68679
PORTUGAL	0.122189238**	0.189028945***	1	0.75463	0.71853	0.73658
	0.191784952*	0.348389262***	1	0.60236	0.84216	0.72226
	0.098874919**	0.125101349***	1	0.94401	0.45425	0.69913
FRANCE	-0.029582241***	-0.022155539***	0	0.59858	0.46168	0.53013
	0.0016844543	0.0025448032	1	0.93347	0.79199	0.86273
AUSTRIA	0.023553594***	0.0106848476***	0	0.7594	0.3875	0.57345
	0.034423913	0.075027280***	1	0.92617	0.97174	0.94896
	0.006922680	0.010378748*	1	0.97271	0.92882	0.95077
SWEDEN	-0.056280198***	-0.025757233***	0	0.39482	0.49893	0.44688
	-0.057638970***	-0.025904349***	0	0.38638	0.49006	0.43822
	-0.032573462*	0.002915748	0.08216	0.02891	0.02333	0.02612
GERMANY	-0.064987177***	-0.029042301	0	0.14634	0.41851	0.28243
	-0.016745861	0.0046220782	0.21631	0.10036	0.00544	0.05290
UK	-0.006203019	-0.040927906***	1	0.96296	0.98724	0.97510
	-0.027422671	-0.057589911***	1	0.81524	0.89024	0.85274
	-0.002859413	0.0013273502	0.31703	0.26161	0.20987	0.23574
AUSTRALIA						
	-0.010373012**	-0.011250403***	1	0.72264	0.77148	0.74706
	-0.016373036	0.007400989	0.31131	0.32389	0.3525	0.33820
NEW ZELAND	-0.000531672	-0.010731823***	1	0.99999	0.9989	0.99945
	-0.014187582	0.007612627	0.34920	0.35468	0.39976	0.37722

Cointegrating vector with CDS and asset swap spread. */**/*** stand respectively for 10%, 5% and 1% significance values

Table 7. Price discovery analysis

COUNTRY	λ_1	λ_2	Gonz-Grang	HAS1	HAS2	MID
BELGIUM	-0.004917977	-0.007143918*	1	0.99852	0.65686	0.82769
	0.0018519978	0.0030698675**	1	0.99732	0.74060	0.86896
	0.016915001	0.017089042	1	0.88833	0.96687	0.92760
GREECE	-0.022638249	0.005084217	0.18340	0.00662	0.84218	0.42440
	-0.013022458	0.002256271	0.14767	0.00428	0.82861	0.41645
	0.004582476	0.178740691*	1	0.21431	0.99984	0.60708
IRELAND	-0.004594014	-0.002618797	0	0.43606	0.01781	0.22694
	-0.000606615	-0.000295620	0	0.32386	0.00030	0.16208
	0.001386371	0.0405022487*	1	0.70294	0.99942	0.85118
ITALY	-0.006045622*	-0.003703919*	0	0.89876	0.00000	0.44938
	0.010122336	0.007181742*	0	0.98465	0.30559	0.64512
	0.014646430	0.019443774	1	0.80516	0.83794	0.82155
PORTUGAL	-0.005736466	-0.003938810	0	0.43431	0.12396	0.27914
	0.153036687 *	0.254486022***	1	0.68582	0.78091	0.73337
	0.142946418**	0.188780537***	1	0.90729	0.52614	0.71672
SPAIN	-0.004254044	-0.002268188	0	0.45617	0.00837	0.23227
	0.050154740	0.0755999763	1	0.89879	0.76343	0.83111
	0.024414644	0.021142810	0	0.94207	0.22881	0.58544
FRANCE	-0.017308066**	-0.016347816***	0	0.73966	0.59135	0.66551
	-0.011947340**	-0.012133498***	1	0.77656	0.63256	0.70456
	-0.008887458	-0.004563276	0	0.40426	0.21311	0.30869
NETHERLANDS	-0.018780105**	-0.012015779**	0	0.60263	0.22172	0.41218
	-0.007139568**	-0.005379989**	0	0.72290	0.33783	0.53037
	-0.011699924	0.002203484	0.15849	0.04323	0.35916	0.20120
AUSTRIA	-0.024828629**	-0.011443638***	0	0.76910	0.39515	0.58213
	0.007990630*	0.005733342***	0	0.96769	0.70229	0.83499
	-0.007810859	0.008751398	0.52839	0.56895	0.92404	0.74650
FINLAND	-0.022254410**	-0.020054708**	0	0.52073	0.35734	0.43904
	-0.021209230**	-0.019454354**	0	0.53162	0.36790	0.44976
	-0.014732322	0.002785220	0.15900	0.03054	0.14233	0.08644
SWEDEN	-0.028121912***	-0.012000824**	0	0.36653	0.46009	0.41331
	0.0051453428	0.008286678***	1	0.88197	0.92015	0.90106
	-0.016865509	0.011465120*	0.40469	0.64310	0.64061	0.64186
GERMANY	-0.016712461*	-0.016142433*	0	0.39631	0.68556	0.54094
	-0.012871199	-0.014452655**	1	0.45251	0.73713	0.59482
	-0.027102902	0.0083721949	0.23600	0.05429	0.00580	0.03005
UK	-0.010004775*	-0.010713732**	1	0.57702	0.67801	0.62752
	-0.024193523**	-0.019478528**	0	0.43873	0.55538	0.49706
	-0.009813183	0.0017528337	0.15155	0.04686	0.02647	0.03667
USA	0.000106038	0.000355797**	1	0.88265	0.93159	0.90712
	-0.000974074	0.002554125	0.72392	0.91991	0.88049	0.90020
	-0.028315002*	-0.016304000	0	0.24101	0.32615	0.28358
NORWAY	-0.007811670**	-0.022851394*	1	0.40001	0.39101	0.39551
	-0.010461878**	-0.026580242	1	0.33464	0.32053	0.32759
	-0.007885424	-0.018812974	1	0.31656	0.28237	0.29947
SWITZERLAND	-0.056891584*	0.0396195819***	0.41052	0.84798	0.65247	0.75023
	-0.200080687***	0.0447313788*	0.18272	0.19018	0.05515	0.12267
	-0.014492136	-0.002706978	0	0.10808	0.33993	0.22401
AUSTRALIA	-0.023176454**	-0.016625787***	0	0.54876	0.60528	0.57702
	-0.020219100**	-0.016132145***	0	0.59789	0.65891	0.62840
	-0.023750653*	-0.001342544	0	0.00807	0.00617	0.00712
NEW ZELAND	-0.003995346	-0.010378396*	1	0.94272	0.93711	0.93992
	-0.002207595	-0.008560914*	1	0.97564	0.97087	0.97326
	-0.03091934*	-0.001786780	0	0.01875	0.01123	0.01499
DENMARK	-0.046491644***	-0.020793150	0	0.16843	0.13623	0.15233
	-0.037398688***	-0.019218362*	0	0.10546	0.18111	0.14329
	-0.018926206	0.003278996	0.14767	0.59010	0.09763	0.34387

Cointegrating vector with CDS, asset swap spread and 3m Euribor. */**/*** stand respectively for 10%, 5% and 1% significance values.

Table 8. Basis vs common risk factors

Country /Variable	Constant	Δ iTraxx Europe	Δ VSTOXX	Δ Ratio	R-sq	DW STAT	LB(1)	LB(4)
Austria	1.091	0.631***	-0.247	-2.268**	0.409	1.325	0.001	0.000
Belgium	1.730***	0.245**	-0.049	-0.439	0.106	1.768	0.269	0.058
Denmark	0.534	0.476***	-0.030	-0.796**	0.389	2.033	0.821	0.011
Finland	1.015**	0.236*	-0.003	-0.173	0.157	1.557	0.041	0.001
France	1.221**	0.232	-0.011	-0.941*	0.264	1.745	0.244	0.128
Germany	0.815*	0.264**	0.116	-1.410***	0.459	1.590	0.072	0.005
Greece	1.077	0.666*	0.638	1.760	0.032	1.415	0.007	0.044
Ireland	0.986	0.337	-0.087	-3.505*	0.140	1.233	0.000	0.000
Italy	1.059	0.309	-1.089**	-1.750***	0.148	1.802	0.377	0.099
Netherlands	0.849	0.196**	0.096	-1.185***	0.341	1.725	0.353	0.072
Norway	1.258**	-0.047	-0.568	0.842***	0.162	1.860	0.659	0.707
Portugal	1.664	0.085	1.461**	0.124	0.101	1.647	0.091	0.000
Spain	1.258	0.106	0.379	-0.908	0.081	1.877	0.561	0.003
Sweden	-0.096	0.536***	-0.452	-0.851*	0.333	1.442	0.022	0.002
Switzerland	0.277	-0.077	-0.367	-3.444***	0.266	1.369	0.014	0.062

Dependent variable: Δ basis. Period: January 2009 - Sept 2010. HAC standard errors. */**/*** stand respectively for 10%, 5% and 1% significance values.