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ABSTRACT

Sovereign CDS and Bond Pricing Dynamics in the Euro-area*

This analysis tests the price discovery relationship between sovereign CDS premia and bond yield spreads on the same reference entity. The theoretical no-arbitrage relationship between the two credit spreads is confronted with daily data from six Euro-area countries over the period 2004-2011. As a first step, the supposed non stationarity of the two series is verified. Then, we examine whether the non-stationary CDS and bond spreads series are bound by a cointegration relationship. Overall the cointegration analysis confirms that the two prices should be equal to each other in equilibrium, as theory predicts. Nonetheless the theoretical value [1, -1] for the cointegrating vector is rejected, meaning that in the short run the cash and synthetic market's valuation of credit risk differ to various degrees. The VECM analysis suggests that the CDS market moves ahead of the bond market in terms of price discovery. These findings are further supported by the Granger Causality Test: for most sovereigns in the sample, past values of CDS spreads help to forecast bond yield spreads. Short-run deviations from the equilibrium persist longer than it would take for participants in one market to observe the price in the other. That is consistent with the hypothesis of imperfections in the arbitrage relationship between the two markets.

JEL Classification: F34, G12 and G15

Keywords: asset pricing, CDS, euro area, international finance and sovereign bonds

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1 Introduction

As Duffie (1999) and related literature point out, a theoretical no-arbitrage condition between the cash and synthetic price of credit risk should drive investment decisions and tie up the two credit spreads in the long run. Insofar as credit risk is what they price, cash and synthetic market prices should reflect an equal valuation, in equilibrium. If in the short run they are affected by factors other than credit risk, such elements may partially obscure the comovement between bond yield spreads and CDS premia.

The first contribution of this study lies in checking the accuracy of credit risk pricing in the CDS market by comparing the theoretically implied CDS premia with the one established by the market. The existence of a stable cointegration relationship between the two credit spreads presupposes a statistically significant long-run connection between bonds and CDS contracts on the same reference entity. On the one hand, this rules out the possibility that credit risk is priced in unrelated ways in the derivative and cash market. On the other, we cannot discard the hypothesis that large common pricing components rather than credit risk affect both prices to some extent.

As a second contribution, we address the relative efficiency of credit risk pricing in the bond and CDS market. In order to explore the price discovery relationship between CDS and bond yield spreads, we estimate a Vector Error Correction Model (VECM). We proceed in three steps: first, we apply the augmented Dickey-Fuller test for each bond yield spread and CDS premia series. If the credit spreads are cointegrated of order one at the 5% level, for each country in the sample we then perform a Johansen cointegration test to determine if bond yield spreads and CDS premia move together in the long run. If the cointegration hypothesis is not rejected at the 5% level, we then estimate a Vector Error Correction Model to investigate whether the CDS market can anticipate the bond market in pricing, or merely adapts to the cash market valuation of credit risk.

Several recent papers study the credit derivative markets. The majority focus on CDS contracts written on corporate bonds,¹ and their data do not cover the past several years, in which the CDS market grew rapidly and then went through the financial crisis. Of the few papers devoted to the

¹J. Hull, M. Predescu, and A. White, 2004; R. Blanco, S. Brennan, and I.W. Marsh, 2005. Blanco et al. do take an approach similar to our own, unlike the studies cited in fn. 2.

study of sovereign CDS spreads, most focus on emerging markets. We know of only two papers on sovereign credit risk in the European Union based on CDS market data.² The size of the markets, the intrinsic interest of the recent period, and the policy relevance of CDS market performance would seem to justify further work with a different approach.

The most relevant studies following the accuracy and efficiency dimensions of credit risk are Zhu (2006) and Ammer and Cai (2011). Zhu examines how CDS spreads interact with bond rates, using daily data of corporate names over the period 1999-2002. His analysis confirms that the long-run parity condition holds in the data for corporate reference entities, even though short-run price discrepancies can exist between the two markets. VECM analysis shows that the derivative market moves ahead of the bond market in terms of price discovery. Ammer and Cai (2011) find that the parity relationship between the two credit spreads holds for a sample of nine emerging market economies over the period 2001-2005. They provide no conclusive evidence regarding which market leads price discovery, but they argue that the relatively more liquid market tends to lead.³ Our study similarly brings the theoretical parity relation between CDS and bond spreads to the data, but it differs from their papers in several ways. First, we cover a substantially longer and more recent period than does Zhu (2004-2010 vs. 1999-2002). We include in the analysis the period of maturity of CDS market,⁴ and we extend the analysis over the current financial crisis. Although the theoretical framework we refer to is similar to that of Zhu (2006), we examine the Eurozone

²O. Arce et al., 2011. Their country sample and approach differ from ours. They apply a statistical arbitrage test (Hogan, Teo, and Warachka, 2004) on the CDS-bond basis trying to assess whether the existence of a non-zero basis has either to be seen as a consequence of market frictions or has to be understood as an opportunity for arbitrage. In their price discovery analysis, they use rolling windows estimation, while we apply a static price discovery metric. Our results are not directly comparable.

A. Fontana and M. Scheicher, 2010. They focus on ten EU countries over the period 2006-2010. They do regression analysis to investigate the determinants of the sovereign CDS-bond basis. This is a rather different perspective. In addition, they apply VECM framework to 10 year bond and CDS series to investigate their price discovery relation. They split their sample into pre and post crisis, hence producing results not directly comparable to ours, as we decided not to break up the sample period (see discussion below).

³Ammer and Cai show that the Gonzalo and Granger measure of CDS price leadership is positively correlated with the ratio of the bond bid-ask spread, to CDS bid-ask spread and negatively with the number of bonds outstanding, respectively a proxy for relative and collective bond market liquidity. Arce, Mayordomo and Pena find that price discovery is state-dependent, and they argue that market liquidity is a significant factor in determining which market leads price discovery.

⁴According to the International Swap and Derivative Association (ISDA) Market Survey (2008), after 2003 the CDS market reached its maturity, characterized by a rapid growth, and by the shift in its primary use from hedging to speculation. The global notional amount of CDS contracts outstanding started to fall only after a series of large scale incidents in 2008, beginning with the failure of Bear Stearns.

credit risk, an issue largely ignored until spring 2010.

Compared to Ammer and Cai (2011), we also focus the analysis on sovereign debt, but we refer to credit risk in developed economies. Our results seem to convey a more clear-cut picture of the role of the CDS market in sovereign credit risk pricing. Our principal results are as follows. There is clear evidence that CDS and bond yield spreads diverge substantially in the short run. VECM results suggest that this may be attributed largely to a different timing of response to new information available in the short run. Nonetheless, cointegration analysis supports the long-run price accuracy of CDS relative to the underlying bond market, suggesting long-run equilibrium between the two credit prices.

In the baseline VECM estimation with two lags, four out of six countries in the sample show the existence of a significant *two-way* price interaction between the CDS and the underlying bond markets. For these countries, the CDS market reacts relatively more quickly to changes in credit conditions. For the remaining two sovereigns in the sample, we observe a one-way credit risk pricing dynamic where information is essentially revealed in the CDS market, and the cash market adjusts to eliminate deviations from the long-run equilibrium.

Short-term deviations show surprising persistence. On average, only 2% of price discrepancies are eliminated within two business days. This suggests that there may be some rigidities at play in one or both markets.

The approach and conclusions of our study are also similar to those in Blanco et al. (2005), even though they focus on corporate credit risk and include also US reference entities in their study. An important difference with their paper is that they focus on data from 2001-2002, before the real boom of the European CDS market starting in 2003, while we rely on a much longer time span, including the financial crisis.

Section 2 provides a market overview and introduces the theoretical pricing framework. Section 3 describes the econometric methodology and summarizes the empirical results. Section 4 concludes.

2 The CDS Market

2.1 Pricing Framework and Related Literature

This study relates to a specific branch of the literature on credit risk pricing based on the approximate arbitrage relationship between CDS prices and credit spreads for a given reference entity. According to Duffie (1999), elaborated by Hull and White (2003), there is a perfect arbitrage opportunity between a risky bond traded at par, a riskless par bond, and a CDS contract of the corresponding maturity. Under certain assumptions, the price of a CDS contract can always be deduced from the asset swap spread of a bond. Specifically, one needs to assume no frictions to short-selling the risky bond in the repo market, and that the recovery rate of a defaulted bond is zero. A rigorous theoretical measure of CDS spreads would require an estimate of the risk-neutral probability that the underlying bond defaults at different future times and an estimate of the recovery rate in case of default. Making use of this loose proximate arbitrage relation instead allows us to provide an approximate upper bound to the true CDS spread. Given the assumption of zero recovery rate in case of default, our estimate of the true spread is always biased upwards. Following the same logic, our estimates of the yield to maturity on the bond can be seen as a lower bound to the true one, as we are not taking into account the cost associated to shorting the risky asset. Under these assumptions, the annual yield of a risk-free bond must be equal, in equilibrium, to the difference between the annual yield of the corresponding risky bond and the cost of credit protection expressed as a percentage of the risky bond nominal value.⁵ If the annual premium paid in the CDS market for credit protection is CDS_{spread} and the annual yield of the risky and risk-free bond are respectively BY and BY_{rf} , then:

$$BY_{rf} = BY - CDS_{spread} \tag{1}$$

Whenever $BY_{rf} > BY - CDS_{spread}$ investors would make a profit buying the risk-free product, shorting the risky bond and selling protection in the CDS market. If $BY_{rf} < BY - CDS_{spread}$, then buying a risky bond, buying protection on it in the CDS market and shorting the risk-free

⁵Duffie originally used LIBOR as the risk free rate, whereas Hull and White used US Treasuries as the riskless benchmark.

bond would be profitable.

The same condition can be expressed in terms of the basis. The bond-CDS basis is the difference between the CDS spread and the bond yield spread on the same reference entity, defined as the spread of a risky bond over a risk-free bond of the same maturity. Based on the previous relation, and assuming perfect arbitrage between the cash and synthetic market, the basis should equal zero in equilibrium:

$$BASIS = CDS_{spread} - (BY - BY_{rf}) = 0 \quad (2)$$

For this theoretical arbitrage relation to hold, each parameter of the two bonds must be identical, and we must disregard the counterparty risk associated with CDS contracts, i.e., the possibility that the protection seller might be unable to make payment in case of default event.

The intrinsic difficulty of quantifying repo costs and counterparty risk would seem to justify the choice of this simplified approach. This method is the most used by market practitioners to determine theoretical prices. It is often referred to as the “No Arbitrage” approach. Another consideration is that several non-fundamental factors seem to have an impact on CDS prices, among which liquidity premia, rating agencies outlooks and speculative predatory behaviour may play a non trivial role. Providing an accurate representation of the true theoretical relationship between bond and CDS prices would require netting out the effect of any large common factor that affect bond and CDS pricing. It seems to go beyond the scope of our study, which aims at describing how new available pricing information is received in the two markets, regardless how noisy such information is. The choice of our method seems consistent with our intended limited objective.

Duffie (1999) started a sequence of empirical work analyzing how well the theoretical relation between bond yield spreads and CDS premia holds in practice. Most empirical research has focused on CDS contracts written on corporate names. Longstaff et al. (2003) and Zhu (2006) found significant differences between CDS premia and bond yield spreads and showed that the CDS market often moves ahead of the bond market in price discovery. Both studies focus primarily on the effects of liquidity on basis spreads. This is their main contribution to the related literature, as

the issue of liquidity in CDS pricing was hardly addressed in the period before the 2008 liquidity crunch. Zhu (2006) finds that for CDS contracts written on corporate bonds price discrepancies may exist in the short run, but the price equilibrium is recovered over the long horizon. Overall, the CDS market seems to lead price discovery.

Blanco et al. (2005) find that the theoretical arbitrage relationship between the two credit spreads is mainly respected in the long run, and they also find evidence of CDS leading in price discovery. They base their analysis on investment-grade corporate names, however, leaving uncertainty regarding whether the same conclusion could apply to speculative-grade investment names or sovereigns. Hull et al. (2004) test the zero basis theoretical condition for a list of corporate names in the US market, and find strong support for the equilibrium hypothesis. By contrast, Houweling et al. (2001) claim there is no price equilibrium between corporate CDS spreads and bond yield spreads. They argue the average price difference is around 10 basis points. The contradictory results may reflect the different sample periods under analysis in these studies; the relationship between CDS and bond yield spreads may change over time.

There has been relatively little work comparing the CDS and bond markets for sovereign debt. The most relevant work in the field of emerging market sovereign credit risk is Ammer and Cai (2011). The authors test for nine emerging countries using a rich dataset from February 2001 to March 2005. The main point of their study is to emphasize the role of the “cheapest to deliver” option⁶ in affecting CDS premia, driving the basis above zero. They find that CDS premia and bond yield spreads are linked by a stable linear long-run equilibrium relation. In the short run, they cannot conclude which of the two markets leads price discovery, although they suggest that the most liquid market tends to lead.

Another strand in the literature has focused on credit risk in the European Union, even though evidence for European credit markets is so far limited. A number of studies have focused on

⁶Some CDS contracts provide investors with the right to deliver different grades of the underlying asset. It happens when the reference entity has more than one long-term debt instrument outstanding that matches the debt seniority specified in the contract. This mechanism is known as the Cheapest to Deliver (CTD) option. It is considered to be one of the concurrent elements pushing CDS spreads above bond yield spreads in the short run. There can always be an incentive to deliver the lowest-priced instrument that the protection buyer can convey, according to its contractual clauses.

government bond spreads in the EU,⁷ but, as far as we know, only Varga (2009) and Arce et al. (2011) have tried confronting explicitly the theoretical parity condition between CDS and bond market using Eurozone data.

2.2 Terms of a Typical CDS Contract

CDS are over the counter (OTC) financial instruments that offer investors a very high degree of flexibility. CDS contracts transfer the credit risk associated with corporate or sovereign bonds to a third party, without shifting any other risks associated with such bonds or loans. According to Trade Information Warehouse Reports on OTC Derivatives Market Activity, the outstanding gross notional value of live positions of CDS contracts stands at 15 trillion USD (31 August 2011) across 2,156,591 trades.⁸

The theoretical use of a CDS contract is to provide insurance against unexpected losses due to a default by a corporate or sovereign entity. The debt issuer is known as the reference entity, and a default or restructuring on the predefined debt contract is known as a credit event. In the most general terms, it is a bilateral deal where a “protection buyer” pays a periodic fixed premium,⁹ usually expressed in basis points of the reference asset’s nominal value, to a counterpart known by convention as the “protection seller”. The total amount paid per year as a percentage of the notional principal is known as the CDS spread. Most features of sovereign CDS are identical to those of corporate ones, except that for sovereigns there may be fewer asymmetries of information among market participants, as most relevant information about the health of the economy and public finances is common knowledge. As a result, new publicly available information should be immediately reflected in prices. If there are any differences in the timing of response between the cash and synthetic market, it is the more liquid market that should lead price discovery.¹⁰ While

⁷L. Codogno, 2003; L. Pagano and E.L. Von Thadden, 2004; C. Favero et F. Giavazzi, 2008; A. Beber et al., 2009.

⁸The Depository Trust and Clearing Corporation (DTCC) announced in October 2008 its intention to turn public the information regarding the notional amounts of CDS transactions registered in its Trade Information Warehouse. Weekly updated free of charge data streams are now available to the public: www.dtcc.com/products/derivserv/data/index.php.

⁹Usually paid quarterly in arrears.

¹⁰For an overview on the role of liquidity in sovereign CDS pricing see Ammer and Cai , 2011.

CDS contracts written on sovereign names accounted for half the size of the CDS market in 1997, in the early 2000s this ratio declined to 7 per cent.¹¹ The market share of sovereign CDS dropped to 5 per cent at the end of 2007, with contracts written on emerging economies accounting for over 90 per cent of the global volume of trade.¹² Since the Eurozone debt crisis began, however, the share of sovereign CDS has risen sharply. At the end of May 2010, the gross notional value of the whole CDS market accounted for 14.5 trillion USD, with about 2.1 million contracts outstanding. The sovereign segment of the market reached 2.2 trillion USD, with 0.2 million contracts.¹³ Hedge funds, global investment banks and non-resident fund managers seem to be the most active participants in the market.¹⁴

Before the introduction of credit derivatives, there was no way to isolate credit risk from the underlying bond or loan, and there was no such concept as “credit basis”, which is, by definition, the difference between the return on a cash asset and the synthetic form of the same asset. While theory predicts that cash and derivative market price of the same asset should be the same, differences in asset quality and a number of other technical factors imply that a non-zero basis is normal. Thus the credit basis is used to search for arbitrage opportunity. Basis trades involve holding a simultaneous position on the same asset both in the cash and the derivative market. Such an investment strategy aims at exploiting any short term price differences between the cash and synthetic markets to make risk-free profits. Prior to the expiration of the derivative contract, the basis can be positive or negative. In the simple case of a fixed-coupon bond hedged via CDS, when the cash market price increases by more than the derivative price, the basis increases. Therefore, the basis turns positive when the risk premium on the risky bond is “too low” or the CDS spread is “too high”. A positive basis can be adjusted back to zero by short selling the risky bond, but this could take some time due to the rigidities in the cash market, implying that the basis could remain positive persistently. On the other hand, the CDS-bond basis decreases when the derivative market price increases by more than the spot price. The basis turns negative when the credit risk premium on a risky bond is higher than its theoretical value, or the CDS spread is too low. In this latter case, arbitrage is

¹¹F. Packer and C. Suthiphongchai, 2003.

¹²BIS (2007).

¹³Source: DTCC.

¹⁴Report on Sovereign CDS (2010) <http://ft.com/CDSreport>.

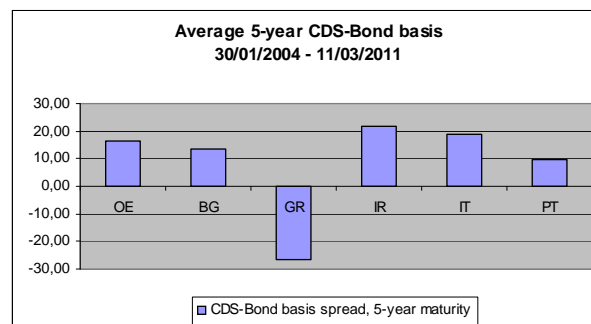
easier to conduct: a negative basis can be adjusted back to zero faster by short-selling the risk-free bond.

Rather than hedging, a CDS contract can be used for speculative purposes by an investor who does not own any debt to hedge.¹⁵ He buys a “naked” CDS.¹⁶ This investor speculates on a deterioration of the creditworthiness of the reference entity, as he can then sell the CDS contracts written on the reference asset at a profit. In terms of risk profile, a naked CDS holder makes a profit only if a credit event occurs. His position in the credit market is similar to short selling a bond, taking a short position in credit risk. From 2002 onwards, naked CDS have become increasingly used for trading both sovereign and corporate risks.

2.3 Basis Trends and Basis Drivers

The existence of a long run parity relationship between bond yield spreads and CDS spreads is a testable hypothesis. For the theoretical no-arbitrage condition to hold, either the basis should cluster around zero in the data, or it should converge to zero in a longer time horizon.

Figure 1.



Sources: CMA and authors' calculation

¹⁵For instance when Lehman Brothers went bankrupt, it had approximately 155 billion USD of outstanding debt, but twice as much notional value of CDS contracts written on its debt, meaning that many investors had entered CDS contracts for speculative reasons.

¹⁶R. Portes, 2010.

Figure 2 showing the time series of the basis over 2004-2011 is presented in appendix. Market observation suggests that the annual average basis clustered around zero for the period 2004-2007. Since the second half of 2007 it started to fluctuate. The average basis became positive for all the six sovereigns over the period 2008-2009, with the country means ranging from 4 to 40 basis points. After 2008, an average positive basis seems to be the norm in the market, even taking into account the large negative basis spread fluctuations that Greece, Ireland, and Portugal have shown since the second half of 2010. Over the whole sample period, the average basis has remained positive for five out of six countries in the sample, with the sole exception of Greece; the country means range from 9 to 21 basis points. Basis spreads are small for the most part of the sample period, but persistent.

A positive basis seems to be the norm in developing economies; this may reflect an elevated or volatile fear that governments will default. We might ask why a non zero basis exists in the EU area, and how changes in the credit spreads should be interpreted knowing that the basis is the variable that ties up the cash and synthetic credit market, in the long run.

The size of the CDS-bond basis provides a rough measure of the gain arising from arbitrage opportunities that can result from pricing inefficiencies in the credit market. It is important to notice that the logic behind basis trading is that investors actually expect the basis to fluctuate significantly away from zero. For example, if the basis is positive, the standard arbitrage trade is to sell the basis, which means sell the cash bond and sell protection on it on the CDS market. The gain arises from the fact that if the credit quality of the reference entity improves (and the basis gets narrow) no protection “payment” will be executed, while the protection seller profits from the flow of CDS premia payments. No significant arbitrage profit can be gained if the basis remains stable or fluctuates close to zero. On the other side, if the basis is negative, the potential arbitrage trade is to buy the basis, which means to buy the cash bond and buy protection on it on the CDS market. Again, the profitability of the trade is linked to worsening in the credit quality of the reference entity. Upon default, the protection buyer gets compensation from the protection seller. If no credit event occurs, he can still resell the protection on the reference asset at a higher rate, as the reference entity is now considered riskier. It is possible that once a non-zero basis is established

in the market, the dynamics of basis trades may contribute to keep it away from its theoretical value. Strong market demand from protection buyers will drive the basis upwards, while strong market supply from protection sellers will drive the basis down.

The size and direction of the basis spread appear to be influenced by a mix of technical and market factors whose impact varies with market conditions. Hull et al. (2004) as well as Blanco et al. (2005) discuss several factors that might interfere in the arbitrage relation between CDS and bond spreads and lead to a non- zero basis in the short run. Among the factors that can drive the basis positive we cite the following:

(i) CDS premia are always positive. They correspond to fixed payments to the protection seller, and even for highly rated bonds whose market view of credit risk is very low, a protection seller writing protection on such a bond still expects a positive premium for selling protection on the asset. This may positively bias the basis measure.

(ii) The Cheapest to Deliver (CTD) option embodied in many physically settled CDS contracts may affect the basis, although the impact of this factor might be small for sovereign CDS, because they are more frequently settled in cash.

(iii) In certain cases, the accrued coupon on the reference bond is also delivered to the protection buyer in case of default; nevertheless, this is not the norm. The positive bias deriving from this factor is likely to be small.

(iv) If the reference bond of a CDS contract is trading below par, in case of default the protection seller will experience a greater loss compared to an investor who holds the asset in the cash form. This is because upon default the protection seller will have to pay out the par value minus the asset price at the time of default. This might bias the basis spread upwards.

(v) For illiquid segments of the CDS market, protection sellers may charge a premium which drives the basis upwards. Protection sellers may in fact be seen as liquidity providers to the market in times of financial distress, when reference entities may default on their debt.

Among the factors that may lead to a negative basis, we have:

(i) Counterparty risk: the protection buyer takes on the risk that the protection seller will not be able to fulfill his commitment to deliver a compensation payment in case a credit event occurs. The

protection seller is also exposed to counterparty risk, but if the buyer defaults, the CDS contract is terminated, leaving the size of this risk negligible for the seller.¹⁷

(ii) There may be a liquidity premium in either the bond or the CDS market, and if the market for the risky bond is (plausibly) less liquid than the market for risk-free bonds, this might increase bond yield spreads, driving the basis negative.¹⁸

All factors that affect more the risk profile of the CDS contract tend to increase the basis, while factors that appear to affect more the creditworthiness of the bond relative to the CDS will drive the basis down. Any factor that may increase the return of the bond relative to the CDS contract can drive the basis upwards, and equally depress the basis if it tends to increase the relative return of the CDS.

3 Empirical Analysis

3.1 Data

All bond yields and CDS spreads series used in this study are collected from CMA, one of the leading sources of credit market data. The sample period runs from 30 January 2004 through 11 March 2011. The time span covered by the regression analysis is equal for each country, at the price of using fewer observations. We restricted our analysis to six countries for which daily estimates of 5-year government bond yields are available on DataStream market curve analysis, to make sure that market data are reasonably comparable. Stored government bond yield curves were available for 9 EU countries. Among those, CDS quotes for Spain were available for only 1556 days, instead of 1879 as for the rest of the sample. Therefore, Spain has been excluded from the analysis.¹⁹ The countries in our resulting sample are Austria, Belgium, Greece, Ireland, Italy, and Portugal. Due to the heterogeneity in the debt characteristics across the six reference entities, we conduct each step of the analysis separately on each country without grouping them for credit class.

¹⁷Arora et al. (2011) show that the effect of counterparty risk on CDS spreads is small.

¹⁸Bongaerts et al. (2011) find such effects in CDS spreads.

¹⁹Arce, Mayordomo, and Pena include Spain nevertheless.

CMA provides information on mid-quotes and bid-ask prices for different maturity sovereign CDS series. Due to the very limited coverage in CDS market before 2003, sovereign CDS data before 2004 show significant inconsistencies. It is common to find in DataStream “pegged” values for 2003 CDS premia for a significant number of consecutive days. Missing information might be due to late development of an active CDS market for some countries, or initial scarce market liquidity, or may simply depend on when CMA started to collect data for that particular country. As it was impossible to distinguish between missing information and effective “price runs”, linked to scarce liquidity, data from 2003 have been excluded from the analysis. Inconsistency of the premia across the different maturities was used to filter the available time series. CDS quotes from 1 to 5 year and 10 year maturity are generally available for all EU countries. To avoid the problem of “pegged” values, the 5-year CDS spread series has been chosen. The 5-year maturity seems to be the most liquid maturity segment in the sovereign CDS market, the most actively traded, as confirmed by market practitioners.

All the sovereign CDS premia are averages across different CDS dealers. CMA partner agencies collect daily quote information and then average them to provide a single daily average quote. Therefore, CDS premia are constructed out of aggregate data. They do not reflect any actual transaction costs, but rather compound information on various transactions quotes by several brokers, reflecting the total market response for each trading day. During the selected time span, 5-year CDS mid quotes are available on a daily basis for all the six chosen reference entities.

DataStream stored yield curves are available for all the major bond markets since September 1990. In order to determine the government bond yield spread for each country in the sample, we compare the risky government bond yield for each country with its comparable risk-free benchmark across the specific 5-year maturity. Consistently with previous studies on sovereign credit spreads, for the risk-free benchmark we refer to the market yield of euro-denominated German government bonds.²⁰ Ideally for each sovereign entity a constant maturity 5-year bond had to be matched to the corresponding CDS for each of the observation days in the sample. In reality, the number of outstanding bonds is rather limited. To overcome this problem we refer to the 5-year constant

²⁰Although Dunne et al. (2008) show that this is in fact a contestable assumption.

maturity government bond stored yield curve downloadable from the DataStream fixed income market curve analysis window. Such yield curves are constructed with an optimization model that takes into account simultaneously all maturity points and best fits the existing yields' information. The alternative procedure is to estimate a 5-year yield to maturity on a daily basis by linearly interpolating the yields of available bonds in the smallest possible horizon around the 5-year exact maturity. Bond yield estimates provided by DataStream appear to be more reliable in terms of approximation and are much smoother than those constructed by linear interpolation.

3.2 Cointegration Analysis

To examine the long term consistency between CDS premia and bond yield spreads we proceed in two steps. First, a cointegration check is performed. CDS rates and bond yield spreads for which a cointegrated relationship holds can be used in the Vector Error Correction Model (VECM) representation to test the relative price efficiency of the cash and derivative markets. An issue we need to deal with in our dataset is the potential structural break introduced in our data by the financial crisis that began in autumn 2008. Perron (1989) was the first to argue that stationary models with structural breaks could easily be confused with unit root models. Unit root tests that do not account for possible breaks in the series are known to have low power.²¹ There is no consensus yet on the reliability of the results of standard unit root tests in presence of potential multiple breaks in the data, and no general agreement on the best methodology to perform unit root tests in such circumstances. Moreover, non-stationarity affects the results of tests for a structural break.²² Our sample period is longer than in most other referenced studies. We believe it is a value added in its own: splitting the tests into a non-crisis and crisis period may lose the advantage of length of our time series, reducing the power of tests. Our results seem stable. In addition, in view of the length of our sample, formal testing for structural break would have to take into account a lot of possible break points, such as the 2007 subprime crisis, the September 2008 banking crisis, and the Greek sovereign debt crisis.

²¹A.W. Gregory et al., 1994.

²²P. Perron, 2005.

With these reservations, we perform the standard Augmented Dickey-Fuller unit root test on each set of CDS and bond spreads trying to provide a parsimonious representation of the true data generating processes. Table II reports the results of the unit root check. For each country, the null hypothesis of a unit root is not rejected at the 5% percent level for both the CDS premium and bond yield spread series.

The second step of the analysis examines whether the two credit spreads are cointegrated. Any equilibrium theories that involve bond and CDS spreads require a combination of such variables to be stationary; otherwise, any deviation from the equilibrium will not be temporary. On the other hand, if CDS premia and bond yield spreads do not cointegrate, it implies that the two prices can, in fact, move in unrelated ways over the long run, and credit risk pricing in the two markets may be significantly different.

For each country in the sample, we estimate the following cointegration equation:

$$CDSspread_t = \alpha + \beta BYspread_t + \varepsilon_t \quad (3)$$

Where $\varepsilon_t = [CDSspread_t - \alpha - \beta BYspread_t]$ is $I(0)$.

The expression in square brackets is the cointegrating vector; it has normalized coefficients $[1, -\alpha - \beta]$. Since theory predicts that the two credit spreads should be equal in equilibrium, a natural candidate for the cointegration relationship is the $[1, -1]$ cointegrating vector, with $\alpha = 0$. But this is just a theoretical possibility. If α is non zero and $\beta = 1$ in the cointegration equation, we still cannot reject the hypothesis that the cash and synthetic market price the credit risk equally. The two markets are probably closely related, but price discrepancies between bond and CDS rates may arise and remain persistently.

If CDS and bond spreads do cointegrate, but the cointegrating vector is not the desired $[1, -1]$, the two credit spreads move together in the long run, but the two markets may price credit risk differently in the short run. This might indicate that there are structural differences between the two markets, such as significant transaction costs that impede arbitrage or that the markets have different liquidity.

The Johansen Cointegration test allows testing for cointegration with unknown cointegrating vec-

tors, estimating both the cointegrating vectors and determining the number of cointegrating relationships. We deal with a system of two $I(1)$ variables, so our results will show at most one cointegrating relationship. Performing the standard Johansen test without assuming any structural breaks may cause the over-rejection of the cointegration hypothesis. Structural breaks in the series can make the cointegration vector trend-stationary and influence the test statistics in favor of rejecting the stationarity of the cointegration vector.²³ Table III and Table IV show trace statistics and p-values of Johansen test from two-equation system in CDS premia and bond yield spreads for each country in the sample. The hypothesis of no cointegration is rejected at the 5% level over the whole sample. Overall it suggests that a long run linear relationship exists between CDS premia and bond yields spreads for each of the six countries in the sample.

Table IV shows that the value of the cointegration parameter differs from 1 across all sampled countries. The difference is small but significant for all countries in the sample. The cointegration results seem consistent with the overall picture showing non zero basis spreads over the whole sample period. Bond and CDS markets price credit risk compatible with the long-run no arbitrage equilibrium. But CDS premia and bond yield spreads may still permanently deviate from each other, generating significant arbitrage opportunities.

3.3 Vector Error Correction Model (VECM)

The non-zero basis that we observe in the data proves that not all the information relevant to the valuation of credit risk is completely reflected in the short-run pricing dynamics in the cash and derivative markets. This suggests a market inefficiency, leading us to ask which market reacts more promptly to signals perceived as informative of the underlying sovereign entity's credit standing. In particular, it is not known whether credit risk is priced according to a two-way dynamic, where both cash and synthetic market information content is valued; or whether, alternatively, price discovery is always driven by one market, and the other merely adjusts, bringing no real contribution to the equilibrium price assigned to sovereign default risk. When we find evidence of both markets

²³J. Attfield, 2003.

contributing to price discovery, we try to assess the relative speed of adjustment of the two credit spreads. Alternatively, we observe a one-way price discovery process where all perceived information regarding credit risk is first revealed in one market. Since the leading market in price discovery provides the most up to date information about the perceived level of credit risk, in this sense is the more efficient in its pricing. Prices in the more liquid market should be quicker to reflect public information. However, such information can be characterized by a significant transitory noise that is ultimately incorporated in CDS spreads.

The VECM is a linear representation of the stochastic data generation process. Each of the variables in the model is considered endogenous, comprising of two components: a linear function of the past realizations of all variables in the system,²⁴ and an unpredictable innovation component. In the Error Correction setting, the changes in a variable are modeled depending on the deviation from some equilibrium relation, whose form is described by the cointegrating vector. The Error Correction term is in fact an expression in α and β that corresponds to the same parameters in the Johansen Cointegration analysis.²⁵ The Cointegration vector is itself an expression of the long-run relationship between CDS and bond yield spreads in levels. The adjustment coefficients estimate to what extent the error is corrected each period, and therefore they provide a measure of the relative speed of adjustment of bond and CDS markets towards the long run equilibrium.

The VEC representation of the model is:

$$\Delta CDS_t = c_1 + \lambda_1 (Cds_{t-1} - \alpha - \beta BYs_{t-1}) + \sum_{i=1}^n \gamma_1 \Delta Cds_{t-i} + \sum_{i=1}^n \delta_1 \Delta BYs_{t-i} + \varepsilon_{1t} \quad (4)$$

$$\Delta BYS_t = c_2 + \lambda_2 (Cds_{t-1} - \alpha - \beta BYs_{t-1}) + \sum_{i=1}^n \gamma_2 \Delta Cds_{t-i} + \sum_{i=1}^n \delta_2 \Delta BYs_{t-i} + \varepsilon_{2t} \quad (5)$$

where CDS_t and BYS_t stand for CDS spreads and bond yield spreads at time t , and ε_{1t} and ε_{2t} are i.i.d. shocks. The first term is the error correction mechanism through which the sovereign credit spreads evolves in the bond and CDS markets to adjust in the long run. It can be seen as the “error” from the long term equilibrium relation.

²⁴Including a variable’s own lagged values.

²⁵When $\alpha=0$ and $\beta=1$, the first term in the model becomes the first lag of the basis spread.

According to our model specification, $[-,+]$ are the expected set of signs for the adjustment coefficients λ_1 and λ_2 which imply that both credit spreads contribute to the error correction mechanism. If both the estimated adjustment coefficients are statistically significant, we can infer that there is a significant price interaction between the bond and CDS market.

If one market always lags the other, then the coefficient in the equation for the market that always leads price discovery should be not significantly different from zero. If λ_1 is negative and significant, it means that the CDS market adjusts to remove pricing errors, meaning that the bond market prices credit risk first. If λ_2 is significant and positive, it means that the cash market adjusts, and the CDS market is quicker in reflecting changes in the credit conditions of the underlying reference entities. If both coefficients are significant and with the proper sign, the relative magnitude of the adjustment coefficients determines the relative importance of each market in price discovery. The more “reactive” market is the more efficient in terms of credit risk pricing.

Table V shows our VECM results. For Austria, Belgium, Greece and Italy, the price discovery turns out to be a two-way pattern, overall directed by the derivative market. Both adjustment coefficients show statistically significant estimates, with the required set of signs. The λ_1 coefficient estimate is not statistically significant for Ireland and Portugal, meaning that for these countries credit risk is priced in the CDS market first, and the underlying bond market adjusts. Overall, there is evidence that the CDS market tends to lead the bond market in price discovery.

The VECM regression is estimated allowing parameters α and β to be freely determined within the model. For all the six sovereign names in the sample, the estimate of β is slightly but significantly different from 1: it ranges from 0.8 to 1.89, consistent with the presence of short term pricing discrepancies. These deviations exhibit considerable persistence: on average only around 2% of price discrepancies is eliminated within two business days.

Following Ammer and Cai (2011), we refer to $\frac{\lambda_2}{\lambda_2 - \lambda_1}$, the Gonzalo and Granger (1995) measure, to assess the relative contribution of each market to price discovery. It corresponds to the ratio of the speeds of adjustment of the two markets. According to the way we specified the Error Correction Representation of the model, when the Gonzalo and Granger measure is close to 1, it means that the CDS market leads the price discovery, and the bond market follows to correct for

pricing discrepancies. When it is close to 50%, both markets contribute approximately equally to price discovery. When it is close to 0, the bond market leads the derivative market. The average ratio of 0.61 over the sovereigns for which we discovered a two-way price relationship suggests that the CDS market leads somewhat more than it adjusts.²⁶ It is important to stress that the present analysis is conducted over the most liquid part of the CDS curve, i.e. the 5-year segment. When the desired liquidity requirements are matched, the CDS market tends to be more efficient than its cash counterpart in pricing credit risk.

3.4 Granger Causality Test

In order to get stronger evidence of which market leads price discovery, we also perform a pairwise Granger Causality test over each set of CDS premia and bond yield spreads in the sample. Note, however, that Granger causality testing results may be greatly affected by the non-normality of the underlying residuals.

The Granger hypothesis is used to infer whether the cash market helps to predict the pricing of credit risk in the derivative market, or the relation between the two credit spreads goes the other way round. Granger causality does not imply true causality. If CDS spreads Granger-cause bond yield spreads, then past values of CDS premia should contain information that helps predict bond spreads beyond the information contained in past values of bond yield spreads alone.

There are several ways to test for Granger causality. Here, we consider the simplest case of bivariate Granger causality.²⁷ Formally it means estimating the following regression:

$$Cds_t = c_1 + \alpha_1 Cds_{t-1} + \alpha_{t-p} Cds_{t-p} + \beta_1 Bys_{t-1} + \dots + \beta_{t-p} Bys_{t-p} + u_t \quad (6)$$

for a particular lag length p , that can be estimated by OLS. Then conduct an F-test on the null Hypothesis: $H_0: \beta_1 = \dots = \beta_p = 0$. If the statistic exceeds the 5% critical value, the null

²⁶But the estimated standard error of the ratio is 0.22, so that it is not in fact significantly different from 0.5. We do take the 0.61 value as suggestive, however.

²⁷The test results are more valuable when the two markets under analysis do not show a two-way relationship, as they do for four of our six countries. The Granger Causality test results must then be interpreted with additional care, and they need to be confronted with the VECM analysis.

hypothesis of absence of Granger Causality is rejected.

Table VI shows the Granger-Causality test results over a two-day horizon. For Greece, Ireland, and Italy, past values of CDS spreads help predict the price of credit risk in the bond market. For Belgium and Portugal the test shows Granger-causality working through both directions; nonetheless, we can reject the null hypothesis of CDS spread not Granger causal for bond yield spreads with a higher level of significance, meaning that the CDS role in forecasting bond yield spreads seems confirmed. The Granger causality test for Austria shows a one way Granger-causality driven by bond yield spreads. This contradicting result may be an indication that the Granger causality modeling is particularly sensitive to the non normality of the underlying distribution, leading at times to inconsistent results.

Conclusion

The rapid expansion of the CDS market over the last decade represents one of the most interesting recent developments in financial markets. Its fast growth in volume, as well as its role in the current financial crisis,²⁸ indicate the importance of studying this financial product.

Since both CDS and bond contracts on the same reference entity offer compensation for the same credit risk, their price should be equal in equilibrium. To explore their long term relationship, as a first step, the supposed non stationary of the two series is verified. In order to test for a unit root we refer to the Augmented Dickey-Fuller test: for each country in the sample, the null hypothesis of a unit root in the CDS and bond yield spread series is not rejected at the 5% level. In a second step, we verify whether the non stationary CDS and bond spreads series are bound by a cointegration relationship. For all countries in the sample, the null hypothesis of no cointegration between CDS premia and bond yield spreads is rejected at the 5% level. Overall the cointegration analysis confirms that the two prices should be equal to each other in long-run equilibrium, as theory predicts. One interpretation is that the derivative market prices credit risk correctly: sovereign CDS contracts written on Euro area borrowers seem to be able to provide new up to date information to sovereign

²⁸M. Brunnermeier et al., 2009.

cash market during the period 2004- 2011. The theoretical value $[1, -1]$ for the cointegrating vector is overall rejected, however, meaning that in the short run the cash and synthetic markets price credit risk differently to various degrees. Note also that even if the CDS market prices credit risk “correctly” in the long run, that does not mean that credit risk as priced by either the CDS or the cash market reflects “fundamentals”.

The VECM analysis suggests that, in general, the derivative market moves ahead of the bond market in price discovery. This goes in line with the results of Zhu (2006), but contrasts with Ammer and Cai (2011), suggesting that the dynamics for developing and developed economies may be very different as far as sovereign credit risk is concerned. According to our findings, Eurozone sovereign risk seems to behave closer to developed countries’ corporate credit risk than to developing economies’ sovereign risk. The credit structure in the euro zone is certainly different from that of developing countries studied by Ammer and Cai, especially in terms of overall liquidity, and may justify the difference between our results and theirs. Our results are in line with Varga (2009), who finds that Hungarian bond and CDS markets are in a close relationship, even though in the case of Hungary short term price discrepancies seem to be less persistent, and the CDS-bond basis fluctuates around zero for the most part of the period under analysis.

The VECM estimation provides information about the dynamics of adjustment to the long term equilibrium between sovereign CDS and bond yield spreads. Deviations from the estimated long-run equilibrium persist longer than if market participants in one market could immediately observe the price in the other, consistent with the hypothesis of imperfections in the arbitrage relationship between the two markets. Following Gonzalo and Granger (1995), we construct a measure that reflects the relative contribution of each market to price discovery. Our estimate of an average 61% for this measure over the whole sample suggests that the CDS market plays a leadership role in the Eurozone countries we study, where the derivative market for sovereign debt is overall rather liquid. As a whole, Granger Causality Test results do not seem to contradict the findings of the VECM analysis, but they suggest a less clear-cut strong impact of past CDS information on bond yield spreads.

Due to its liquid nature, the euro area CDS market seems to move ahead of the corresponding

bond market in price adjustment, both before and during the crisis. There is an alternative causal interpretation of our results. The CDS market may lead in price discovery because changes in CDS prices affect the fundamentals driving the prices of the underlying bonds. If the CDS spread affects the cost of funding of the sovereign (or corporate), then a rise in the spread will not merely signal but will cause a deterioration in credit quality, hence a fall in the bond price (see Portes, 2010). Moreover, the change in spread may not signal at all: various non-fundamental determinants can affect the spreads (as in Tang and Yan, 2010) and therefore the fundamentals of the reference entity. To confront this hypothesis with the data will require a dynamic model admitting multiple equilibria. Research along these lines is just beginning (e.g., Fostel and Geanakoplos, 2011).

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Figure 2.
CDS-Bond Basis 2004-2011

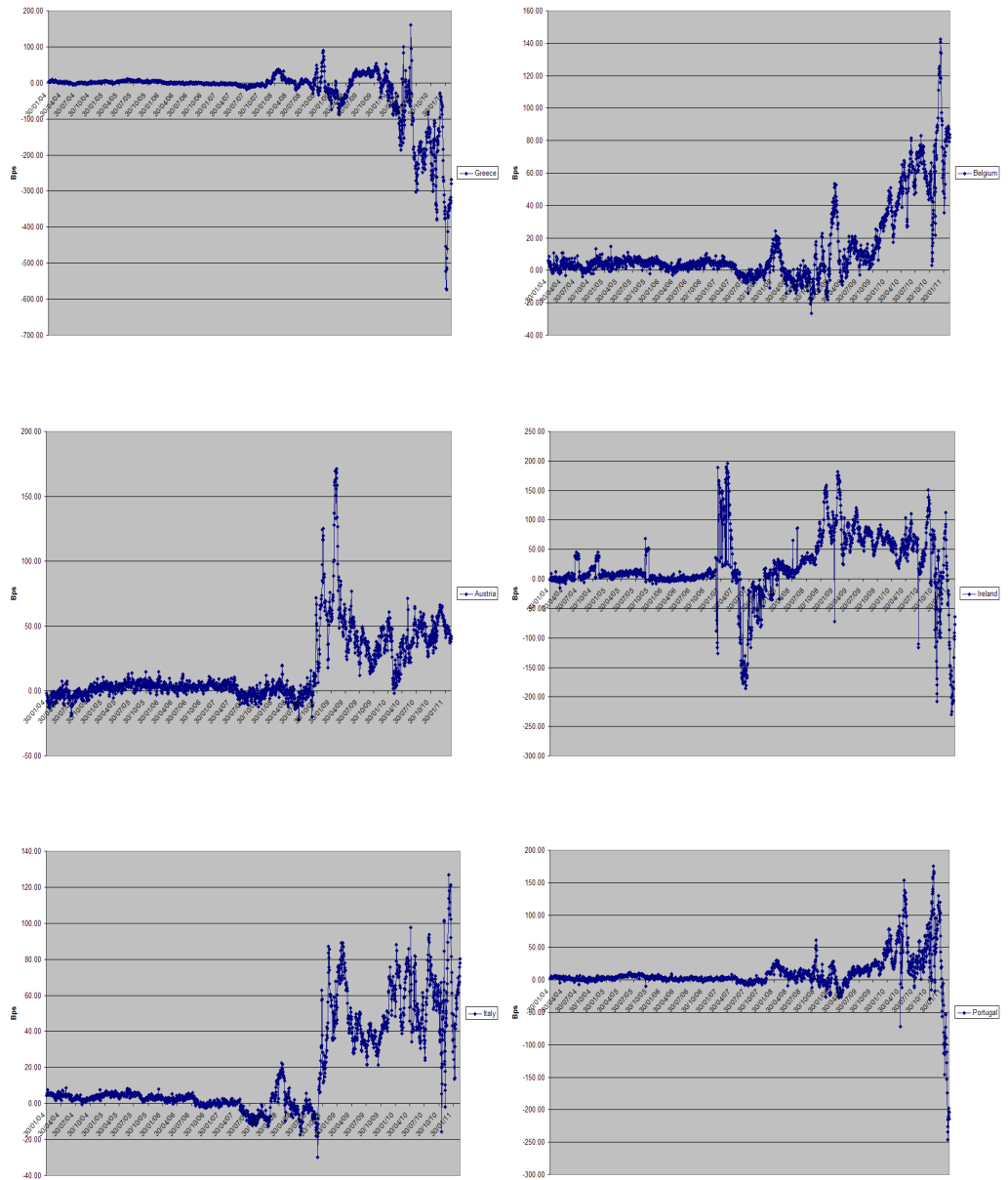


Table I.

Descriptive statistics of five-year CDS-Bond Basis

For each country in the sample, with the only exception of Greece, the average bond-CDS basis spread remains positive over the sample period. The maximum and minimum values show that between 2007 and 2010 all countries experienced both positive and negative peaks. The second column shows the average absolute basis spread. This measure does not take into account the alternation between positive and negative basis, thus providing a more straightforward measure of the distance between CDS and bond market valuation of credit risk in each country.

	Average Basis	Absolute Basis	Minimum	Maximum	Standard Deviation
Austria	16.42	18.60	-21.98	171.06	26.34
Belgium	13.37	15.25	-26.46	142.46	23.60
Greece	-26.78	36.45	-573.69	161.35	80.76
Ireland	21.62	40.51	-229.97	195.99	56.65
Italy	18.92	20.83	-29.69	126.88	27.12
Portugal	9.89	16.17	-246.32	174.92	31.92

Source: CMA, Thomson DataStream, own calculations.

Table II**Augmented Dickey-Fuller Test**

The ADF test indicates the presence of a unit root at the 0.05 level for all the five-year CDS and bond yield spread series. The first and third columns present the t-Statistics for the null hypothesis of a unit root. The second and fourth columns show MacKinnon-Haug-Michelis (1996) one sided p-values.

	Null Hp. BYS series has a unit root		Null Hp. CDS spread series has a unit root	
	t-Statistic	P Value	t-Statistic	P Value
Austria	-1.94	0.3150	-1.85	0.3537
Belgium	-1.74	0.4097	-0.36	0.9125
Greece	1.50	0.9993	1.11	0.9976
Ireland	0.47	0.9856	1.01	0.9967
Italy	-1.45	0.5567	-1.13	0.7075
Portugal	2.92	1.0000	1.64	0.9996

Table III**Johansen Cointegration Trace Test**

The first columns for each null hypothesis tested present Johansen Trace test statistics for the five-year bond yield spreads and CDS premia for each country in the sample. The number of lags in the underlying vector autoregression estimation is determined by the Akaike Information Criterion (AIC). We found a significant cointegration relationship over the whole sample period for all the six sovereigns under analysis.

	Null Hp.	P Value	Null Hp.	P Value
	Zero coint. vector		At most 1coint. vector	
Austria	86.97*	0.0000	2.57	0.1088
Belgium	21.55*	0.0054	0.05	0.8280
Greece	52.56*	0.0000	3.84	0.0508
Ireland	31.63*	0.0001	1.04	0.3080
Italy	36.01*	0.0000	0.81	0.3683
Portugal	19.57*	0.0115	2.75	0.0974

The Trace test indicates 1 cointegrating eqn(s) at the 0.05 level.

* denotes rejection of the hypothesis at the 0.05 level. MacKinnon-Haug-Michelis (1999) p-value.

Table IV

Estimated Cointegration Coefficients from Johansen Procedure

The first column displays test statistics for restrictions on parameter β of the cointegration vector. For all the six countries in the sample, the theoretical value $\beta = 1$ is rejected. Its value ranges from 0.78 to 1.66. The cointegration parameter β exceeds 1 for Austria, Belgium, and Italy meaning that, over the long run, a 1bps change in the CDS spread is accompanied by a larger change in the bond yield spread over the same reference entity. This implies that the bond market seems to be the most volatile for these countries, while the opposite applies for Greece, Ireland and Portugal.

	Null Hp: $\beta=1$	
	Estimated β	Standard Error
Austria	-1.97*	0.06262
Belgium	-1.66*	0.12732
Greece	-0.78*	0.01573
Ireland	-0.89*	0.05765
Italy	-1.51*	0.06521
Portugal	-0.78*	0.08605

* denotes rejection of the hypothesis at the 0.05 level. MacKinnon-Haug-Michelis (1999) p-value.

TableV

VECM Estimates. Two Lags Model

The table shows the estimated values of the adjustment parameters of the two lags VECM estimated for each country in the sample. For Austria, Belgium, Greece, and Italy the parameters λ_1 and λ_2 are both significant meaning that both markets contributed to the price discovery of these sovereign credit spreads. In contrast, for Ireland and Portugal the adjustment parameter λ_1 is not significant meaning that it was primarily the sovereign CDS market where the price discovery of the credit spread took place. The correspondent bond yield spreads merely followed the change of the CDS spreads.

The last columns show the Gonzalo and Granger measure. It corresponds to the ratio of the speed adjustment in the two markets. When the Gonzalo and Granger measure is close to 1, it means that the CDS market plays a leading role in price discovery, and the bond market moves afterwards to correct for pricing discrepancies. When the measure is close to 50%, both markets contribute approximately equally to price discovery. When it is close to 0, the bond market leads the derivative market. For all the countries in the sample except for Greece the measure exceeds 50%, meaning that the CDS market leads price discovery more often than it adapts to the bond market valuation of credit risk.

	N° of Obs.	β in Coint. Vector	λ_1	λ_2	$\frac{\lambda_2}{\lambda_2 - \lambda_1}$
Austria	1879	-1.98 (0.06135) [-32.35]	-0.01 (0.00485) [-2.45]	0.06 (0.00631) [9.39]	0.86
Belgium	1879	-1.61 (0.10991) [-14.67]	-0.01 (0.0325) [-2.12]	0.02 (0.00433) [4.29]	0.66
Greece	1879	-0.80 (0.01396) [-57.07]	-0.05 (0.00887) [-5.48]	0.02 (0.00653) [2.86]	0.28
Ireland	1879	-0.92 (0.05249) [-17.55]	-0.01* (0.00339) [-0.28]	0.05 (0.00898) [6.08]	0.83*
Italy	1879	-1.51 (0.05938) [-25.41]	-0.01 (0.00568) [-2.05]	0.02 (0.00489) [4.80]	0.66
Portugal	1879	-0.84 (0.0772) [-20.73]	-0.01* (0.00498) [-0.62]	0.02 (0.00555) [3.12]	0.66*

* indicates non significant parameters at the 5% level.

Table VI**Granger Causality Test**

For each null hypothesis, the first columns present the Chi-square statistics respectively for the bond yield spreads and CDS premia for each country in the sample. The null hypothesis that bond yield spread does not Granger-cause CDS spread is rejected at the 5% level for Austria, Belgium, and Portugal. Belgium and Portugal show Granger causality directed in both directions meaning that past values of bond yield spread variable do help forecast the actual level of CDS spreads, as well as the opposite is true. At the same time, the null hypothesis that CDS spread does not Granger-cause bond yield spread is rejected at the 5% level for all countries in the sample, except for Austria. Overall, Granger causality results are not in contrast with VECM predictions, and tend to confirm that CDS spreads convey pricing information to the bond market. In the case of Austria, the test results may be affected by the non normality of the underlying distribution of residuals, potentially leading to inconsistent results.

	Null Hp: BYspread		Null Hp: CDS spread	
	<i>doesNOT</i> \Rightarrow CDS spread		<i>doesNOT</i> \Rightarrow BYspread	
	Chi-sq	Prob.	Chi-sq	Prob.
Austria	9.02*	0.0110	1.46	0.4806
Belgium	13.49*	0.0012	48.90*	0.0000
Greece	0.03	0.9824	43.45*	0.0000
Ireland	1.63	0.4421	12.78*	0.0017
Italy	4.31	0.1160	88.25*	0.0000
Portugal	33.93*	0.0000	214.17*	0.0000