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An analysis of euro area sovereign CDS and their relation with government bonds ☆

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ABSTRACT

We compare the market pricing of euro area government bonds and the corresponding Credit Default Swaps (CDSs). In particular, we analyse the "basis" defined as the difference between the premium on the CDS and the credit spread on the underlying bond. Our sample of weekly data covers the period from January 2007 to December 2012 and contains several episodes of sovereign market distress. Overall, we observe a complex relationship between the derivatives market and the underlying cash market characterised by sizable deviations from the no-arbitrage relationship (i.e. basis equal to zero). We show that short-selling frictions explain the persistence of positive basis deviations while funding frictions explain the persistence of negative basis deviations which are observed for countries with weak public finances. Moreover, we show that the "flight-to-quality/liquidity" phenomenon in bond markets is a key driver of the large positive basis of better rated countries.

1. Introduction

Sovereign debt markets in a number of euro area countries came under unprecedented stress from the first half of 2010 onward. This period of stress significantly affected the market pricing of government debt. Before the global financial crisis, valuation of debt issued by developed country governments had typically treated a default as a very low probability event. In fact, empirical modelling (e.g. in term structure analysis) was mainly oriented towards interest rate risk or liquidity risk, rather than default risk. The lack of defaults among developed country governments underpinned the widely used assumption that government bonds provide a good proxy for the long-horizon (default-) risk-free rate; a core feature of asset pricing.[3]

The purpose of our paper is to study the relative pricing of sovereign credit risk in the euro area. In particular, we compare the market pricing of euro area sovereign CDS and the corresponding bonds issued by the same government. This CDS-bond "basis"

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2 The opinions in this paper do not necessarily reflect those of the ECB, the SSM or the Eurosystem.

3 In a related analysis, Monfort and Renne (2014) find that a substantial share of changes in euro area sovereign spreads during the recent euro area sovereign crisis is liquidity driven. Groba et al. (2013) analyse the channels of risk transmission from distressed to central European Economic and Monetary Union (EMU) economies and show that the contagion channel represented by the risk premium is relatively more important than the one by default probabilities. There is also a related literature on pricing emerging market sovereign risk (see e.g. Pan and Singleton (2008) or Longstaff et al. (2011)).

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is defined as the CDS premium minus the spread of a fixed-coupon government bond of similar maturity over a risk-free benchmark. Sovereign CDS and the underlying government bonds offer investors a similar exposure to the risk and return of sovereign debt and therefore their relative pricing is linked by a no-arbitrage relation.[4] Deviations from parity can provide information on the existence and size of arbitrage opportunities which should typically be very small or disappear quickly if credit markets are functioning normally. We document that, since the onset of the US subprime crisis and even more so during the euro area sovereign debt crisis, all euro area countries' CDS-bond bases deviated from zero persistently and exhibited strong co-movement. A Principal Component Analysis reveals that the 1st PC and 2nd PCs explain respectively 45% and 13% the total variation of the basis. Further analysis of the loadings suggests that the 1st PC captures the co-movement, while the 2nd PC differentiates between "core" (AT, BE, DE, FR and NL) and "peripheral" (GR, IE, IT, PT and SP) countries. In fact, while the basis for "core" countries was persistently positive the basis for "peripheral" countries went negative in several occasions from 2011 on.

A number of authors have already investigated the relation between CDS premia and bond spreads. In the non-crisis period of 2002/03, Blanco et al. (2005) show that the theoretical arbitrage relationship linking corporate credit spreads to CDS holds reasonably well on average, but also that the repo cost of short-selling the cash bond affects the positive basis and that short-lived deviations are due to a lead for CDS prices over bond spreads in the price discovery process. Ammer and Cai (2011) point out that the "cheapest-to-delivery" option explains the positive basis observed for sovereign emerging markets in the period 2001/05.[5] Recent work has documented large and persistent negative basis deviations in the corporate sector during the US subprime crisis and in particular after the Lehmann collapse in 2008. As discussed by Duffie (2010) special capital impediments to capital formation have caused asset price distortions. Garleanu and Pedersen (2011) argue that due to funding problems "securities with nearly identical cash flows (such as CDS and bond spreads), but different margins, traded at a different price, giving rise to price gaps (basis)" violating the law of one price. Mitchell and Pulvino (2012) suggest capital shortages at major dealers as the most plausible explanation of the negative CDS-Bond basis. Bai and Collin-Dufresne (2011) point to drivers related to funding risk, counterparty risk and "collateral quality". Fontana (2012) highlights the role of funding liquidity risk and "convergence-trading" activity in driving the basis negative during the crisis.

We contribute to the empirical literature by highlighting and explaining basis deviations in the context of the euro are sovereign crisis. Our first result is that variables, which previous research has identified as key drivers of credit spreads (cf. Collin-Dufresne et al., 2001, Campbell and Taksler, 2003; Raunig and Scheicher, 2009; Ericsson et al. 2009), do not affect CDS premia and bond spreads during the credit crisis in the same manner. In the credit risk literature, a commonly used theoretical framework is the structural model of Merton (1974), which has been extended towards sovereign credit risk by Gapen et al. (2008). Our analysis shows that, in the cross-section, for both CDSs and bond spreads, the signs of the coefficients of our country-specific covariates, which are significant, correspond to our hypotheses. In the time-series perspective, CDSs correlate with country-specific covariates and with proxies for risk premium while bond spreads only proxies for risk premium. Overall, CDS premia are more sensitive to country specific drivers of credit risk.[6]

Our second result is that when the basis is positive (i.e. CDS premium exceeds bond spread), "short-selling frictions" play a significant role. To profit from positive deviations arbitrageurs have to be able to take short positions without major frictions. We use the variable "*Active Utilisation*" (obtained from Data Markit Explorers) as a proxy for "short-selling frictions". "*Active Utilisation*" is the share (%) of securities in lending programs which are currently out on loan. This information is available to us at the bond-level for all ten benchmark bonds in our sample. Our assumption is that when this value is high there is a lack of bonds available to short in the market. We find that bonds with stronger "short-selling frictions" tend to have larger positive bases, that the basis dynamics correlates significantly with "short-selling frictions" and that pricing deviations lag the emergence of these frictions.

Two additional results on positive basis deviations are worth noting. First, throughout the sample, "core" countries have larger positive bases. Because of the "flight-to-quality" bond trading activity has shifted from "peripheral" countries to "core" countries, especially to the German bund driving its yield to a historically unprecedented low. As higher bond liquidity reduces the bond yield spread, it should also be reflected in a larger CDS-bond basis. Against this background, we show that bonds characterized by lower (higher) credit risk, which tend to have larger (smaller) positive bases, are also more (less) liquid. We also show that these more liquid (and creditworthy) bonds are characterized by stronger "short-selling frictions". Our interpretation of this finding is that the "flight-to-quality/liquidity" effect is a key determinant of the positive basis and that bond liquidity and short-selling frictions together drive the positive basis. Second, the ECB's SMP purchases have a positive impact on the basis. To address shrinking liquidity in some euro area government bond markets and contribute to restoring an appropriate monetary policy transmission mechanism, in May 210 the ECB introduced the Securities Markets Programme (SMP), which stopped purchases in September 2012. We find that SMP purchases during May 2010 and August 2011 were associated with increasing bond spreads. The SMP has been active to the largest extent when credit spreads were increasing sharply and the bond markets were extremely illiquid. Since, in May 2010 and August 2011, its impact on the basis is positive, our interpretation is that the buying pressure generated by the SMP was reflected in relatively stable (but still increasing) bond yields and in a temporary improvement of bond liquidity, as measured e.g. by bid-ask spreads. Positive deviations persisted because the ECB is a "big buy – and – hold investor" (Corradin and Maddaloni (2015)) and, with the SMP, it has affected "short-selling frictions", as captured both by bond specialness (a pricing measure of the cost of short selling) and, on the quantity side, by the lack of bonds to short-sell.[7]

Our third result is that for two countries with weaker public finances (Italy and Spain), we observe the significant role of sharp increases in haircuts applied on government bonds in repo transaction and corresponding negative basis deviations also linked to the deterioration of bond liquidity. This supports the view that "funding frictions" made it difficult for arbitrageurs to finance the purchase of credit risky bonds (via repo) for profiting from "negative basis trades" (in line with the argument of Duffie (2010)).

Overall, our results indicate that more creditworthy bonds exhibit larger positive bases, due to a liquidity price premium, which

[4] This no-arbitrage relationship is discussed in detail in Section 2, while the arbitrage strategies are covered in Section 3.

[5] CDS contracts that are most widely traded do not apply to a specific debt instrument. In practice, a variety of senior obligations are eligible for delivery. All else equal, the CTD option is expected to have a stronger effect on CDS pricing when it is more likely that a protection buyer will be able to exercise the CTD option, hence the CDS-bond basis is an increasing function of the probability of default. In our view, it is unlikely to be the explanation of the positive basis for creditworthy countries.

[6] In the paper, we report results for weekly data. These results are confirmed also for daily and bi-weekly data.

[7] Corradin and Maddaloni (2015) show that the cost of shorting Italian government bonds via reverse-repo (i.e. "specialness"), is linked to "short-selling pressures" and that ECB outright purchases have exacerbated the repo market squeeze.

cannot be arbitraged away because of stronger "short-selling frictions". In contrast, riskier bonds in terms of perceived default risk are often characterized by negative bases, due to an illiquidity yield premium, which is difficult to arbitrage away because of "funding frictions".

The rest of this paper is organized as follows. Section 2 provides some background on sovereign CDS. Section 3 develops the main hypotheses we test. Section 4 describes the data we use and discusses some preliminary result on the behaviour of the basis. Section 5 presents the results of the econometric analysis. Section 6 concludes.

2. Background on sovereign CDSs

A CDS contract transfers the risk that a certain individual entity defaults from the "protection buyer" to the "protection seller" in exchange for the payment of a regular fee. In case of a "credit event" such as a default, the buyer is fully compensated by receiving the difference between the notional amount of the loan (made to the defaulted entity) and its recovery value from the protection seller.[8] The CDS premium, typically expressed in basis points per annum as a fraction of the underlying notional is the cost for protection against default. As in the case of an interest rate swap the premium is set such that the CDS transaction has a value of zero at the time of origination.[9] In a standard CDS contract two parties enter into an agreement terminating either at the stated maturity or earlier when a previously specified credit event occurs and the protection component is triggered. Three important credit events defined by the International Swaps and Derivatives Association are: (1) Failure to pay principal or coupon when they are due. Hence, already the failure to pay a coupon can represent a credit event, albeit most likely one with a high recovery (i.e. "technical default"). (2) Restructuring: The range of admissible events depends on the currency and the precise terms which materialise. (3) Repudiation/moratorium.

For corporate as well as sovereign CDSs, the premium can be interpreted as a credit spread on a bond issued by the underlying name. Based on a no-arbitrage argument (Duffie, 1999) the CDS premium should be equal to the yield spread over a risk-free benchmark on a par floating-rate bond. According to this pricing analysis, the risk-reward profile of a protection seller, who is "long" credit risk, is equivalent to a trading strategy which combines a bond, by the same name, with a short position in a default-risk-free bond. While a protection buyer's exposure is equivalent to a strategy which combines a long default risk-free bond and a short position on the defaultable bond. Based on this theoretical equivalence, traders try to arbitrage price differences between a defaultable bond, a risk-free bond and the CDS. Sovereign CDSs, compared to CDSs on corporations, can be used for two additional purposes. First, investors can hedge macro risk of portfolios composed of loans to corporations in foreign emerging countries. Second, investors can hedge counterparty risk in interest-rate derivative transactions in the case of bank exposure to governmental bodies (e.g. debt management offices), as many of these public-sector entities do not provide collateral.

Even if CDSs are a better proxy for market pricing of credit risk than bonds a number of additional factors may influence CDS spreads. First, CDSs on euro area governments can be denominated both in Euro and in USD. In the case of a credit event, a severe depreciation of the bond's currency is likely. As euro area countries CDSs denominated in USD provide a hedge to "depreciation risk" they tend to be traded with a premium with respect to those quoted in Euro. Second, CDS contracts have several restructuring clauses which affect their pricing. Cumulative Restructuring (CR) is the most common for European sovereigns. This clause includes "restructuring" as a default event and allows the protection buyer to deliver bonds of any maturity after restructuring of debt.[10] Third, as the value of protection depends on sellers' creditworthiness, an additional element which affects the pricing of CDSs is counterparty risk. CDSs on major countries may not always provide genuinely robust insurance against a large-scale default given the close linkages between sovereigns and the financial sector. As discussed by Arora et al. (2012) market participants typically collateralize these transactions, hence counterparty risk is expected to be negligible.[11]

3. The relation between CDSs and bonds and the main hypotheses

In order to investigate the behavior of the basis during the euro are sovereign crisis we formulate five hypotheses.

As discussed in Section 2, CDSs and bonds offer investors a similar exposure to the risk and return of debt issued by governments, hence, their pricing is expected to be determined by the same set of factors. Whether the crisis has affected the pricing of sovereign credit risk differently across the derivatives and the cash market is ultimately an empirical question.

Hypothesis 1. During the crisis, the key drivers of sovereign credit risk have had different effects on CDS premia and bond spreads.

The CDS-bond basis should be approximately zero due to the no-arbitrage principle. To exploit a negative basis an arbitrageur has to finance the purchase of the underlying bond, via a repo transaction, and buy protection (CDS), so that a bond's default risk is fully hedged. To exploit a positive basis an arbitrageur has to short-sell, via a reverse-repo transaction, the underlying bond and sell protection. In a basis trade the investor "locks-in" an annuity which stops at the maturity of the bond or at default, whichever comes first. Deviations of the basis from zero provide information on the existence and size of arbitrage opportunities which should typically be very small and disappear quickly if credit markets were functioning normally. We explore the idea that basis deviations are generated by the presence of "frictions" which impair arbitrage activity across the derivative and cash market.

Hypothesis 2. "Short-selling frictions" explain persistent positive basis deviations.

"Short-selling frictions" represent the difficulty for market participants to short-sell bonds. These bonds are often not available or the rates at which these can be obtained in reverse-repo transactions are lower than the rates on other types of collateral (i.e. the

[8] After a credit event the protection seller compensates the protection buyer for the incurred loss by either paying the face value of the bond in exchange for the defaulted bond (physical settlement) or by paying the difference between the post-default market value of the bond and the par value (cash settlement). The post-default value of the bond is fixed by an auction procedure. In the context of sovereign risk, the first such auction procedure was held for Ecuador in January 2009.

[9] Since May 2009, CDS trading has undergone a "big bang" with prices now consisting of an upfront payment and a regular premium fixed at either 100 bps or 500 bps (depending on credit quality). Combining the two components leads to the CDS premium which is comparable to the previous contracts. http://www.markit.com/cds/announcements/resource/cds-big-bang.pdf.

[10] CR was the standard contract term in the 1999 ISDA definition. The modified-restructuring (MR) clause, which has become common practice in US from 2001 on, limits deliverable obligations to bonds with a maturity of 30 months or less after a restructuring. The modified- modified-restructuring (MM) clause has been introduced in 2003. Under this rule, which is more common for corporations in Europe, deliverable obligations can be maturing in up to 60 months after a restructuring. The no-restructuring (XR) clause excludes all restructuring events under the CDS contract as "trigger events".

[11] Sellers of protection are exposed to counterparty risk too since they face "mark-to-market" losses in the event of the failure of the protection buyer. Therefore, counterparty risk is "two-sided" and it is non-trivial to assess its pricing impact on the CDS premium.

bond is then "special"); lending cash, in a reverse-repo, for a lower rate is an opportunity cost. A positive basis then persists because "short-selling frictions" prevent arbitrageurs to short-sell the bond (in a "positive basis trade") in order to profit from the relative mispricing.

Hypothesis 3. More creditworthy countries with more liquid government bonds (i.e. driven by "Flight-to-quality") have larger CDS-bond bases.

With the "Flight-to-quality" bond trading activity has shifted from "peripheral" countries to "core" countries, especially to German bunds, driving their yield to historically very low levels. We expect bond liquidity to be reflected in a price premium, hence in a relatively lower bond yield spread and a larger CDS-bond basis.

Hypothesis 4. ECB bond purchases have a positive impact on the basis.

The ECB's SMP, which targeted bonds of "peripheral" countries, was aimed at lowering the illiquidity yield premium required by investors due to the absence of trading activity in situations of high credit risk. The SMP's sizable purchases should increase bond prices and are expected to temporarily increase the basis. As described by Corradin and Maddaloni (2015) the SMP portfolio is oriented towards the long term and the bonds are not repo-ed out again. Therefore, the ECB activity is also likely to have exacerbated "short-selling frictions", further fostering the persistence of a positive basis.

Hypothesis 5. "Funding frictions" explain persistent negative basis deviations.

"Funding frictions" represent the high cost to fund the purchase of bonds. Difficulties in access to sufficient funding (e.g. lending from prime brokers) are due to the presence of "haircuts" (i.e. margins) in repo transactions which fund bond purchases. Analogously to the positive basis and "short-selling frictions", a negative basis persists because "funding frictions" make it difficult for arbitrageurs to finance the purchase of the bond (via repo transaction) for implementing a "negative basis trade".

4. Data and descriptive statistics

4.1. CDS premia and bond spreads

Our sample comprises the following ten euro area countries: Austria (AT), Belgium (BE), France (FR), Germany (DE), Greece (GR), Ireland (IE), Italy (IT), Netherlands (NL), Portugal (PT) and Spain (SP) and covers the period from 1 January 2007 to 31 December 2012.[12] We obtain ten-year benchmark bond yields from Datastream and CDS premia with a ten year maturity from Markit.[13] Fig. 1 shows the time-series of the CDS premium and the bond spread for one selected country (France).

During our sample period, credit spreads increased and reached their maximum level between September 2011 and August 2012. Notice that, in the case of France, the CDS premium was substantially larger than the bond spread (as discussed in the next paragraph). Table 1, Panel A provides the descriptive statistics of

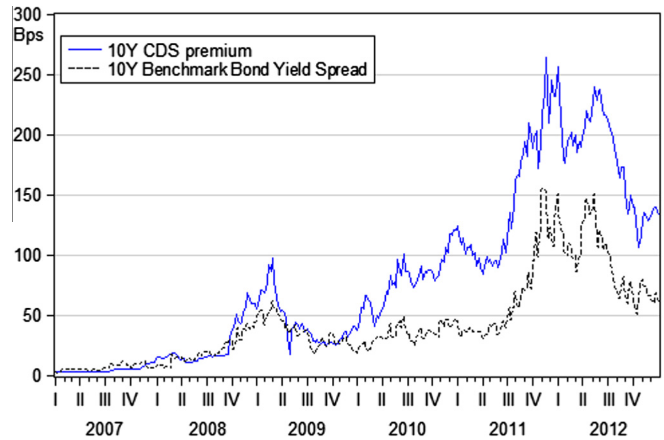

Fig. 1. The CDS Premium and the Bond Yield Spread – France. This figure shows the time-series of the CDS premium and the bond yield spread for France. The CDS premium, the national benchmark bond and the risk-free benchmark (i.e. the German bund), used to calculate the bond spread, have a 10-year maturity. The sample period is January 2007 to December 2012. Observations are in basis points and are at a weekly frequency.

CDS premia and bond yield spreads (calculated over the German Bund) weekly changes for the ten sample countries.

"Peripheral" (GR, IE, IT, PT and SP) countries' spreads increased more and exhibited a larger variability. Throughout the sample, the average CDS change (standard deviation), expressed in basis points, was 0.45 (9.74) for "core" countries (AT, BE, FR, DE, NL) and 2.27 (35.72) for "peripheral" countries. Similarly, the bond spread average change (standard deviation), was 0.16 (8.37) for "core" countries and 0.97 (39.5) for "peripheral" countries. The average correlation, across countries, between CDS and bond spreads changes respectively was 0.60 and 0.67, hence significantly different from one as would be expected in the case of a "perfect" no-arbitrage relation. We proceed by analysing the degree of co-movements of credit spreads across countries by means of a principal component analysis. In Table 2, Panel A, the first and second columns list the percentage of explained variation by the first three components.

In the case of CDS premia, the 1st PC explains 64%, the 2nd PC 12%, and the first three PCs together explain 84% of the total variation. As shown in Panel B, the 1st PC places similar weights (eigenvectors), across all countries and the average weight within the two groups of "core" and "peripheral" countries is 0.34 vs. 0.30. Therefore, the 1st PC can be defined as a "level factor", in the sense that when this factor increases, CDS premia across countries all increase. For the 2nd PC the average weights within the two different groups of "core" and "peripheral" countries are -0.24 vs. 0.32. As this 2nd component differentiates well across countries it can be defined as a "core" vs. "periphery" factor. This result is in line with Groba et al. (2013).

In the case of bond spreads, the 1st PC alone explains 50% of the variation, the 2nd PC the 14%, whereas the first three PCs in total explain 75%. Note that the economic interpretation of the 1st and 2nd components is identical for CDSs and bonds spreads and that the degree of co-movement is very similar. To compare these results with previous studies on sovereign CDSs we consider a proxy for domestic stock market performance, i.e. the returns on country-specific equity indexes.[14] We find that commonality in equity returns and CDSs is similar. In the case of the equity indexes,

[12] We censor the series for Greece in June 2012 as credit spreads reached very high levels and trading activities reduced dramatically. For Germany the bond yield spread over the bund is by definition zero.

[13] In our empirical analysis, daily data are transformed into weekly, taking the last observation of the week. We focus both on CDS quoted in Euro and in USD, the former are available only for a subsample period and the latter are more liquid, as discussed in Section 2. We select the Cumulative Restructuring (CR) clause as this is most common for European sovereign CDS.

[14] Longstaff et al. (2011) focus on a global rather than EU sample and on a time-span which ends before the onset of the euro area sovereign debt crisis. They find that the diversification benefits of sovereign credit portfolios (CDS) are lower than for international equity portfolios.

Table 1

CDS premia, bond spreads, basis and "adjusted" basis – descriptive statistics. Panel A. reports descriptive statistics for weekly CDS premia and bond yield spread (over the bund and with 10-year maturity) changes measured in basis points. Panel B. descriptive statistics for weekly CDS-bond basis and "adjusted" CDS-bond basis changes. The sample period is January 2007–December 2012.

	Δ(CDS)				Δ(Bond spread)				N. Obs:	Correlation
	Mean	Std. Dev.	Max.	Min.	Mean	Std. Dev.	Max.	Min.		Δ(CDS) vs. Δ(bond spread)
Panel A										
AT	0.41	12.58	71.55	−59.75	0.13	8.01	47.70	−49.20	326	0.56
BE	0.60	15.69	74.13	119.09	0.23	13.72	78.40	−110.30	326	0.82
DE	0.32	5.25	24.41	−22.46	//	//	//	//	326	//
FR	0.58	8.86	28.42	−53.82	0.21	7.26	35.90	−40.10	326	0.60
GR	5.04	46.69	260.31	−325.71	−0.08	84.71	347.17	−1289.90	232	0.20
IE	1.36	38.11	227.37	−279.83	1.03	30.92	157.70	−191.90	326	0.79
IT	1.40	21.93	86.80	−99.00	0.95	18.70	75.90	−100.60	326	0.77
NL	0.34	6.32	31.48	−34.67	0.05	4.50	18.00	−15.10	326	0.41
PT	1.99	50.31	310.15	−248.66	1.70	42.22	210.30	−173.08	326	0.77
SP	1.53	21.58	71.52	−101.49	1.26	21.22	71.30	−120.80	326	0.83
Core	0.45	9.74	46.00	−57.96	0.16	8.37	45.00	−53.68		0.60
Periphery	2.27	35.72	191.23	−210.94	0.97	39.55	172.47	−375.26		0.67
	Δ(CDS-bond basis)				Δ(Adjusted CDS-bond basis)				N. Obs:	Correlation
	Mean	Std. Dev.	Max.	Min.	Mean	Std. Dev.	Max.	Min.		Δ(Basis) vs. Δ(Adj basis)
Panel B										
AT	0.15	10.05	56.51	−55.94	−0.06	8.34	32.10	−38.44	326	0.85
BE	0.13	8.54	36.38	−33.68	−0.08	8.23	30.81	−30.47	326	0.80
DE	0.20	5.18	24.41	−22.46	//	//	//	//	326	//
FR	0.21	7.27	30.72	−26.79	0.00	6.12	19.86	−29.20	326	0.71
GR	0.03	30.30	117.52	−177.32	0.05	29.87	128.02	−174.37	232	0.98
IE	−0.20	22.81	109.57	−97.80	−0.40	22.18	99.55	−100.41	326	0.97
IT	−0.01	14.54	101.86	−53.77	−0.21	13.05	96.29	−46.83	326	0.93
NL	0.16	5.97	26.84	−22.25	−0.05	5.20	13.85	−24.13	326	0.57
PT	−0.19	31.43	144.56	−198.49	−0.39	30.32	152.45	−176.03	326	0.98
SP	−0.16	12.86	50.03	−55.81	−0.36	12.09	45.26	−51.47	326	0.91
Core	0.17	7.40	34.97	−32.22	−0.05	6.97	24.16	−30.56		0.73
Periphery	−0.10	22.39	104.71	−116.64	−0.26	21.50	104.31	−109.82		0.95

Table 2

CDS, bond spread and CDS-bond basis – principal component analysis. This table reports results of a principal component analysis of weekly changes of CDS premia, bond spreads and national equity index returns, CDS-bond bases and "adjusted" CDS-bond bases changes. Panel A. reports the percentage of explained variation by 1st, 2nd and 3rd PC and the cumulative percentage of explained variation by the first three PCs. Panel B. reports the eigenvectors (loadings) of PC1 and PC2 across the various countries. At the bottom of the averages of the loadings within the two groups of "core" and "peripheral" countries are reported. The sample period is January 2007 to December 2012.

PC	ΔCDS %		ΔBond spread %		Equity Ret.		ΔBasis %		ΔAdj. Basis %	
Panel A										
1	64%		50%		70%		45%		34%	
2	12%		14%		7%		13%		16%	
3	7%		11%		6%		10%		12%	
Tot 3	84%		75%		82%		67%		61%	
Country	PC 1	PC 2	PC 1	PC 2	PC 1	PC 2	PC 1	PC 2	PC 1	PC 2
Loadings (Eigenvectors) Panel B										
AT	0.33	−0.32	0.37	−0.33	0.33	0.10	0.35	−0.28	0.32	−0.31
BE	0.36	−0.07	0.40	−0.18	0.32	−0.08	0.34	0.11	0.43	−0.07
DE	0.33	−0.28	//	//	0.34	−0.02	0.35	−0.29	//	//
FR	0.36	−0.20	0.39	−0.32	0.36	−0.02	0.37	−0.24	0.37	−0.34
GR	0.28	0.38	0.02	0.32	0.23	0.79	0.16	0.33	0.23	0.08
IE	0.27	0.43	0.30	0.46	0.29	−0.06	0.20	0.56	0.24	0.43
IT	0.36	0.06	0.39	0.13	0.35	0.05	0.34	0.11	0.36	0.25
NL	0.33	−0.31	0.32	−0.29	0.32	−0.35	0.36	−0.33	0.34	−0.45
PT	0.24	0.56	0.24	0.57	0.31	0.20	0.27	0.45	0.25	0.55
SP	0.35	0.15	0.36	0.15	0.29	−0.43	0.34	0.14	0.39	0.15
Average	Loadings									
Core	0.34	−0.24	0.37	−0.28	0.33	−0.08	0.36	−0.20	0.36	−0.29
Periph.	0.30	0.32	0.26	0.33	0.29	0.11	0.26	0.32	0.30	0.29

the 1st PC alone explains 70%, the 2nd PC 7%, whereas the first three PCs explain 82% of the variation. The 1st PC places similar weights (approximately 0.30), across all countries and can be interpreted again as a "level factor". In contrast, the 2nd PC lacks a clear economic interpretation. These results suggest that elements of differentiation across euro area countries are better captured by the dynamics of sovereign debt markets rather that the equity market.

4.2. The CDS-bond basis

We define the CDS-bond basis as the difference between a country's CDS premium and the corresponding government bond yield spread for the same maturity. Furthermore, we define the "adjusted" basis as the difference between the CDS-bond basis of a country relative to that of Germany, taken as the benchmark

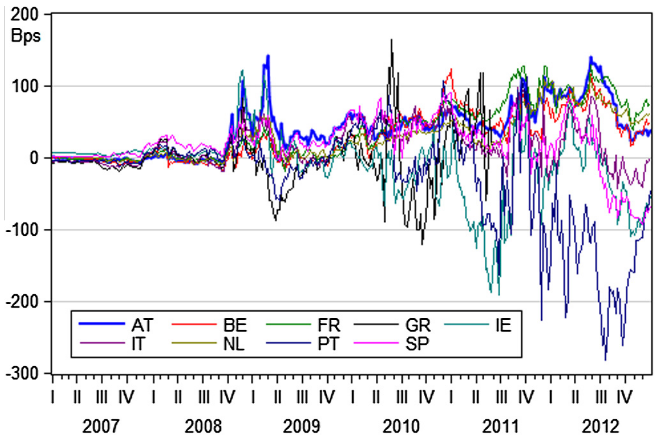

Fig. 2. CDS-bond Basis – Euro Area Sovereigns. This figure shows the time-series dynamics of the CDS-bond basis for nine euro area countries. The CDS premia, the national benchmark bonds and the risk-free benchmark (i.e. the German bund), used to calculate the bond spread have a 10-year maturity. The sample period is January 2007 to December 2012. Observations are expressed in basis points and are at a weekly frequency.

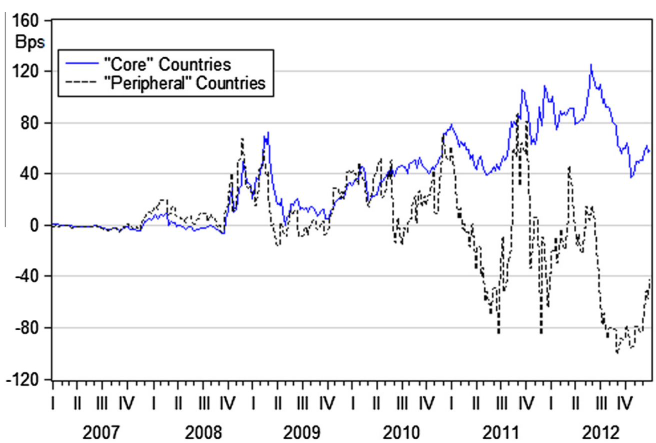

Fig. 3. CDS-bond Basis – "Core" vs "Periphery" Countries. This figure shows the time-series dynamics of the within group average of the CDS-bond basis for "core" (AT, BE, DE, FR and NL) and "peripheral" (GR, IE, IT, PT and SP) countries. The CDS premia, the national benchmark bonds and the risk-free benchmark (i.e. the German bund) used to calculate the basis have a 10-year maturity. The sample period is January 2007 to December 2012. Observations are expressed in basis points and are at a weekly frequency.

country. This second measure is also equal to the difference between the respective country's risk premium over Germany (which has the most liquid and well-functioning government bond market in the euro area), as priced in the CDS market and in the government bond market. A negative "adjusted" CDS-bond basis implies that a country's bond spread over the German bund is larger than its CDS differential vis-à-vis Germany.

Fig. 2 plots the time series of the basis and shows that since the onset of the US subprime crisis and even more so during the euro area sovereign debt crisis it deviated from zero persistently and exhibited strong co-movements across countries.

To quantify the co-movement in the basis we again conduct a principal component analysis. In Table 2, Panel A, the third and fourth columns list the percentage of explained variation by the first three components of the basis and the "adjusted" basis. For the CDS-bond bases (and "adjusted" bases) the 1st PC alone explains 45% (34%), the 2nd PC the 13% (16%), whereas the first three PCs explain 67% (61%) of the total variation. As shown in Panel B, the 1st PC places similar weights, across all countries

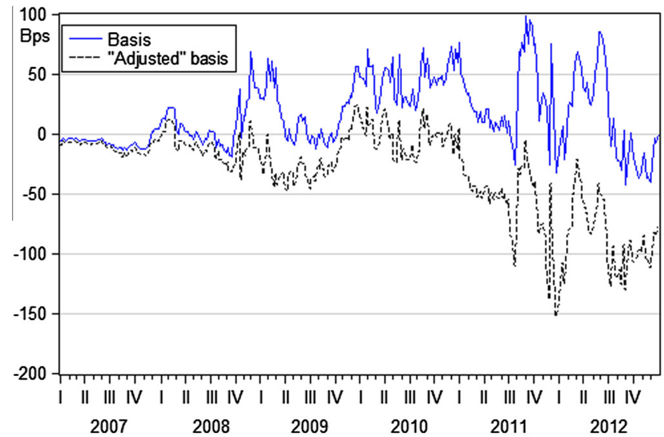

Fig. 4. CDS-bond Basis vs. "Adjusted" CDS-bond Basis – Italy. This figure shows the basis and "adjusted" CDS-bond basis for one selected country: Italy. The "adjusted" basis is defined the difference between the respective country's risk premium over Germany, as priced in the CDS market and in the government bond market. The CDS premium, the national benchmark bond and the risk-free benchmark (i.e. the German bund) used to calculate the bond spread have a 10-year maturity. The sample period is January 2007 to December 2012. Observations are expressed in basis points and are at a weekly frequency.

and the average loading for the CDS-bond basis ("adjusted bases") within the two different groups of "core" and "peripheral" countries is of 0.36 vs. 0.26 (0.36 vs. 0.30). This can therefore be defined as a "level factor". The 2nd PC, instead, differentiates well between countries, as the average loading within the two different groups of "core" and "peripheral" countries is of -0.20 vs. 0.32 (-0.29 vs. 0.29 for the "adjusted" basis). This 2nd PC can, therefore, be interpreted as a "core vs. periphery" factor. Notably, for the basis (and "adjusted" basis), the first two PCs appear to have the same economic interpretation than in the case of CDSs and bond spreads suggesting that its dynamics is strongly linked to conditions in sovereign debt markets. Based on the PCA results we plot, in Fig. 3, the time series of the (within group) average basis for "core" vs "peripheral" countries.

The bases for the two groups of countries were characterized by a strong degree of co-movement, but were at similar levels only up to May 2010; then they diverged substantially. While the basis for "core" countries was persistently positive, the basis for "peripheral" countries fell below zero on several occasions from 2011 on.[15] Fig. 4 compares the basis and the "adjusted" basis for Italy. Even if the two series differ in their levels they co-move strongly; the correlation coefficient calculated on weekly changes is 0.93.

Table 1, Panel B, reports the descriptive statistics of the basis and the "adjusted" basis weekly changes for all countries. The behaviour of the two measures is similar, but "core" and "peripheral" countries have a different characterization: the average change, expressed in basis points, of the basis is positive for "core" countries (0.17) and negative for "peripheral" countries (-0.10). The average change of the "adjusted" basis is approximately zero for "core" countries (−0.05) and negative for "peripheral" countries (−0.26). Also, the volatility is larger for "peripheral" countries (22.39 vs. 7.40) and the correlation between basis and "adjusted" basis weekly changes is larger for "peripheral" countries (0.95 vs. 0.73).

[15] The basis for Portugal, Greece and Ireland temporarily declined below zero in several periods (i.e. April–May 2009 and May–June 2010) and became persistently negative from 2011 onwards. In contrast, the basis for Italy and Spain started declining from the beginning of 2011, fell below zero in summer 2011 and became persistently negative from the summer of 2012 on.

Table 3
Covariates – variable definitions. This table shows variable definitions of the covariates used in the empirical analysis and their data sources. Panel A. contains the proxies for credit risk, Panel B. the proxies for the risk premium, Panel C. the proxies for bond trading activity and "arbitrage frictions" in the credit markets.

	Proxies for credit risk	Source
Panel A		
Rf	Risk-free rate (Euribor 3 m)	Bloomberg
Slope	10 Year Euro Swap rate minus 3 Month Euribor	Bloomberg
Eq Ret	A country's equity index returns minus euro area equity Index	Datastream
Eq Vol	Annualized GARCH (1,1) volatility of idiosyncratic equity returns	Datastream
Debt/Leverage	(Gov Bond outstanding amounts) / GDP	Bloomberg
	Proxies for global risk factors	
Panel B		
Risk Premium	VSTOXX (index of implied volatility of the EuroStoxx50) – annualized GARCH (1.1) realized volatility	Bloomberg
EVZ	Exchange rate Euro/USD Implied Volatility	Bloomberg
	Bond trading activity and "frictions"	
Panel C		
Bond Volume	Weekly bond volume (Billion Euro) and transaction N. (average all maturities)	MTS
Bond Bid-Ask	Weekly bid-ask spread (average all maturities)	MTS
Bond Outst.	Government bond outstanding amounts/ GDP	Bloomberg
SMP Purchases	Weekly ECB euro area government bond purchases	ECB
Bond Haircut	Italian bond haircut (7–10 year maturity)	CCG
Quantity on Loan	Quantity of bonds on loan/borrowed and is a proxy for "short-selling activity"	Data Explorers
Active Utilisation	% of securities in lending programmes which are currently out on loan and gives an indication of the lack of bonds to short in the market.	Data Explorers
Available Quantity	Proxy for "institutional ownership".	Data Explorers
Indicative Fee	Borrowing cost of the bond to short-sell (expressed in steps from 1 to 5)	Data Explorers
Bond Specialness	Repo on the bond – General Collateral Repo rate (available for Italy and Spain)	ECB

4.3. The set of explanatory variables

4.3.1. The determinants of CDS premia and bond spreads

The theoretical framework of the Merton model (1974), which is a cornerstone in the literature on credit risk, is oriented towards corporate credit risk. Gapen et al. (2008) extend this structural modelling approach towards sovereign credit risk, thereby providing a contingent-claim based valuation of default risky government bonds, where the key drivers of the risk of sovereign default are the volatility of sovereign assets and a country's leverage.

Based on this framework, we use a broad set of potential covariates (cf. Table 3 Panel A and B for definitions and data sources[16]).

Risk-free rate. In the Merton (1974) model the level of the risk-free rate is negatively related to credit spreads. A higher risk-free rate implies a higher expected growth rate of the firm value. In turn, this implies a lower price of the put option on the firm value and a lower the credit spread. As a euro-wide proxy for the risk-free rate we use the three-month Euribor rate.

Slope of the term structure. In the Longstaff and Schwarz (1995) structural credit risk model the interest rate is stochastic. In the long run, the short rate is expected to converge to the long rate. Hence, an increasing slope of the term structure should lead to an increase in the expected future spot rate. This in turn, will decrease credit spreads through its effect on the drift of the asset value process. We proxy for the slope of the term structure taking the difference between the ten-year Euro Swap-rate and the three-month Euribor rate.

Idiosyncratic equity returns. Collin-Dufresne et al. (2001) use stock returns as a proxy for the overall state of a country's economy. For the purpose of a clearer identification, we use a country's idiosyncratic stock returns rather than its total returns, which we define as the difference between the national equity-index return and the market-wide index return as represented by the Datastream euro area equity index. Our hypothesis is that the country-specific equity return is negatively related to a country's credit spreads.

Idiosyncratic equity volatility. Campbell and Taksler (2003) document that variation in US corporate spreads is more strongly linked to idiosyncratic stock price volatility than to aggregate stock price volatility. Based on this result, we use the idiosyncratic volatility which we calculate as the annualised GARCH (1, 1) volatility of idiosyncratic stock returns (defined as a country's stock returns minus Datastream euro are equity index). We expect idiosyncratic equity volatility and credit spreads to be positively related.

Country leverage. This variable is the ratio between a country's public debt, i.e. outstanding bonds, and its GDP. The idea is that credit quality of sovereign debt increases with a country's fiscal discipline as captured by a lower debt-to-GDP ratio (see also Gapen et al. 2008). This ratio is also acknowledged in a fiscal policy perspective as the EU's Stability and Growth Pact aims to cap a country's total debt at 60 % of its GDP.[17]

Credit spreads not only compensate investors for pure expected losses. Spreads vary due to changes in investors' risk aversion even if the underlying fundamentals (i.e. the pricing under the "statistical measure") are unchanged. For example, Longstaff et al. (2011) show that also global risk factors drive sovereign credit spreads. Table 3 Panel B. contains variables, which proxy for "global risk factors".

Risk premium. We focus on the VSTOXX, the index of implied volatility (European VIX) based on the EuroStoxx50. In order to obtain a proxy for the risk premium, we deduct a GARCH-based estimate of volatility from the VSTOXX index. This variable represents the risk premium which investors in equity options require in order to compensate them for equity market risk in Europe. We expect the "risk-premium" and credit spreads to be positively related.

[16] Summary statistics of all the explanatory variables are available upon request.

[17] As we focus only on long-term bonds this variable is lower than the usual debt-to-GDP ratio. The amount of bonds outstanding is available in Bloomberg with a monthly frequency. We use linear interpolation to obtain weekly observations.

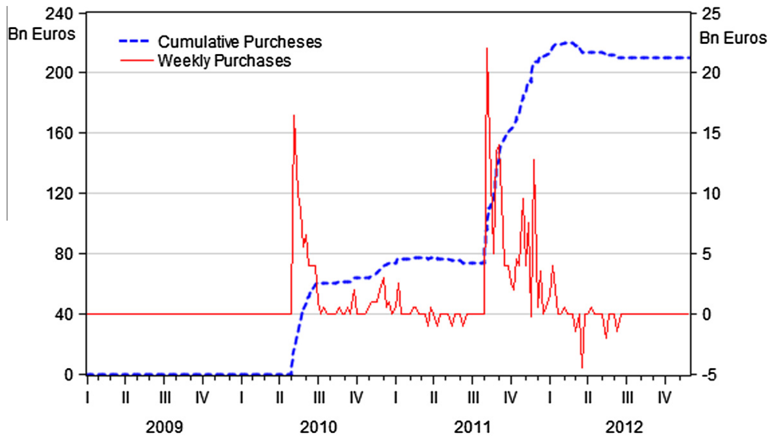

Fig. 5. Total and Weekly Securities Market Programme (SMP) Purchases Amounts. On the left-hand side axis this figure shows the book value of the cumulative SMP purchases, while on the right weekly purchases. Amounts are in billion Euro as of Friday of each given week.

Euro/USD exchange rate uncertainty. Higher uncertainty about the future path of the exchange rate should make protection quoted in USD more expensive than in Euro.[18] As a proxy for the exchange rate uncertainty, we use the 30-day implied exchange rate volatility index (EVZ), provided by CBOE, which follows the methodology of the VIX index. We expect this variable to correlate positively with CDS premia.

4.3.2. Measures of bond trading activity and "frictions"

Table 3 Panel C. shows the variables we use to capture the amount of bond trading activity in the secondary market and the "short-selling" and "funding frictions" in the repo market.

Government bond volume and bid-ask spread. We use transaction data from the MTS Group. We consider government bonds with all maturities. We use daily *trading volumes*, which we sum to obtain weekly data. *Bid-ask spreads* are weekly averages of the daily observations.

Available quantity. This variable, taken from Data Explorers (Markit), is the amount of securities in lending programs and is a proxy for "institutional ownership". The inventories which owners make available to a bond's borrowers will tend to increase or decrease in line with their purchases and sales across their portfolios.

Quantity on loan. This variable, also taken from Data Explorers (Markit), quantifies bonds on loan/borrowed, i.e. a measure for the amount of "short-selling activity" taking place. This information is specific to the benchmark bond of each country in the sample.

Active utilisation. This variable is defined as the share (%) of securities in lending programs which are currently out on loan. When *Active Utilisation* is high there is a lack of bonds available to short in the market, hence it measures "short-selling frictions". This information is available at the bond-level for all our benchmark bonds.

Indicative fee. This variable, taken from Data Explorers (Markit), is an indicative fee, expressed in steps from 1 to 5, of the borrowing cost of the bond to short-sell. Hence, it is a price measure of the cost of "short-selling" and is expected to correlate positively with *Active Utilisation*.

SMP purchases. These data (shown in Fig. 5) refer to the book value, expressed in billion euros, of the total cumulative purchases, as of Friday of each given week. The ECB activated this program on May 10, 2010 to intervene for buying Greek, Portuguese and Irish government bonds and re-activated it on August, 7 2011 for buying Italian and Spanish bonds (Corradin and Maddaloni, 2015).[19]

Bond specialness. This variable is available to us only for Italian bonds. In a repo agreement a security is sold together with the commitment to buy it back at a given later date. The party buying the security is providing collateralized financing to the other party which has entered a reverse repo. This type of operation is typically conduced to short-sell a security.[20] The bond "specialness", which is defined as the difference between the general repo rate and the rate on a specific bond any given day is a measure of the cost of "short-selling" the bond. When the rate to obtain a specific security is very low "short-selling" becomes costly. In our analysis, this cost directly affects the risk/return profile of a "positive basis trade". Bond specialness is a short-selling friction measure based on prices, i.e. which captures the cost of short-selling a bond in a repo. Active Utilisation is a short-selling friction measure based on quantities as it captures the availability of bonds to short-sell.

Haircuts on government bonds. This variable is available to us only for Italy, Spain and France. Data on haircuts are obtained from LCH-CLEARNET. Garleanu and Pedersen (2011) show that during the crisis, funding problems have had significant asset pricing effects. As an example they mention the violation of the law of one price in the case of CDS and bond yield spreads: "securities with nearly identical cash flows, but different margins, traded at a different price, giving rise to price gaps (basis)". Therefore, we expect negative basis deviations, during periods of high market stress, to be related to increasing haircuts in the repo market.

Government bonds outstanding. We standardize a country's total outstanding bonds by calculating the relative ratio over its GDP. These two variables are taken from Bloomberg. As discussed in Subsection 4.3.1 this is a proxy for a country's debt level

[18] The euro is expected to devaluate in case of a euro area country default, hence protection in USD is more costly because it provides a currency hedge.

[19] Interventions focused on bond from 2 to 10 year maturity. The ECB initially did not disclose the target and the amount of these operations, but has provided, on February 21, 2013, securities holdings at the country level. Out of 218 billion euros of total purchases, 103 refer to Italian bonds, 44 to Spanish bonds, 34 to Greek bonds, 32 to Portuguese bonds and 14 to Irish bonds.

[20] As documented by Corradin and Maddaloni (2015), tensions in the unsecured inter-banking market, due to increase of counterparty risk, have shifted a substantial amount of the financial intermediaries' financing activity to the secured repo market.

Table 4
Credit Spreads and the Basis – Cross-Sectional Analysis. This table reports results from a panel regression with time-fixed effects on credit spreads and the basis. The regression specification is given by $Y_{it} = \alpha + \beta_1\ EqRet_{it} + \beta_2 EqVol_{it} + \beta_3 Debt_{it} + \upsilon_t + \varepsilon_{it}$ Reported coefficients are in basis points and *p*-values are (in parentheses) are adjusted for heteroskedasticity. Significance levels at 1%, 5% and 10% are denoted by ***, ** and * respectively. Panel A. reports results in levels, Panel B. in changes. The sample period is November 2008–December 2012. Observations are at a weekly frequency.

Variable	CDS	Bond spread	Basis	Adj Basis
Panel A				
C	−54.396***	38.749	48.847***	−31.66***
	(0.002)	(0.134)	(0.000)	(0.000)
EqRet	−0.142	0.017	−0.031	−0.028
	(0.275)	(0.920)	(0.406)	(0.456)
EqVol	0.243***	0.093***	−0.037***	−0.033***
	(0.000)	(0.000)	(0.000)	(0.000)
Debt	1.549***	1.301***	−0.277***	−0.156***
	(0.000)	(0.000)	(0.000)	(0.000)
Time FE	Yes	Yes	Yes	Yes
N.	2160	1941	1941	1941
Adj. R-sq	0.453	0.121	0.125	0.214
Variable	Δ (CDS)	Δ (Bond Spread)	Δ (Basis)	Δ (Adj Basis)
Panel B				
C	1.292***	1.247	−0.216**	−0.350***
	(0.000)	(0.847)	(0.020)	(0.000)
ΔEqRet	−0.039***	−0.013	−0.005	−0.006
	(0.004)	(0.727)	(0.520)	(0.474)
ΔEqVol	0.012	0.000	−0.011	−0.010
	(0.268)	(0.911)	(0.132)	(0.157)
ΔDebt	−1.085	−0.006	0.118	0.133
	(0.395)	(0.896)	(0.899)	(0.873)
Time FE	Yes	Yes	Yes	Yes
N.	2160	1941	1941	1941
Adj. R-sq	0.347	0.128	0.256	0.194

Table 5
Time-Series Analysis of Credit Spreads. This table reports results from a panel regression with country-fixed effects on credit spreads and the basis. The regression specification is given by $\Delta Y_{it} = \alpha + X_{it}^T\ \beta_1 + \beta_2\Delta Rf_t + \beta_3\Delta Slope_t + \beta_4\Delta RP_t + \beta_5\Delta EVZ_t$ + - $\beta_3 \Delta Slope_t \sum \beta_4 \Delta RP_t \sum \beta_5 \Delta EVZ_t \sum \rho_i \sum \varepsilon_{it}\varrho$ Υθε χεγυοσΔX_{it} σεπσετεξυτ υθε βατε γατε γοχασιαυετ οζ γοφξυσϖτπεγιζιγ χασιαβμετϱ Σεποσυεδ γοεζζιγιεξυτ ασε ιξ βατιτ ποιξυτ αξδ ϱϖχαμφετ ασε ιξ πασεξυθετετ ασε αδκφτυεδ ζοσ θευεσοτλεδατυιγιυϱ Τιηξιζιγαξγε μεχεμτ αυ ςκ αξδ ς ασε δεξουεδ β ***κ ** αξδ * σετπεγυιχεμϱ Σετφμυτ ασε ιξ γθαξηετϱ Υθε ταvπμε πεσιοδ ιτ Ξοχενβεσ υο Δεγενβεσ ςϱ Οβτεσχαυιοξτ ασε αυ α ψεελμ ζσερφεξγϱ

Variable	Δ(CDS)	Δ(Bond spread)	Δ(Basis)	Δ(Adj basis)
C	1.357	0.371	−0.121	−0.181
	(0.289)	(0.794)	(0.890)	(0.819)
Δ(Rf)	−0.214	−0.259	0.013	0.113
	(0.355)	(0.209)	(0.927)	(0.319)
Δ(Slope)	−0.157*	−0.076	−0.042	−0.008
	(0.079)	(0.404)	(0.455)	(0.869)
Δ(EqRet)	−0.046***	0.006	−0.011	−0.008
	(0.001)	(0.870)	(0.234)	(0.362)
Δ(EqVol)	0.018*	0.004	−0.011	−0.015**
	(0.088)	(0.839)	(0.125)	(0.030)
Δ(Debt)	−0.920	−0.757	0.277	0.265
	(0.520)	(0.397)	(0.771)	(0.764)
Δ(RP)	0.015***	0.013***	0.003	0.000
	(0.001)	(0.003)	(0.215)	(0.659)
Δ(EVZ)	0.026***	0.028***	0.000	−0.004
	(0.004)	(0.000)	(0.979)	(0.979)
Country FE	Yes	Yes	Yes	Yes
N.	2160	1941	1941	1941
Adj R-sq	0.129	0.041	0.028	0.026

(i.e. "leverage" in the Merton framework), but it might have two other interpretations. For bonds, in a market with elastic demand this variable also reflects bond market liquidity because a larger bond market generally contributes to lower transaction costs. However, if new issuance exceeds existing demand, then an adverse impact on bond market liquidity could materialise. For these reasons, we expect this variable to capture also illiquidity conditions in the bond market, not only the level of credit risk.

5. Empirical analysis

5.1. The determinants of credit spreads

In this section we investigate whether our selected key drivers of credit risk affects the variation of CDS premia and bond spreads differently during the euro area sovereign debt crisis, as discussed in Hypothesis 1. Data are weekly observations.[21] We start with a cross-sectional analysis. For this purpose, we estimate a panel regression with time-fixed effects of credit spreads on a set of country specific variables:

$$Y_{it} = \alpha + \beta_1 EqRet_{it} + \beta_2 EqVol_{it} + \beta_3 Debt_{it} + \upsilon_t + \varepsilon_{it} \tag{1}$$

with Y_{it} being a vector of dimension ten representing the CDS premium or the bond spread of a country i at time t. Time fixed effects (FE) are captured by υ_t. Table 4 Panel A reports results from regressions in levels, while Panel B from regressions in changes. We find that most coefficients are significant and their signs correspond to our hypothesis. In the case of regressions in levels, *equity volatility* and *leverage* are positively related to credit spreads. For regressions in changes the significance of the results is weaker. *Equity returns* negatively affect credit spreads, but are significant only for CDS premia. Overall, considering the significance of the coefficients and the explanatory power of the regressions, CDS premia are more sensitive to "country specific" determinants than bond yield spreads.

As a second step we implement a time-series analysis. Our aim is to test whether other variables, beyond country-specific variables, also have explanatory power. These new factors cannot be added in Eq. (1) because of the lack of cross-sectional variation. For this purpose, we estimate the following panel regression model with country-fixed effects:

$$\Delta Y_{it} = \alpha + X_{it}^T\beta_1 + \beta_2\Delta Rf_t + \beta_3\Delta Slope_t + \beta_4\Delta RP_t + \beta_5\Delta EVZ_t + \rho_i + \varepsilon_i t \tag{2}$$

with Y_{it} being a vector of dimension ten representing the CDS premia or the bond spread of a country i at time t. X_{it} is the vector of country specific covariates from model (1). Country fixed effects (FE) are captured by ρ_i. Table 5 reports results. The hypothesis of a unit-root is not rejected by the Augmented Dickey-Fuller test for credit spreads and for the explanatory variables expressed in levels, therefore we estimate this equation in changes only.[22] In the case of CDS premia, we find that for most of the covariates, such as the "country specific variables", the *risk-free rate (Slope)* and the "*proxies for risk premium*" the signs of the coefficients, which are significant, correspond to our hypothesis. In contrast, in the case of bond spreads, only proxies for "*risk premium*" are significant and with the expected sign. This analysis further confirms that CDS premia are more sensitive to "country specific" drivers than bond spreads.

We also investigate the role of variables which according to previous research influence credit spreads in determining the basis. For this purpose, we proceed by again estimating respectively model (1) and (2) as for CDS premia and bond spreads. Results of the cross-sectional analysis reported in Table 4 Panel A show that

[21] In the reported analysis observations are weekly. These results are confirmed also for daily and bi-weekly data.

[22] Results are omitted for reasons of space.

the basis and the "adjusted basis" are negatively related to *equity volatility* and *leverage*. As reported in Table 4 Panel B. and Table 5, basis changes in the cross-section and the basis time-series dynamics are not explained by the covariates considered in the regressions. Groba et al. (2013) use a similar set of explanatory variables to proxy for country-specific and global factors in euro area CDS premia and obtain similar findings.[23]

The CDS premium and the bond spread, within each country, do not correlate perfectly (average correlation is 0.60) as would be expected in the case of a no-arbitrage relation. In our view, this observation and the results discussed in this section altogether support hypothesis (H.1) that the key drivers of sovereign credit risk have affected CDS premia and bond spreads in a different way during the crisis.

5.2. Short-selling frictions

The CDS-bond basis is not explained by the country specific and global variables which explain credit spreads; at the same time it exhibits a strong degree of co-movement across countries, as highlighted by the PCA in Section 4, meaning that it is driven to a large extent by common determinants.

When the basis is positive (CDS premium exceeds bond spread), arbitrageurs can in principle profit from this deviation. A "positive basis trade" involves short-selling the bond and selling protection (i.e. the CDS) on the underlying bond. Here, we test the hypothesis (H.2) that "short-selling frictions", preventing arbitrageurs to short-sell a bond and profit from a "positive basis trade" explain persistently positive basis deviations. First, we explore the role of "frictions" in the cross-section. For this purpose, we estimate the panel regression model (1), with time-fixed effects, where we include *active utilisation*, our proxy for "short-selling frictions":

$$Basis_{it} = \alpha_0 + X_{it}^T\beta_1 + \gamma_1 ActiveUtilisation_{it} + v_t + \varepsilon_{it} \tag{3}$$

X_{it} is the vector of country specific control variables from model (1). Time fixed effects (FE) are captured by v_t. As shown in Table 6, the basis and the "adjusted" basis are both positively related to short selling frictions (coefficients 0,378 and 0,379).

Second, to study time-series implications we estimate the following panel regression with country-fixed effects:

$$\Delta Basis_{it} = \alpha_0 + \Delta X_{it}^T\beta_1 + \Delta Z_t\beta_2 + \gamma_1 \Delta ActiveUtilisation_{(it-k)} + \rho_i + \varepsilon_{it} \tag{4}$$

Z_{it} is the vector of the global proxies for the risk premium from model (2). Country fixed effects (FE) are captured by ρ_i. Table 6 shows that the basis and the adjusted" basis increase when *active utilisation* increases (coefficients are 0.141 and 0.133). The coefficient is significant only with a lag of two. Hence, pricing deviations take place with some delay with respect to the appearance of frictions. To further investigate the time-series link between "short-selling frictions" and the basis, we apply the Engle–Granger two-step approach (Engle and Granger (1987)). First, we estimate a specification of the model with the variables in levels. Our assumption is that the long run relationship between the basis and *active utilisation*, on a country by country level is:

$$Basis_t = \alpha_0 + \alpha_1 ActiveUtilisation_t + u_t \tag{5}$$

Table 6
The basis and "short-selling frictions" – panel regressions. This table reports results from a panel regression of the basis and "adjusted" basis on short-selling frictions. Panel A. reports results of regressions in levels with time fixed effect. Panel B. reports results in changes. *P*-values are (in parentheses) are adjusted for heteroskedasticity. Significance levels at 1%, 5% and 10% are denoted by ***, ** and * respectively. The sample period is November 2008 to December 2012. Observations are at a weekly frequency.

Variable	Basis	Adj Basis
Panel A. cross-section		
C	Yes	Yes
Active Utilisation	0.378***	0.379***
	(0.004)	(0.004)
Country Specific Covariates as controls	Yes	Yes
Time FE	Yes	Yes
N.	1941	1941
Adj. R-sq	0.125	0.233
	Δ(Basis)	Δ(Adj basis)
Panel B. time-series		
C	Yes	Yes
Δ(Active utilisation)	0.141*	0.133**
	(0.076)	(0.013)
Δ(Country specific covariates)	Yes	Yes
Δ(Global proxies risk premium)	Yes	Yes
Country FE	Yes	Yes
N.	1941	1941
Adj. R-sq	0.022	0.023
ADF	2.020	2.000

If we reject the hypothesis of a unit root in the residuals there is a long run relationship between the variables, i.e. they are cointegrated. When residuals are unit-root stationary,[24] we estimate the short-run regressions, using first differences of the variables and the lagged error, obtained in the long run Eq. (5), by means of the following Error Correction Model:

$$\Delta Basis_t = \beta_0 + \lambda\hat{u}_{(t-1)} + \beta_1 \Delta ActiveUtilisation_{(t-k)} + \varepsilon_t \tag{6}$$

As shown in Table 7 Panel A the *basis* and *active utilisation* comove positively in levels. This is the case for almost all the countries across the euro area, as the coefficient is positive and we reject the hypothesis of a unit-root of the residuals.

As shown in Panel B the lagged error (estimated in the first step) explains future changes of the basis, implying that the basis tends to revert back to its equilibrium whenever it deviates from it. As expected, *active utilisation* tends to anticipate *basis* movements. We conclude that there is strong support in favour of hypothesis 2.

5.3. The basis and the "flight-to-quality/liquidity" phenomenon

In periods of market distress investors tend to rebalance their portfolios towards less risky and more liquid securities. This phenomenon is usually referred to as a "flight-to-quality" or a "flight-to-liquidity". It is usually difficult to disentangle the two effects. In the context of the euro are sovereign crisis, if investors increase their German Bund holdings but reduce their holdings of other countries' debt it is unclear whether they do so because of their concerns about credit risk or market liquidity risk as these two risks are strongly correlated. Evidence of the "flight to quality/liquidity" phenomena is provided by the fact that CDS premia and bond spreads (i.e. respectively −0.42, −0.41) correlate negatively with the German bund.

In this section we test the hypothesis (H. 3) that more creditworthy countries with more liquid government bonds have larger CDS-bond bases. As the "flight-to-quality" effect has shifted bond

[23] In particular Groba et al. (2013) find that exchange rate fluctuations and a factor representing distressed economies explain the variation of CDS premia. They also find that the explanatory ability of local and global factors is not as high as reported in Longstaff et al. (2011).

[24] We check for unit-root stationarity of the residuals by mean of the Augmented Dickey Fuller Test. In this case the OLS estimator is super consistent and there are no spurious regression problems when we estimate the vector of parameters in (5).

Table 7
The basis and "short-selling frictions" – cointegration analysis. This table presents the results of the Engle-Granger two-step estimation. (Panel A) First, we estimate the model using the variables in levels. The long run relationship between the basis and Active Utilisation is: $Basis_t = \alpha_0 + \alpha_1\ ActiveUtilisation_t + u_t$. We check for unit-root stationarity of the residuals by mean of the Augmented Dickey Fuller Test. (Panel B) Second, we estimate the short-run regressions, using first differences of the variables and the lagged error, obtained in the long run equation, by mean of the following Error Correction Model: $\Delta Basis_t = \beta_0 + \lambda\hat{u}_{(t-1)} + \beta_1 \Delta ActiveUtilisation(_{t-k}) + \varepsilon_t$. Reported coefficients are in basis points and p-values are (in parentheses) are adjusted for heteroskedasticity. Significance levels at 1%, 5% and 10% are denoted by ***, ** and * respectively. The sample period is November 2008 to December 2012. Observations are at a weekly frequency.

	AT	BE	DE	FR	NL	IE	IT	PT	SP
	Long-Run Regressions Basis								
Panel A									
C	31.762***	36.496***	37.988***	14.483	8.731	-13.298	8.690*	-24.162**	16.43***
	(0.000)	(0.000)	(0.000)	(0.129)	(0.111)	(0.137)	(0.087)	(0.040)	(0.143)
Active Utilis.	0.668***	0.177	0.725***	0.988***	1.039***	−0.173	0.707***	−1.012***	0.167***
	(0.000)	(0.415)	(0.000)	(0.000)	(0.000)	(0.535)	(0.000)	(0.013)	(0.522)
Adj. R-sq	0.167	0.003	0.143	0.283	0.355	0.001	0.279	0.097	0.004
Prob. Resid ADF	0.002	0.084	0.095	0.003	0.004	0.004	0.003	0.003	0.217
	Short-Run Regressions Δ(Basis)								
Panel B									
Long-Run Resid	−0.093**	−0.054**	−0.028*	−0.037**	−0.042**	−0.120***	−0.018*	−0.132***	−0.054*
Lag 1	(0.012)	(0.015)	(0.072)	(0.036)	(0.032)	(0.001)	(0.010)	(0.000)	(0.052)
Δ(Active Utilis.)	0.151**	0.046	−0.047	0.109**	0.143**	−0.163	0.545***	0.001**	0.120**
	(0.045)	(0.552)	(0.223)	(0.067)	(0.027)	(0.191)	(0.002)	(0.995)	(0.242)
Δ(Active Utilis.)	0.076	−0.038	0.001	0.011	0.004	−0.113	0.327**	0.057	−0.114
Lag 1	(0.370)	(0.766)	(0.805)	(0.893)	(0.370)	(0.422)	(0.028)	(0.761)	(0.220)
Δ(Active Utilis.)	0.074	−0.048	0.041	−0.007	0.015	−0.051	0.097	0.430	−0.028
Lag2	(0.343)	(0.647)	(0.288)	(0.904)	(0.343)	(0.584)	(0.494)	(0.169)	(0.773)
Adj. R-sq	0.051	0.014	0.021	0.011	0.021	0.050	0.138	0.068	0.019
ADF	2.051	1.924	2.121	2.004	2.106	1.906	2.091	2.002	2.051

Table 8
The basis and the "flight-to-quality/liquidity"– cross-sectional analysis. Panel A. reports results from a panel regression, with time-fixed effects, of the basis on various liquidity and credit risk measures: $Basis_{it} = \alpha + \beta X_{it} + \upsilon_t + \varepsilon_{it}$ (7), X_{it} is the vector of the proxies for liquidity and credit risk. Panel B. shows the result of a panel regression, with time-fixed effects, of various liquidity measures such as bid-ask spreads and bond volumes on credit risk as proxied by the level of the CDS Premium: $Bond\ Liquidity_{it} = \alpha + \beta\ CDS_{it} + \upsilon_t + \varepsilon_{it}$ (8). Panel C. shows the result of a panel regression, with time-fixed effects, of Active Utilisation on liquidity measures such as bid-ask spreads and bond volumes and on credit risk as proxied by the level of the CDS Premium: $Active\ Utilisation_{it} = \alpha + \beta X_{it} + \upsilon_t + \varepsilon_{it}$ (9). Time fixed effects (FE) are captured by υ_t. Reported coefficients are in basis points and p-values are (in parentheses) are adjusted for heteroskedasticity. Significance levels at 1%, 5% and 10% are denoted by ***, ** and * respectively. The sample period is November 2008 to December 2012. Observations are weekly.

	CDS-bond basis				
Panel A					
C	49.912***	23.434***	−144.006***	9.210***	6.384**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.024)
CDS Premia	−0.156***				
	(0.000)				
Bid-Ask Spread		−1.277**			
		(0.012)			
Log(bond volume)			8.357***		
			(0.000)		
Log(Bond N.Trd)				7,456***	
				(0.000)	
Active Utilisation					0.531***
					(0.000)
Time FE	Yes	Yes	Yes	Yes	Yes
	Bid-ask	Log(Bond Vol.)	Active utilisation		
Panel B			*Panel C*		
C	−0.922***	21.845***	35.034***	29.251***	4.825***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,432)
CDS Premia	0.010***	−0.579***	−0.031***		
	(0,000)	(0,000)	(0,000)		
Bid-ask				−0.634***	
				(0,000)	
Log(Bond Volume)					1.711***
					(0,000)
Time FE	Yes	Yes	Yes	Yes	Yes

trading activity away from "peripheral" countries we expect bond liquidity to be reflected in a price premium (or yield discount), hence in a relatively lower bond yield spread and a higher CDS-bond basis. Also, we expect bond illiquidity to be reflected in a yield premium, hence in a relatively higher bond yield spread and a lower CDS-bond basis. As discussed in Section 5.1, the basis

Table 9
The basis, CDS and Bond spreads and the SMP. Panel A. reports results regression for the basis, Panel B. for the CDS premia and Panel C. for the bond spreads. *P*-values are (in parentheses) are adjusted for heteroskedasticity. Significance levels at 1%, 5% and 10% are denoted by ***, ** and * respectively. The sample period is November 2008 to December 2012. Observations are at a weekly frequency.

	AT	BE	DE	FR	GR	NL	IE	IT	PT	SP
	Δ(Basis)									
Panel A										
C	0,086	0.213	0.877**	0.534	0.296	0.236	−0.125	0.479	1.288	−0.311
	(0.907)	(0.793)	(0.062)	(0.462)	(0.936)	(0.672)	(0.956)	(0.717)	(0.692)	(0.686)
SMP	0.000	0.000	−0.001	0.000	−0.005	0.000	−0.002**	−0.002	−0.006	−0.001
	(0.924)	(0.664)	(0.400)	(0.714)	(0.138)	(0.747)	(0.016)	(0.006)	(0.000)	(0.276)
SMP May 2010	0.000	0.001	0.000	0.001	0.011***	0.000	0.004***	0.001	0.006***	0.001
	(0.987)	(0.348)	(0.875)	(0.603)	(0.002)	(0.748)	(0.000)	(0.243)	(0.000)	(0.570)
SMP August 2011	0.001	0.001	0.001	0.001	//	0.001	0.002***	0.003***	0.006***	0.001*
	(0.473)	(0.235)	(0.355)	(0.429)	//	(0.463)	(0.001)	(0.000)	(0.000)	(0.070)
Adj. R-sq	0.027	0.011	0.045	0.006	0.191	0.002	0.012	0.109	0.756	0.034
D-W	1.931	1.951	1.952	1.989	2.216	1.970	2.031	1.916	2.000	2.038
	Δ(CDS)									
Panel B										
C	0.306	0.974	0.419	0.592	9.264	0.384	1.869	1.530	2.525	1.860
	(0.831)	(0.499)	(0.771)	(0.680)	(0.008)	(0.789)	(0.194)	(0.288)	(0.079)	(0.196)
SMP	−0.001	−0.002**	−0.001	−0.001	−0.004	−0.001	−0.003***	−0.002**	−0.003**	−0.002**
	(0.426)	(0.022)	(0.596)	(0.446)	(0.387)	(0.514)	(0.002)	(0.027)	(0.018)	(0.035)
SMP May 2010	0.001	0.002	0.000	0.001	−0.005	0.364	0.002*	0.001	−0.002	0.002
	(0.651)	(0.110)	(0.920)	(0.610)	(0.364)	(0.701)	(0.100)	(0.464)	(0.253)	(0.307)
SMP August 2011	0.002	0.003**	0.001	0.001	//	0.001	0.003**	0.003**	0.003**	0.002
	(0.234)	(0.036)	(0.561)	(0.374)	//	(0.445)	(0.019)	(0.021)	(0.013)	(0.196)
Adj. R-sq	0.043	0.043	0.001	0.001	0.102	0.001	0.001	0.025	0.028	0.065
D-W	1.985	1.985	1.999	2.000	1.851	1.999	2.000	2.000	2.002	2.031
	Δ(Bond spreads)									
Panel C										
C	0.306	0.973	//	0.592	2.000	0.384	1.869	1.530	2.526	1.860
	(0.840)	(0.523)	//	(0.697)	(0.690)	(0.800)	(0.220)	(0.312)	(0.097)	(0.222)
SMP	−0.001	−0.002**	//	−0.001	0.000	−0.001	−0.003***	−0.002**	−0.003**	−0.002*
	(0.452)	(0.030)	//	(0.4719)	0.968	(0.538)	(0.003)	(0.037)	(0.025)	(0.046)
SMP May 2010	0.001	0.002	//	0.001	−0.015***	0.001	0.002	0.001	−0.002	0.002
	(0.670)	(0.131)	//	(0.630)	(0.000)	(0.716)	(0.127)	(0.489)	(0.280)	(0.334)
SMP August 201	0.002	0.003**	//	0.001	//	0.001	0.003**	0.003**	0.003**	0.002
	(0.261)	(0.048)	//	(0.401)	//	(0.471)	(0.027)	(0.029)	(0.019)	(0.227)
Adj. R-sq	0.043	0.056	//	0.002	0.038	0.026	0.016	0.003	0.017	0.060
D-W	1.953	1.955	//	1.970	1.913	1.972	1.946	1.957	1.958	1.962

is negatively related to credit risk as proxied by *equity volatility* and *leverage*, in other words, more (less) creditworthy countries tend to have larger (lower) CDS-bond bases.

Extending model (3) to include liquidity proxies would be problematic given our small cross-sectional sample, the high number of variables and their correlation. Therefore, for the purpose of studying the empirical link between the basis, credit risk, liquidity and "short-selling frictions" we estimate the following univariate panel regressions on the basis:

$$Basis_{it} = \alpha + \beta X_{it} + \upsilon_t + \varepsilon_{it} \tag{7}$$

X_{it} is either the *bid-ask spread*, or *bond volumes*, or *number of transactions*, or the *CDS Premium* or *Active Utilisation*.[25] Time fixed effects (FE) are captured by υ_t. Table 8 Panel A. shows that bonds characterized by lower credit risk, higher liquidity and stronger "short-selling frictions" tend to have more positive bases.

For studying the relation between credit risk and bond liquidity we estimate the following univariate panel regression:

$$BondLiquidity_{it} = \alpha + \beta CDS_{it} + \upsilon_t + \varepsilon_{it} \tag{8}$$

Where bond liquidity is proxied either by the *bid-ask spread*, *bond volumes* or *number of transactions* and *credit risk* by the level of the *CDS premium*. Time fixed effects (FE) are captured by υ_t. Of particular interest is trying to better understand the relation between "short-selling frictions" and credit risk and bond liquidity. For this purpose, we estimate the following panel univariate regression:

$$ActiveUtilisation_{it} = \alpha + \beta X_{it} + \upsilon_t + \varepsilon_{it} \tag{9}$$

X_{it} is either the *bid-ask spread*, *bond volumes*, *number of transactions*, or the *CDS Premium*. Time fixed effects (FE) are captured by υ_t. As shown in Table 8 Panel B. bonds with higher credit risk tend to be characterized by lower liquidity, i.e. by higher bid-ask spreads and lower trading volume. More creditworthy and more liquid bonds (as captured by lower CDS premia, lower bid-ask and higher transaction volumes) tend to be characterized by stronger "short-selling frictions". These results altogether support the view that "core" countries' larger positive bases are an implication of the "flight to quality/liquidity" phenomenon. These positive deviations tend to persist in time as these more creditworthy and highly liquid bonds tend to trade with a price premium and are, at the same time, also characterized by stronger "short-selling frictions".

5.4. Effects of the ECBs' bond purchases on the basis

In May 2010, in order to address government bond markets liquidity problems and to contribute to restoring an appropriate monetary policy transmission mechanism, the ECB started to conduct interventions in dysfunctional euro area bond market segments, using the Securities Markets Programme (SMP). This programme, which targeted bonds of peripheral countries, was aimed at

[25] For brevity we report regression results only for the basis. For the "adjusted" basis results are similar.

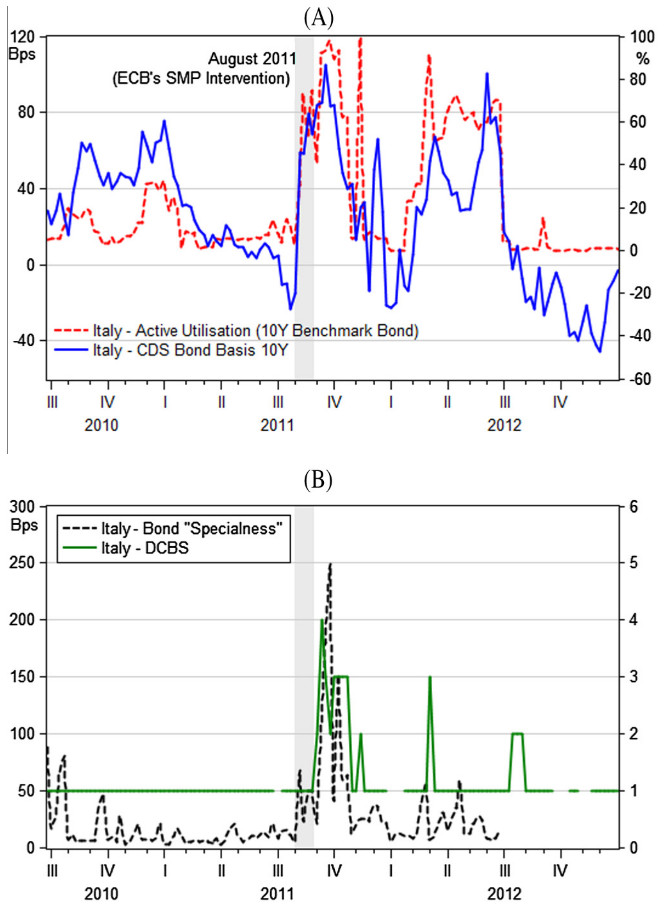

Fig. 6. The Basis and Short-selling Frictions: The case of Italy. On the left-hand side axis Chart A. shows the dynamics of the basis and on the right-hand side of the variable "Active Utilisation". On the left-hand side axis Chart B. shows the time-series dynamics of the "specialness" of the 10 years Italian benchmark bond and on the right-hand side of DCBS, i.e. the Indicative Fee (expressed in steps from 1 to 5) of the borrowing cost of the bond to short-sell. The ECB as purchased (among others also) Italian government bonds through the SMP in August 2011.

lowering the liquidity premium required by investors mainly due to the absence of trading activity, in situations of high credit risk. The impact of the SMP cannot be assessed merely from declines in government bond yields, nor in declining credit spreads, as neither measure gives an exact picture of market impairments.[26]

In this Section we test the hypothesis (H 4.) that ECB bonds purchases have had a positive effect on the basis. The idea is that upward bond price pressure generated basis deviations which then were difficult to arbitrage away. To investigate this issue we regress the basis on the SMP weekly purchases; moreover we interact the SMP variable with two dummies[27]. The first dummy is 1 for the month of May 2010, while the second dummy is 1 for the month of August 2011 otherwise they are zero; these are supposed to capture the effect of the purchases in the two months. Results in Table 9 Panel A. show that SMP purchases have had a positive effect on the basis for the countries for which the bond are purchased and in the specific "purchasing-periods". The ECB activated the program on May 10, 2010 to intervene for buying Greek, Irish and Portuguese government bonds and re-activated it on August, 7 2011 for buying Italian and Spanish bonds. The significance of the coefficients is consistent with the timing of these interventions.

We run the same regression separately for CDS and bond yield spreads. Results are reported in Table 9 Panels B and C. For peripheral countries, SMP purchases are associated with a decrease of both CDS and bond spreads, as the coefficients are negative and generally significant. *SMP*, interacted with the *May2010* and *August2011* dummies, tends to be associated with an increase of both CDS premia and bond spreads. The SMP programme has been implemented, to the largest extent, when credit spreads were increasing sharply and bond markets were extremely illiquid. The fact that the bond purchases in May 2010 and August 2011 had a positive impact on the basis supports the view that the buying pressure generated by the SMP had a stabilising effect on bond yields and was reflected in a temporary improvement of bond liquidity, e.g. reduction of the bid-ask spreads (see also Eser and Schwaab (2015)).[28]

As described by Corradin and Maddaloni (2015) the SMP portfolio has a long term horizon and bonds are not repoed-out. Therefore, the ECB intervention has significantly affected "short-selling frictions". For a more detailed analysis we focus on August 2011 when the ECB purchased Italian government bonds. Fig. 6, Chart A, shows that the basis and "*Active Utilisation*" have increased sharply and instantaneously and have persisted for around three months after the intervention.

Moreover, Fig. 6, Chart B shows that the "specialness" of the 10 years Italian benchmark bond (see Corradin and Maddaloni (2015)) and the *Indicative Fee* of the borrowing cost of the bond to short-sell (this is expressed in steps from 1 to 5) have increased sharply. Fig. 6 shows also that link between the basis and "short-selling frictions", which has been already discussed extensively in Section 5.3, is quite strong even in periods in which there are no ECB purchases.

5.5. The role of "funding frictions"

The basis of countries with weaker public finances was negative in several situations as already documented in the Section 4. Our hypothesis (H. 5) is that this was due to the appearance of "funding frictions" which made it difficult or costly for arbitrageurs to finance the purchase of the bond (via repo transaction) for implementing "negative basis" trades. As the time-series of the "haircut" on the 10Y benchmark bond is available to us only for Italy and Spain (also for France, but it is not a "periphery" country), we cannot formally test our hypothesis, so we proceed by discussing anecdotal evidence. Chart A and B of Fig. 7 show that, in the cases of Italy and Spain, the basis went negative in reaction to sharp increases of the "haircut".

More specifically, for Italy the basis became negative when the first haircut increase took place, from 3–4% to 6–7%, around mid-July 2011. It was again negative in the first two months of year 2012 right after the haircut was increased from 7% to 11–12% in November 2011. Finally, it became persistently negative from mid-July 2012 on after the haircut was increased from 8% to 11–12%. Throughout this period of stress the basis was not only negative, it also fluctuated quite substantially.[29] The increase of

[26] Government bond yield spreads are affected by a multitude of factors beyond the ECB's interventions: by market perceptions about the sustainability of public debt, by investors' risk aversion as well as by other European measures such as the actions and prospects of the European Financial Stability Facility (EFSF). We focus on the impact of the SMP on the basis; the overall impact of the SMP on bond yields has been studied e.g. by Eser and Schwaab (2015) who find an impact of approximately −3 basis points at the five-year maturity for purchases of 1/1000 of the outstanding debt.

[27] For brevity we report regression results only for the basis. For the "adjusted" basis results are qualitatively similar.

[28] Eser and Schwaab (2015) show that bond yield volatility and tail risk are lower on intervention days for most SMP countries.

[29] The positive spikes in August 2011 and in the period from March to July 2012 were shown to be due to the appearance of "short-selling frictions" as extensively discussed in Section 5.2.

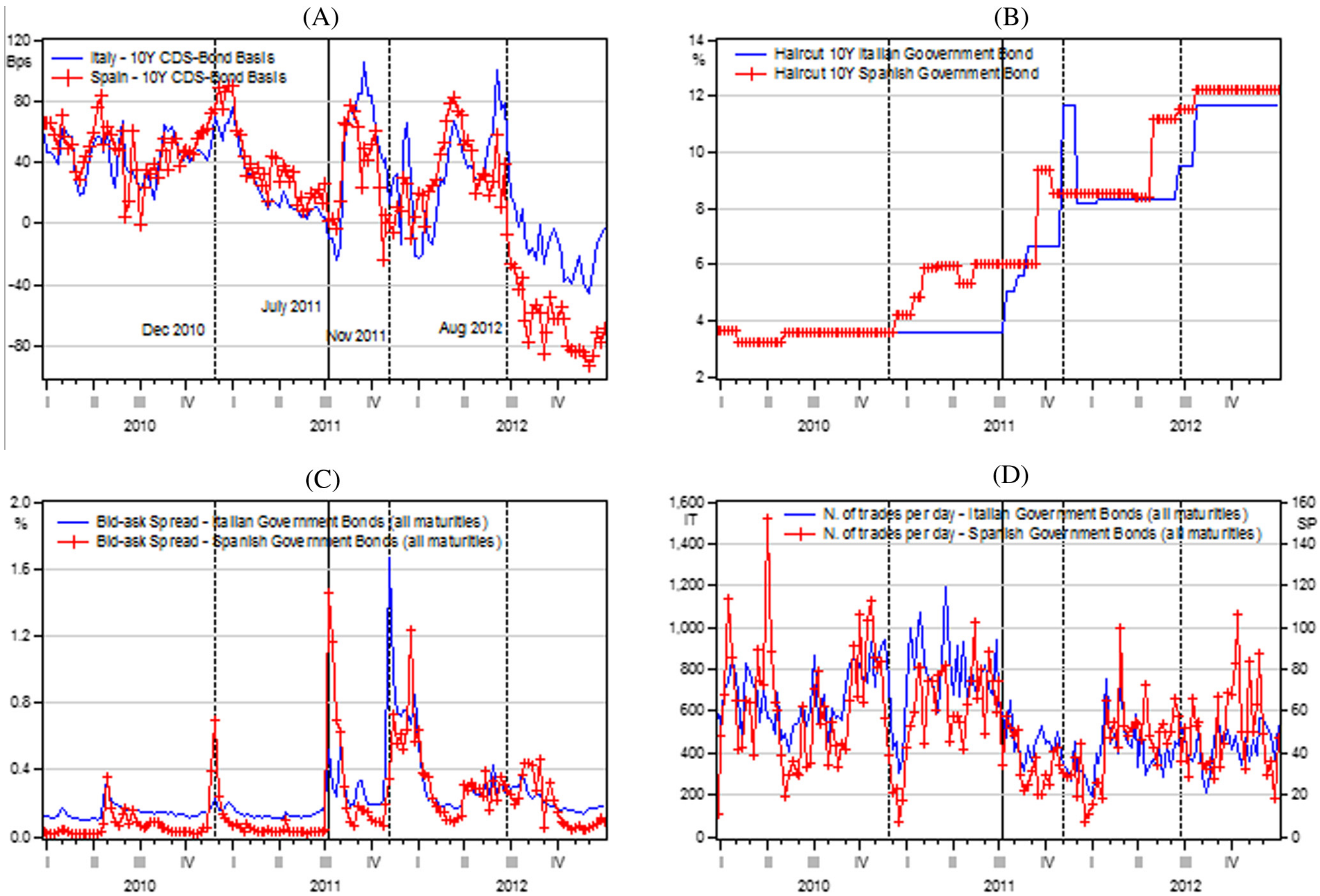

Fig. 7. Basis, "Haircuts" and Liquidity of the Italian and Spanish Government bonds. Chart A. shows the time-series dynamics of the 10Y CDS-Bond Basis. Chart B. shows the time-series dynamics of the Haircuts (expressed in % of the par notional) for the Italian and Spanish Government bonds with a maturity from 7 to 10 years. Chart C. shows the time-series dynamics of the average bid-ask spread (across all maturities). Chart D. shows the number of daily trades on government bonds (across all maturities). On the right-hand side axis the figure shows the figure for Italy, while on the left-hand side axis for Spain. Data are weekly observations.

the haircut for the Spanish benchmark bond anticipated that of the Italian one both in November 2011 and in August 2012. Consistently, the basis shifted into negative territory. As shown in Chart 8 C and D the increase of the "haircut" in July and November 2011 was associated with a dramatic deterioration of bond liquidity (as captured by a sharp increase of the bid-ask spread and by a reduction of trading activity).[30] For example, before July 2011 in the Italian (Spanish) bond market on average 627 (around 60) daily transactions were taking place, while afterwards only 436 (around 40).

Haircuts and credit risk are related, in the sense that the haircut on repos has increased as a result of credit quality deterioration. The interesting issue is why the deterioration of credit quality has had different effects on the cash and the derivatives market (i.e. the basis deviates from zero). What is noteworthy is that credit quality deterioration has coincided with a dry-up of the liquidity of the government bond, as captured by an increase of bid-asks and a reduction of transactions. This is suggestive of the fact that the illiquidity of the government bond is the driver of the negative basis (i.e. bond spreads larger than the CDS). Our interpretation is that the increase in the haircut has triggered large bond sales (deleveraging) and, most importantly, at the same time made it more costly for arbitrageurs to finance the purchase of the bond (via repo transaction) for implementing "negative basis" trades. The role of "funding frictions" in explaining negative basis deviations on corporate entities have been extensively studied both theoretically and empirically in the context of the US Subprime and Lehman crisis. As discussed by Duffie (2010) "slow-moving capital" has contributed to asset price distortions. Garleanu and Pedersen (2011) argue that funding problems have had significant asset pricing effects: "securities with nearly identical cash flows, but different margins, traded at a different price, giving rise to price gaps (basis)". Mitchell and Pulvino (2012) see capital shortages at major dealers during the financial crisis as the most plausible explanation of the negative CDS-Bond basis. Bai and Collin-Dufresne (2011) point to drivers related to funding risk, counterparty risk and "collateral quality". Fontana (2012) highlights the role of liquidity risk and "convergence-trading-activity" in driving the basis negative during the crisis.

[30] An increase of the haircut was also associated with massive bond sell-offs as captured by a reduction in institutional ownership (available quantity) from August 2011 on. This chart is not reported for brevity.

6. Conclusion

In principle, CDSs and bonds offer investors a similar exposure to the risk and return of debt issued by governments; hence, their pricing should be determined by the same set of risk factors. Instead, in the euro area sovereign crisis, we observe a complex relationship between the derivatives market and the underlying cash market, which is characterised by sizable deviations from the no-arbitrage relationship.

First, we find that both CDSs and bond spreads correlate positively with measures of the "risk premium", but CDSs exhibit a stronger correlation with country specific drivers of credit risk.

There is evidence that during times of market stress the number of market participants who acted as arbitrage traders declined sharply due to decreasing risk appetite and the exit of several major institutions (see Duffie (2010)). Second, our analysis shows that the pricing in the CDS and the government bond market has drifted apart because of "flight to quality/liquidity" effects in the latter, but also because of increasing hurdles for those traders who were trying to exploit what seemed to be sizable arbitrage opportunities. The increase of sovereign credit risk exacerbated "short-selling frictions" in the government bond market and favoured positive basis deviations and their persistence. Third, the crisis has adversely affected both "market" and "funding liquidity", with the consequence that bonds issued by credit risky (i.e. "peripheral") governments where characterized by negative bases.

Overall, our study highlights the different nature of the pricing in these two closely linked markets and in particular the role of frictions impairing arbitrage activities.

References

Ammer, J., Cai, F., 2011. Sovereign CDS and bond pricing dynamics in emerging markets: does the cheapest-to-deliver option matter? Journal of International Financial Markets 21, 369–387.

Arora, N., Gandhi, P., Longstaff, F.A., 2012. Counterparty credit risk and the credit default swap market. Journal of Financial Economics, 280–293.

Bai, J., Collin-Dufresne, P., 2011. The determinants of the CDS-bond basis during the financial crisis of 2007–2009, Working paper.

Blanco, R., Brennan, S., Marsh, I.W., 2005. An empirical analysis of the dynamic relationship between investment-grade bonds and credit default swaps. Journal of Finance 60, 2255–2281.

Campbell, J., Taksler, G., 2003. Equity volatility and corporate bond yields. Journal of Finance 58, 2321–2349.

Collin-Dufresne, P., Goldstein, R., Martin, J.S., 2001. The determinants of credit spread changes. Journal of Finance 56, 2177–2207.

Corradin, S., Maddaloni, A., 2015. The importance of being special: repo markets during the crisis, ECB Working Paper.

Duffie, D., 1999. Credit swap valuation. Financial Analysts' Journal 83, 635–665.

Duffie, D., 2010. Presidential address: asset price dynamics with slow-moving capital. Journal of Finance 65, 1237–1267.

Engle, R.F., Granger, C.W.J., 1987. Cointegration and error correction representation, estimating and testing. Econometrica 55, 251–276.

Ericsson, J., Jacobs, K., Oviedo-Helfenberger, R., 2009. The determinants of Credit Default Swap Premia. Journal of Financial & Quantitative Analysis 44, 109–132.

Eser, F., Schwaab, B., in press. Evaluating the impact of unconventional monetary policy measures: empirical evidence from the ECB's Securities Markets. Journal of Financial Economics, Available online 12 June 2015.

Fontana, A., 2012. The negative CDS-bond basis and convergence trading during the 2007/08 financial crisis, Working paper.

Gapen, M., Gray, D.F., Lim C. H., Xiao, Y., 2008. Measuring and analyzing Sovereign risk with contingent claims, IMF Working Paper.

Garleanu, N., Pedersen, L., 2011. Margin-based asset pricing and the law of one price. Review of Financial Studies 24, 1980–2022.

Groba, J., Lafuente, J.A., Serrano, P., 2013. The impact of distressed economies on the EU sovereign market. Journal of Banking & Finance 37, 2520–2532.

Longstaff, F.A., Schwatrz, E.S., 1995. A simple approach to valuing risky fixed and floating rate debt. Journal of Finance 50 (3), 789–819.

Longstaff, F.A., Pan, J., Pedersen, L., Singleton, K., 2011. How sovereign is sovereign risk? American Economic Journal: Macroeconomics 3 (2), 75–103.

Merton, R.C., 1974. On the pricing of corporate debt: The risk structure of interest rates. Journal of Finance 29 (2), 449–470.

Mitchell, M., Pulvino, T., 2012. Arbitrage crashes and the speed of capital. Journal of Financial Economics 104, 469–490.

Monfort, A., Renne, J.P., 2014. Decomposing euro-area sovereign spreads: credit and liquidity risks. Review of Finance 18, 2103–2151.

Pan, J., Singleton, K., 2008. Default and recovery implicit in the term structure of Sovereign CDS spreads. Journal of Finance 63, 2345–2384.

Raunig, B., Scheicher, M., 2009. Are Banks Different? Evidence from the CDS Market, OeNB Working paper 152.