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Cross Sectional Default Probabilities in European Corporate Bonds

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Abstract

This study attempts to identify basis-trading opportunities in the European banking sector by comparing two different measures for the market's assessment of risk: market-observed CDS spreads and model-implied Z-spreads. Using a sample of 10 banks, over a period of 3 years following the European banking crisis, it can be concluded that there were arbitrage opportunities in the sector, as evidenced by the derived negative bases.

I. Introduction

In recent years, the global economy has been plagued with prolonged financial turmoil. Western economies have experienced one of the most severe crises in the last decades, and are just now starting to show signs of recovery.

Europe has faced a particularly dark period, experiencing the negative effects of the global crisis on top of a sovereign debt crisis and a banking crisis. The 2008 financial crisis spread out to Europe almost immediately, via exposures of European banks to contaminated US securities, resulting in credit losses and shrinking balance sheets. However, the impacts of the crisis in European economies have been aggravated by the particular institutional framework of the Eurozone.

European sovereign debt and banking crises

With the adoption of the single currency, member countries benefitted from low interest rates, leading to a credit boom (and subsequent consumption boom), especially in periphery countries where lending conditions had never been as lax. Banks could now access international funds more easily, borrowing in their own currency – the euro – instead of foreign currency (Lane, 2012). This low interest rate environment also spurred domestic spending, that, allied to easy credit, resulted in a consumption and property boom (Fagan and Gaspar, 2007). In just under 10 years, private indebtedness levels in countries like Portugal, Ireland, Spain, Italy and Greece increased exponentially, ranging from 70% to over 160% increases between 1998 and 2007.

In addition, increasing current account deficits and historical macroeconomic imbalances further exposed the disparities among Eurozone countries, resulting in asymmetric effects once the global financial crisis began (Lane and Milesi-Ferretti, 2011). The sovereign debt crisis gained its momentum once Greece announced alarming levels of fiscal discrepancies in 2009, causing yields on sovereign bonds for several Euro area countries to move further and further away from the benchmark German yield. The financial burden on governments became increasingly higher, which, in combination with high levels of public deficits, eventually culminated in a bailout program for Greece (2010), Ireland (2010), Portugal (2011) and Cyprus (2012).

Typically, banking crises occur in simultaneous with sovereign debt crises (Laeven and Valencia, 2012). The European banking crisis originated, once again, in the peripheral countries, where credit levels had increased considerably – according to Gourinchas and Obstfeld (2012), preceding credit booms are key predictors of a forthcoming banking crisis. The impacts of all these shocks in the Euro area were reflected in a sharp decrease in banks' balance sheets and, consequently, in a reduction of the banking systems, as many financial institutions went into bankruptcy. During this period, the European Banking Authority, the sector regulator for the monetary union, recommended banks to either strengthen capital or lower exposures by reducing their balance sheets. As the latter choice proved more popular, banks that received State aid experienced greater declines in total assets than those that did not, due to the strict restructuring conditions imposed by the European Commission (Schoenmaker and Peek, 2012).

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It is in the context of the crises and their long-lasting impacts on European economies that this study focuses on the Eurozone banking sector and the dynamics of the underlying measures of credit risk during this period. Following the framework studied by Vrgut (2010), on a first stage, market-implied default probabilities and recovery values of selected bonds will be estimated. Then, a comparison between the bond market and credit default swap (CDS) market will be made, in order to ascertain the existence of arbitrage opportunities during the considered periods.

Credit default swaps and basis trading

Vrgut's method (explained in more detail in the Section II) allows for the simultaneous estimation of risk-neutral default probabilities and implied recovery values from bond prices. It assumes a flexible parameterization of default probabilities, making it possible to observe fluctuations in the slope of the corresponding "term structure", i.e., the market's adjustment for risk during the sample periods.

Using these market-implied estimations for risk will facilitate the comparison with the CDS market, since the credit spread is already a simple measure of the market's perception of the creditworthiness for a particular issuer (Coleman, 2009).

Another proxy for measuring credit risk for a given issuer is the bond spread, that is, the yield difference between securities with different credit profiles. In this study, the bond spread was calculated as the Z-spread, following the framework proposed by Li, Zhang and Kim (2011), defined as the risk premium required for corporate bonds, when compared to a risk-free instrument. It represents a parallel shift of the credit curve such that the present

value of future cash flows, discounted at a flat spread plus the corresponding spot rate, matches the current bond price. This measure has the advantage of capturing the complete term structure of the selected risk-free curve used for discounting each cash flow at its own rate (De Wit, 2006).

It is argued that these two spreads should be co-integrated, as they constitute two alternative investment strategies in credit risk of the same entity, and, therefore, the expected payoff scheme should be the same for both (Hull, Predescu and White, 2004). In other words, in equilibrium, the basis – difference between CDS spread and the bond spread at the same maturity – should be equal to zero. Hence, deviations from this parity may originate arbitrage opportunities, with investors exploiting the anomaly in the expectation of a narrowing of the basis as the bond approaches maturity.

Since interest rates and bond prices are inversely related, the larger the spread, the lower the price of the associated instrument. Therefore, when there is a positive (negative) basis, the CDS (bond) is cheaper than the bond (CDS). In order to capitalize on the non-zero basis, investors should buy the cheap asset and sell the expensive one, so, for example, in the case of a positive basis, one should go simultaneously short on a CDS (buy protection) and on the bond. Traditionally, negative basis opportunities are easier to explore, since shorting corporate bonds may prove to be more challenging than adopting a long position.

Nevertheless, there are limits and risks to arbitrage, and basis trading is no exception. The reasons for the existence of a non-zero basis have been widely discussed and thoroughly studied over the years. Blanco, Brennan and Marsh (2005) argue that contractual differences between CDS agreements and cash bonds give way to non-zero basis; hence, non-zero basis

may simply be a reflection of market imperfections and not an indicator of an arbitrage opportunity. Price discovery has also been used as a justification for non-zero basis: the CDS market usually leads the bond market, as the first reflects private information of informed banks that the latter fails to incorporate (Alexopoulou, Andersson and Georgesu, 2009). De Wit (2006) summarises the main explanatory factors for the existence of a non-zero basis in the market, dividing them into technical (related to the nature of the bond and CDS markets) and fundamental factors (related to the nature of a CDS agreement). Among the multitude of factors, the author identifies four main determinants of the basis: liquidity differences between the two markets, difficulty of taking short positions on cash bonds, the *cheapest-to-deliver* option on CDS agreements, and the increasing issuance of synthetic CDO (collateralised debt obligations) by reference entities.

Li, Zhang and Kim (2011) conclude that the persistence of negative risk premiums during the crisis (including basis risk) are justified by the market's inability to self-adjust in times of extreme turmoil. As such, financially-constrained investors are willing to receive considerable price discounts to exit the credit market, despite knowing that holding their investments would eventually earn them positive returns in the long-term. In addition, the authors find that, historically, the basis is usually negative, especially in older bonds with lower rating, longer maturity and higher duration, convexity and coupons. A different study by Bai and Collin-Dufresne (2013) also concludes that during the crisis, the existence of a cross-sectional negative basis in the market can be explained by liquidity, counterparty and funding risks, as well as quality of collateral. In addition, they observe a persistence of the negative basis in post-crisis periods, mainly due to the same factors.

Arbitraging these inefficiencies does entail, however, new levels of risk, such as counterparty, liquidity and deleveraging risks (Li, Zhang and Kim, 2011). Hence, arbitrage opportunities in basis trading are always accompanied with additional risks, not constituting "pure arbitrage opportunities" in the true sense of the term. Moreover, due to the complexity of factors affecting the basis, the selected "basis measure" may fail to incorporate all determining factors, thus eroding potential/apparent arbitrage gains (De Wit, 2006).

The paper is organized as follows: Section II describes the estimation methods employed on the chosen data set (Vrgut model and basis calculation), Section III presents the results and major findings, and Section IV concludes.

II. Model

The Vrgut Model

As previously mentioned, the first step will be the application of Vrgut's model in selected corporate bonds of the European banking sector. The model's structure allows for a simultaneous estimation of risk-neutral default probabilities and recovery values from observed bond prices. Its flexible parameterization facilitates a more in-depth analysis of the market's expectations and assessment of risk.

This reduced-form model is set in discrete time and follows the risk-neutral valuation framework of Jarrow, Lando and Turnbull (1997), employing a binomial lattice structure, where two possible scenarios are considered: "survival" and "default" (or "no survival"). The default event would be triggered by a restructuring process of the outstanding bonds, as

opposed to the traditional Merton (1974) default view used in structural models, where default is assumed to occur once the value of a firm's assets falls below its liabilities.

The "survival" scenario assumes that the bondholder receives the promised cash flows, where the price of the bond is assumed to be the probability-weighted average of the aforementioned cash flows (coupon and principal at maturity):

$$Survival_n = \sum_{n=1}^{N} df_n \left(CF_n \times S_n \right) \qquad (1)$$

where df corresponds to the risk-free discount factor, CF corresponds to promised cash flows, n corresponds to the cash flow date and S corresponds to the cumulative probability of survival.

In turn, the "no survival" or "default" scenario assumes that the bondholder simply receives the recovery value:

$$Default_n = \sum_{n=1}^{N} df_n \left(RV \times S_{n-1} \times \pi_n \right) \qquad (2)$$

where RV corresponds to the bond's recovery value and π to the probability of default.

The cumulative probability of survival, S, is calculated also assuming "survival" or "default" scenarios:

$$S_n = \prod_{i=1}^{n} (1 - \pi_i) \qquad (3)$$

If the obligor survives until $n-1$ and continues to survive at cash flow date n, then $\pi_n = 0$, which implies $S_n = 1$. However, if the obligor defaults at cash flow date n, having survived until $n-1$, then $\pi_n = 1$, making $S_n = 0$.

In turn, this default probability, π, is estimated using a flexible default rate structure:

$$\pi_i = \alpha + \beta\,(1 - e^{-t_i})/t_i \tag{4}$$

where t is the number of years until the next payment at time i and the unknown parameters α and β are to be estimated. This structure captures the slope of the term structure of default rates, having enough flexibility to accommodate changes in slope that may occur during times of stress in the market. The instantaneous rate of default is $\alpha + \beta$ and α is the infinity-maturity default probability.

Combining both scenarios, it is possible to reach the price of a given bond, since the price of a financial instrument corresponds to the present value of expected future cash flows:

$$P_0 = \sum_{n=1}^{N} df_n[(CF_n \times S_n) + (RV \times S_{n-1} \times \pi_n)] \tag{5}$$

In this case, the main idea is to discount the probability-weighted cash flows at risk-free rates. In order to do so, the riskless instrument was assumed to be the constant maturity German zero-coupon bonds, where the discount factor was obtained using the yields from maturities of 3m, 6m, 1 to 10 years, 15 years, 20 years and 30 years. Maturities were fitted to the exact cash flow horizon using Svensson's method (1994):

$$y_t(n) = \beta_{0t} + \beta_{1t}\left[\frac{1-e^{\left(-\frac{n}{\tau_1}\right)}}{\frac{n}{\tau_1}}\right] + \beta_{2t}\left[\frac{1-e^{\left(-\frac{n}{\tau_1}\right)}}{\frac{n}{\tau_1}} - e^{\left(-\frac{n}{\tau_1}\right)}\right] + \beta_{3t}\left[\frac{1-e^{\left(-\frac{n}{\tau_2}\right)}}{\frac{n}{\tau_2}} - e^{\left(-\frac{n}{\tau_2}\right)}\right] \tag{6}$$

where $y_t(n)$ corresponds to the zero-coupon yield at time t with maturity n and the unknown parameters $\beta_0, \beta_1, \beta_2, \beta_3, \tau_1, \tau_2$ are to be estimated by minimizing the sum of squared residuals between observed and fitted yields at time t.

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Thus, the final bond "pricing" formula is obtained:

$$P_0 = \sum_{n=1}^{N} df_n \left[\left(CF_n \times \prod_{i=1}^{n} (1 - (\alpha + \beta(1 - e^{-t_i})/t_i) \right) \right.$$

$$\left. + \left(RV \times \prod_{i=1}^{n-1} (1 - (\alpha + \beta(1 - e^{-t_i})/t_i) \times (\alpha + \beta(1 - e^{-t_i})/t_i)) \right) \right] \qquad (7)$$

The unknown parameters for default probability (α, β) and recovery value (RV) will be estimated by minimizing the sum of squared pricing errors between actual prices and estimated prices of each bond j, for each day in the sample period:

$$\min_{\alpha, \beta, RV} \sum_{j=1}^{J} (P_j - \widehat{P_j})^2 \qquad (7)$$

It should be noted that, by using a risk-free discount factor, there is an inherent assumption concerning the risk profile of investors, since the obtained default probabilities will necessarily be risk-neutral. In other words, investors do not attribute more/less weight to the probability of default for a given entity since it is assumed that they are risk-neutral market participants.

Basis calculation

The second step in this study uses the estimated model parameters to calculate a bond spread, which will, in turn, allow for the CDS-bond basis to be obtained. As aforementioned, the basis consists of the difference between the CDS spread and bond spread at the same maturity for the same entity.

These two metrics represent two different methods of observing the market-implied credit risk profile of a certain entity. Considering that both constitute proxies for credit risk, and under the assumption of no-arbitrage pricing, the resulting basis should be close to zero.

A CDS agreement is a financial contract between two parties designed to provide insurance against certain credit events, such as bankruptcy, that could lead to the deterioration of credit quality of a certain issuer. The protection buyer (short position) commits to making regular payments (premium or CDS spread) to the protection seller (long position) in exchange for a payout in case a predetermined credit event occurs. Upon default, the contract can be terminated either with a *physical settlement* (the protection buyer receives the par value in exchange for delivering the "defaulted" bond to the protection seller), or with a *cash settlement* (the protection buyer receives the difference between the bond's recovery value and par value). Essentially, the protection buyer is "selling credit risk" in order to reduce his/her exposure, whereas the protection seller is seeking to increase his/her credit risk exposure, thus effectively "buying credit risk".

There are different methods to retrieve bond spreads, varying according to the chosen risk-free benchmark curve and the accuracy of "maturity matching" with the bonds' cash flow dates. This study adopts a Z-spread, or a zero-volatility spread, which consists of the spread added to the selected risk-free benchmark curve – the German yield-curve – in order for the sum of discounted bond cash flows to equal its market price. For every bond *j* in the selected sample, the following equation was applied to the observed daily market price *P*:

$$P_j = \sum_{n=1}^{N} \frac{CF_n}{(1 + y_n + Zspread)^n} \tag{9}$$

Following the lines of Li, Zhang and Kim (2011), the CDS-bond basis will be calculated as the difference between the observed CDS spreads and the estimated Z-spreads at the same maturity, using a simple interpolation process to match CDS maturities to the corresponding bond instrument.

$$Basis_j = CDS\ spread_j - Zspread_j \qquad (10)$$

Despite being argued that the CDS-bond basis should be zero, deviations from this parity have been widely studied and documented. These deviations can either be positive, when CDS spread is larger than the derived bond spread, or negative, when CDS spread falls below the bond spread, and are dependent both on time and on the specifications of the reference entity.

The amplitude and direction of the basis will then be determined by the factors causing the behaviour of CDS to greatly diverge from the observed behaviour of the bond market, and, consequently, from the estimated bond spread.

Data

The final pricing formula (7) was applied to the selected sample of bonds, from which a risk-neutral term structure of default rates and recovery values were obtained.

The dataset is composed of corporate bonds from the Eurozone banking sector, for selected periods over the course of 3 years, from 2012 to 2014. The financial institutions were chosen based on the occurrence of a "default" event, that is, situations involving restructuring programs, government-sponsored bank bailouts and/or recapitalisations. Given the nature of these institutions and their role in the respective national economies, it is more

likely to observe government interventions in this sector during stressful times than in other sectors of the economy. In other words, governments are more prone to provide help in order to avoid the collapse of a given financial institution and its repercussions for the rest of the economy.

Daily prices for the bond curves of each issuer were extracted, including non-trading days in order for periods to be comparable. The sample focused on fixed-coupon bonds with maturities under 10 years, thus excluding floating rate and zero-coupon bonds, inflation-linked bonds, callable bonds and other maturity type bonds.

Additionally, CDS spreads with maturities between 6 months and 10 years for the same selected issuers were obtained, in order to ascertain the existence of arbitrage opportunities.

In total, 10 banks from 5 Eurozone member countries were selected, for which, on a first stage, the unknown parameters α, β and RV in equation (7) were estimated for each day of the corresponding 2-month period – the month leading up to the "default" event and the actual month in which the event occurred; and on a second stage, bond spreads (Z-spread) were calculated and bases were obtained.

III. Results

In order to facilitate the analysis, results will be focused on one bank, as the remaining banks in the sample exhibit similar behaviours and allow for similar conclusions to be drawn up.

In Portugal, one of the most recent controversial subjects in the financial sector has been the case of Banco Espírito Santo (BES), one of the oldest and largest private banking institutions in the country.

In the summer of 2014, after months of uncertainty, the bank reported losses of €3,600M, catching the market by surprise by largely surpassing the anticipated amounts. Investors had been gradually losing confidence in the bank amidst rumours and suspicions of financial turmoil within the institution. The situation culminated with this announcement, as the reaction proved to be so negative that trading had to be suspended on August 1st.

Given the size and the role that BES had in the Portuguese economy, the country's central bank (Banco de Portugal) had to intervene, not only to minimise the inevitable negative impacts, but also to prevent contagion to the rest of the financial sector. As such, a prompt action was taken, and on August 3rd, Banco de Portugal announced a recapitalisation plan for BES: there would be a capital injection of €4,900M and the bank would undergo an organisational restructuring. The bank would be split into two separate entities: the "bad" bank, BES, that would keep the name and the toxic assets; and the "good" bank, a newly created institution (currently designated Novo Banco), that would keep the healthy assets.

Novo Banco would be fully capitalised by the Portuguese Resolution Fund, a fund created in 2012 to aid distressed financial institutions, in the full amount of €4,900M. However, due to a lack of capital in the Fund (mainly due to its recent inception, the Fund had only €367M) the Portuguese State provided a €3,900M loan and a pool of financial

institutions[1] provided the remaining €700M. Ultimately, the final goal would be to shut down BES (the "bad" bank) and sell Novo Banco (the "good" bank), thus reimbursing the loans received for the creation of the new institution.

As such, for the purposes of this study, daily data for selected bonds and CDS instruments for BES during the months of July and August 2014 was considered. In total, 5 bonds with maturities ranging from 1 year to 5 years, and coupons between 4 and 7 (assuming a face value of 100) were obtained. Similarly, daily prices for CDS instruments of comparable maturities (between 1 year and 5 years) during the selected sample period were retrieved.

Following the two estimation stages described in Section II, the long-term default probability (α in equation (7)) throughout the sample period is, on average, 12.74%, while recovery value is 71.83 cents on the euro.

In the beginning of July, BES' long-term probability of default revolves around 6%, with no significant changes in any particular day. However, there is a noticeable jump on July 15th, when the probability of default more than doubles, from 7.0% to 16.0%, representing a 9 percentage point increase in just one day. This behaviour could be interpreted as a reaction to the increasing amount of rumours and uncertainty revolving around the bank, the change in the Management Team and the downgrades in the bank's credit rating that occurred around that date.

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[1] Several Portuguese and some foreign financial institutions operating in the country contributed to the capitalisation of Novo Banco, such as Caixa Geral de Depósitos, Banco Comercial Português, BPI, Santander Totta, Crédito Agrícola, Montepio, BIC and Banco Popular.

From that point onwards, the long-term default probability steadily increases, reaching its highest recorded value on July 31st, 18.3%, the trading day immediately after the losses were made public. As expected, investors' perception of risk for this financial institution increases considerably during this period, as there is increasingly more uncertainty over the bank's ability to comply with its obligations.

On August 4th, the day following the recapitalisation plan, there is a reversal of this behaviour, reflecting a decrease in the perceived default probability as investors get some guarantee regarding the bank's future. The immediate reaction to "good" news results in a 4 percentage point decrease, from 18.1% to 14.4%, which is considerably smaller to the reaction to the announcement of losses on July 15th (that resulted in a 9 percentage point increase). Nevertheless, the long-term probability of default decreases further, reaching 11.39% on the last day of the sample, August 29th. Similar to Vrgut's results, following the recapitalisation plan announcement, the default probability settles around a higher level (~12%) than the observed pre-announcement levels (~6%).

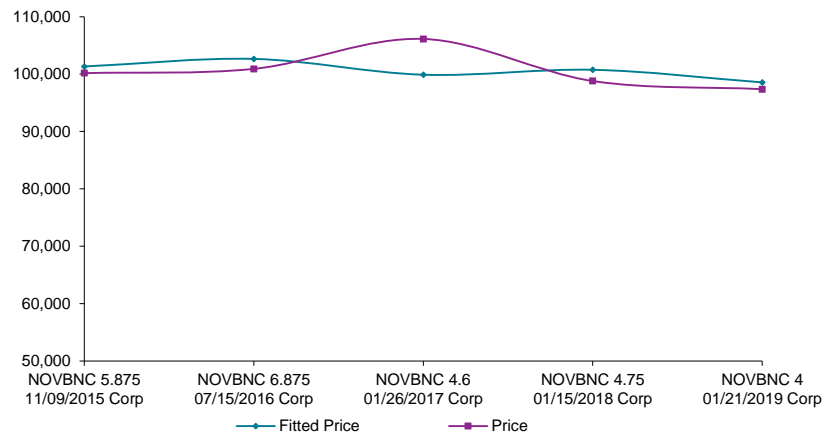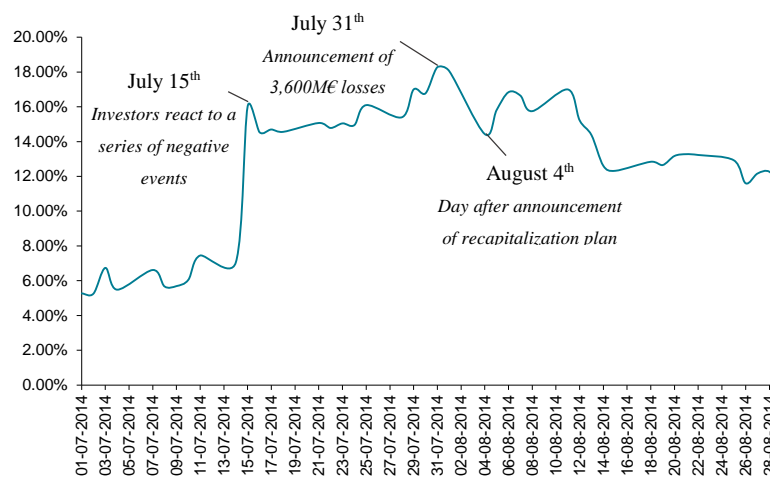**Figure 1: Model-implied price and actual price, August 4th (€)**

Figure 2: Estimated long-term default probabilities (%)

With Vrgut's model, it is also possible to observe the changes in the risk-neutral term

structure of default probabilities, i.e., the way in which default probabilities vary with the

time until the next promised cash flow. In general terms, a positive slope illustrates that the

default probability increases for bonds with a closer cash flow date, whereas a negative slope

shows that bonds with more time until the next promised cash flow date have a higher

probability of default than those with less time until the next payment. In line with Vrgut's

findings, the shape of the term structure of default probabilities for BES' bonds changes with

the announcement of the recapitalisation plan, going from a negative slope on August 1st (the trading day immediately before the announcement) to a positive slope on August 4th. The slope remained positive for the remainder of the sample period.

Figure 3: Estimated risk-neutral term structure of default probabilities (%)
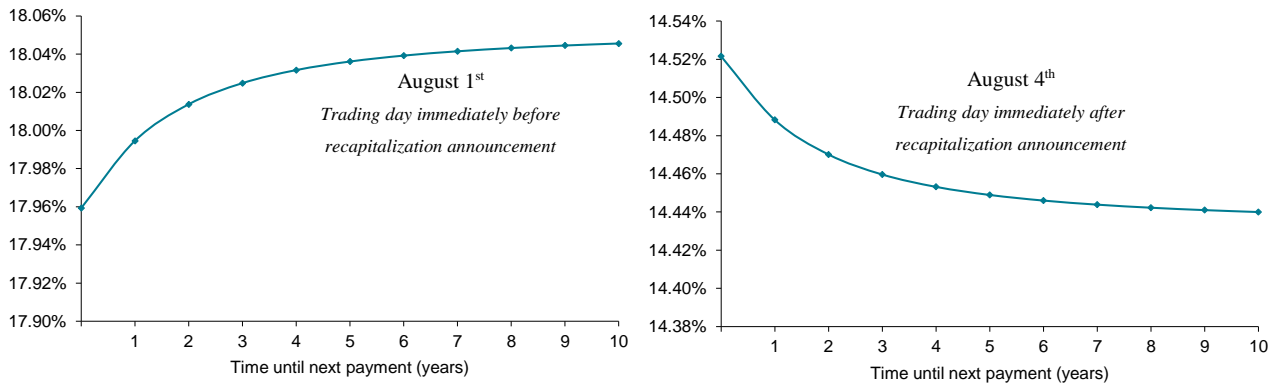
Throughout the selected period, the impacts of the abovementioned events did not affect implicit recovery values to the same extent as in default probabilities. After some fluctuations in the beginning of July, recovery value for BES stabilised around 70 cents on the euro.

In the CDS market, however, the reaction to these events is similar to the behaviour observed in implied default probabilities.

Figure 4: 1-year CDS spread (basis points)
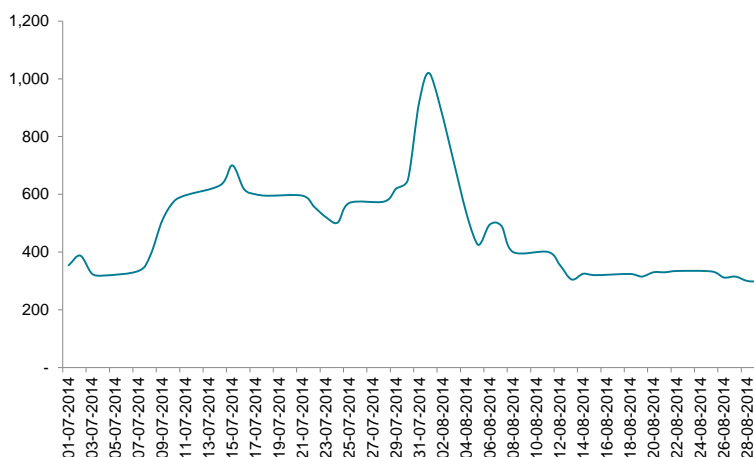
There is a noticeable increase in CDS spreads on July 31st, the day immediately after the losses were made public, thus reflecting investors' lack of confidence in the bank's creditworthiness. As with default probabilities, the maximum values for these spreads are recorded on August 1st. Moreover, there is an immediate reaction to the recapitalisation plan, as evidenced by the significant decrease (3.6 percentage points, on average) in spreads across all CDS maturities on August 4th. This decrease suggests that investors regained some trust on BES' ability to cover its obligations, thus the demanded compensation for a protection buyer/seller is smaller, as a result of a decrease of the perceived default probability. CDS spreads keep decreasing until the end of the sample period, reflecting the market's continued belief on the success of the recapitalisation/restructuring plan.

Comparing implied bond spreads with the prevailing CDS spreads on the market during the sample period allows for an assessment of market-implied perceptions of credit risk for the same entity by two different methods. Whereas CDS spreads directly represent investors' perception of a certain entity's credit risk, bond spreads represent the theoretical risk premium required for corporate bonds in comparison to a risk-free instrument. By using

model-implied bond prices, the calculated bond spreads should incorporate the estimated default probabilities and recovery values, and as such allow for comparisons between model-implied and market credit metrics to be performed.

As detailed in equation (10), the basis results from the difference between CDS and bond spreads for the same maturity. Throughout the considered period, the basis is predominately negative across all selected BES' bonds, meaning that CDS spreads were consistently above bond spreads. Therefore, investors were demanding a higher compensation on the CDS market than in the bond market, i.e., bonds were cheaper than entering into a CDS agreement at that time. Since both metrics echo the market's perception of risk for BES, a negative basis suggests that bond-implied default probabilities were below the ones perceived on the CDS market.

Based on the belief that the two spreads should be co-integrated, an arbitrage opportunity could be considered to exist in this scenario. Assuming that, in equilibrium, the basis should tend to zero, a negative basis could be exploited by simultaneously taking a long position both on the bond and on the CDS markets, that is, buy the cheap instrument (bond) and sell the expensive one (sell credit risk, i.e., buy protection).

The basis becomes less negative as maturities increase, i.e., the difference between bond and CDS spreads is smaller for bonds with longer maturities. The bond with shortest maturity in the selected sample (2015) has, on average, a -3.54% basis (-354 basis points), whereas the bond with longest maturity (2019) has an average basis of -0.81% (-81 basis points). The difference is smallest around the dates of the recapitalisation announcement, which could be

attributed to a similar adjustment for risk on both markets, i.e. perceived risk for BES was similar in both markets.
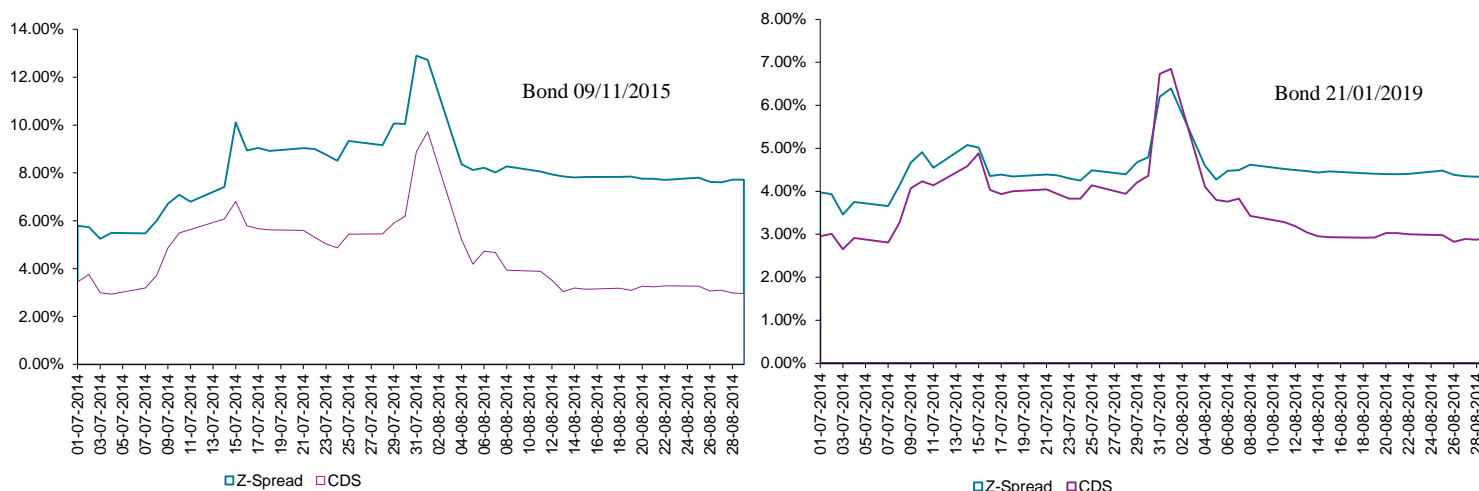
Figure 5: Basis – short vs long maturities (%)

Table 1: Summary of bases results for BES[2]

Bond	Basis		
	Average	Min.	Max.
NOVBNC 5.875 09/11/2015 Corp	-3.54%	-4.81%	-1.16%
NOVBNC 6.875 15/07/2016 Corp	-2.18%	-5.40%	0.86%
NOVBNC 4.600 26/01/2017 Corp	-1.41%	-2.41%	0.18%
NOVBNC 4.750 15/01/2018 Corp	-1.21%	-2.04%	0.12%
NOVBNC 4.000 21/01/2019 Corp	-0.81%	-1.56%	0.53%

It should be noted that the existence of pure arbitrage opportunities is not common, and investors should approach these apparent opportunities with a certain level of precaution. The credit market is exposed to an array of uncontrollable and unpredictable factors, in addition to considerable transaction costs (bid-ask spreads), which have been found to have a sizeable impact on the potential gains of an arbitrageur.

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[2] Bonds for BES have "NOVBNC" denomination, since at the time the data retrieved, these assets had already been transferred to Novo Banco.

Extending the analysis to the rest of the sample, it can be observed that the behaviour of market-implied default probabilities and recovery values varies across banks, time periods and countries.

In terms of basis trading, the majority of the financial institutions included in the study, for which there was CDS data available, exhibit negative bases throughout the 2-month sample period. As aforementioned, the amplitude and direction of the basis is dependent on various factors, for which the impacts are usually hard to quantify. Despite this limitation, the basis amplitude has a tendency to decrease in bonds with longer maturities, a common pattern across all banks included in the sample.

Figure 5: Summary of bases results

Bond	Basis				Bond	Basis		
	Average	Min.	Max.			Average	Min.	Max.
Millenium BCP					*SNS Reaal*			
BCPPL 3.750 08/10/2016 Corp	2.02%	-3.49%	5.70%		SNSSNS 3.500 20/10/2015 Corp	-0.55%	-2.43%	0.56%
BCPPL 4.750 22/06/2017 Corp	3.63%	-1.60%	5.82%		SNSSNS 4.250 26/09/2016 Corp	-0.35%	-2.10%	0.73%
BCPPL 13.000 13/10/2021 Corp	-0.71%	-5.15%	1.46%		SNSSNS 4.515 13/02/2017 Corp	-0.67%	-2.79%	1.17%
Caixa Geral de Depósitos					SNSSNS 5.360 18/09/2018 Corp	0.00%	-1.54%	1.05%
CXGD 3.384 15/12/2014 Corp	-3.85%	-8.14%	-2.34%		SNSSNS 5.000 15/03/2019 Corp	-0.61%	-1.95%	-0.08%
CXGD 4.500 19/01/2016 Corp	-1.78%	-5.07%	-0.51%		SNSSNS 3.500 28/08/2020 Corp	4.20%	3.70%	4.73%
CXGD 4.455 20/08/2017 Corp	-0.30%	-3.43%	0.96%		*Banco Espírito Santo*			
CXGD 4.400 08/10/2019 Corp	1.09%	-1.16%	2.33%		NOVBNC 5.875 09/11/2015 Corp	-3.54%	-4.81%	-1.16%
CXGD 5.320 05/08/2021 Corp	-0.95%	-2.68%	0.01%		NOVBNC 6.875 15/07/2016 Corp	-2.18%	-5.40%	0.86%
Bankia					NOVBNC 4.600 26/01/2017 Corp	-1.41%	-2.41%	0.18%
BKIASM 3.500 13/11/2014 Corp	4.31%	2.78%	6.06%		NOVBNC 4.750 15/01/2018 Corp	-1.21%	-2.04%	0.12%
BKIASM 3.500 14/12/2015 Corp	3.44%	-0.13%	5.45%		NOVBNC 4.000 21/01/2019 Corp	-0.81%	-1.56%	0.53%
BKIASM 5.750 29/06/2016 Corp	2.98%	1.72%	4.45%		*Banca Monte dei Paschi di Siena*			
BKIASM 4.375 14/02/2017 Corp	3.93%	2.23%	5.73%		MONTE 3.750 02/01/2016 Corp	-13.53%	-27.64%	-8.29%
BKIASM 4.250 25/05/2018 Corp	2.98%	1.80%	4.51%		MONTE 2.500 03/02/2017 Corp	-4.26%	-7.31%	-3.04%
BKIASM 5.000 28/06/2019 Corp	2.80%	1.52%	4.41%		MONTE 5.000 09/02/2018 Corp	-2.49%	-4.26%	-1.75%
BKIASM 4.500 26/04/2022 Corp	2.33%	1.19%	3.85%		MONTE 3.000 03/02/2019 Corp	-1.66%	-3.08%	-1.08%
Novagalicia Banco					MONTE 5.000 21/04/2020 Corp	0.01%	-0.78%	0.49%
NOVAGA 3.125 15/04/2015 Corp	-0.38%	-1.70%	0.54%		MONTE 4.100 03/03/2021 Corp	-0.19%	-1.18%	0.29%
NOVAGA 4.375 23/01/2019 Corp	1.05%	-0.21%	1.82%					
NOVAGA 4.900 31/07/2020 Corp	1.17%	0.09%	1.92%					

IV. Conclusion

This study attempts to identify basis-trading opportunities in the European banking sector over a period of 3 years, by comparing two different measures for the market's assessment of risk: market-observed CDS spreads and model-implied Z-spreads (following Vrgut's framework, 2010). Assuming non-arbitrage pricing, these two metrics should convey the same information for a given financial instrument, i.e., the CDS-bond basis should be zero.

Considering a sample of 10 banks, this analysis was performed on periods of a "default" event, such as restructuring programs, government-sponsored bank bailouts and/or recapitalisations. Overall, it can be concluded that, while implied default probabilities and recovery values greatly depend on the reference entity, geography and time, the majority of bases were, on average, negative. Additionally, across the selected sample, the basis is larger for bonds with smaller maturities. This suggests that there were arbitrage opportunities throughout the sample periods, potentially more profitable for smaller maturity bonds. As such, the arbitrageur should buy the bond, while simultaneously buying the CDS instrument (selling protection), capitalizing these opportunities as the basis approaches its long-term equilibrium.

There are, however, some limitations to these conclusions. First, given the lack of available information for the considered periods, both in the bond and CDS markets, the final sample size had to be reduced and the sample periods had to be broadened. The estimated metrics used to obtain the bond spreads assume a risk-neutral term structure of default probabilities, which, when comparing to the market-observed CDS spreads, may result in

artificially larger bases. In addition, given the simplicity of the calculations employed for the bond spread, the estimated basis may not be the most accurate proxy for assessing basis-trading opportunities.

Nonetheless, it is possible to overcome some of these limitations, which would, in turn, allow for a more realistic approach to bond-basis trading. One simple solution would be employing a more robust measure for the basis (effectively incorporating the main parameters/drivers) on a broader sample, thus ensuring a higher degree of confidence in the derived results.

V. Appendix

Table 2: Estimated parameters – Vrgut's model

Bank	Country	Sample period	Default probability			Recovery value		
			Average	Min.	Max.	Average	Min.	Max.
Millenium BCP	Portugal	May/Jun 2012	16.61%	10.13%	22.65%	55.45	6.44	84.15
Caixa Geral de Depósitos	Portugal	May/Jun 2012	31.94%	28.95%	37.94%	91.99	86.65	103.25
Bankia	Spain	Nov/Dez 2012	10.17%	6.47%	14.25%	47.28	33.74	60.51
Novagalicia Banco	Spain	Nov/Dez 2012	6.12%	5.01%	7.03%	19.52	5.95	27.74
Banco de Valencia	Spain	Nov/Dez 2012	5.25%	4.07%	7.75%	27.92	13.18	52.20
SNS Reaal	Netherlands	Jan/Feb 2013	4.80%	3.23%	6.53%	24.43	5.72	39.68
Hypo Group Alpe Adria	Austria	Jun/July 2014	19.00%	2.17%	29.33%	63.25	56.58	77.87
Banco Espírito Santo	Portugal	July/Aug 2014	12.74%	5.26%	18.28%	71.83	29.15	88.03
Oesterreichische Volksbanken AG	Austria	Sep/Oct 2014	3.09%	2.24%	4.14%	60.26	52.87	67.03
Banca Monte dei Paschi di Siena	Italy	Sep/Oct 2014	5.14%	4.45%	6.51%	6.00	0.10	18.28

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