Limits to arbitrage: Empirical evidence from euro area sovereign bond markets

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Abstract

We document that the yield-to-maturity of an USD-denominated bond, once the foreign exchange rate risk is hedged, could be higher by more than 150 basis points than a comparable EUR-denominated bond issued by the same Euro area country between $2008 - 2013$. Using panel and matching techniques, we find that the pricing anomaly (i) is due to the lower haircuts applied to EUR-denominated bonds for the European Central Bank (ECB) liquidity operations; (ii) is strongly positively related to the amount of EUR-denominated bonds pledged in exchange for liquidity when the credit spreads of the sovereign issuer reach extreme levels; (iii) is strongly positively related to the amount of EUR-denominated sovereign bonds pledged in exchange for liquidity with a 3-year horizon; and (iv) widens during the ECB purchases of EUR-denominated bonds.

JEL classification: G01, G12

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1 Introduction

The absence of arbitrage opportunities is a central tenet of asset pricing theory: assets that generate the same identical cash flows must command the same price. Nevertheless, there are instances in which the no-arbitrage condition breaks down for non-negligible periods of time. Recent theory stresses the role that frictions such as funding constraints and segmentation may play in propagating the mis-pricing in financial markets. Brunnermeier and Pedersen (2009) and Garleanu and Pedersen (2011) highlight the role of funding constraints, the limited ability of financial institutions to borrow against their securities. At times of crisis, central banks can affect the funding liquidity varying the haircuts (or margin requirements) on specific securities, expanding the liquidity and extending the maturity of secured loans offered. As a result, the prices of securities with lower haircuts might benefit from these interventions. In addition, the recently revised preferred habitat theory emphasizes that open-market purchases by central banks targeting a specific security class can be expected to affect the price of such securities at times where segmentation and capital constraints are high (see Vayanos and Vila (2009), Gromb and Vayanos (2012) and Greenwood and Vayanos (2010)).

This paper provides support for these recent friction-based theories, studying the euro area sovereign market between $2008 - 2013$. We document a large yield spread, a basis, developed between USD- and EUR-denominated comparable bonds issued by the same euro area country. The basis as the difference between the yield to maturity of an USD-denominated bond, after hedging the foreign exchange rate risk, and the yield to maturity of a comparable EUR-denominated bond became largely positive. During the euro area sovereign debt crisis, the weekly average basis across pairs of bonds for Austria reached 93 basis points, while the basis for Belgium, Italy and Spain reached 199, 152 and 402 basis points respectively.

The main contribution of our paper is to establish a firm empirical link between monetary policy interventions and the basis. We document that a key driver of the basis is a monetary funding premium that is embedded in the EUR-denominated bonds. The latter ones could be used as collateral for liquidity operations with the ECB at lower haircuts than USD-denominated bonds. Moreover, because EUR-denominated sovereign bonds were targeted in its unprecedented open-market purchases through the Security Market Programme (SMP) by the ECB, the EUR-denominated bond yields were mostly affected around these purchases.

We conduct panel regression analysis considering specific bond factors, such as market liquidity, lending activity, differential governing law, and policy uncertainty factors in the euro area. Although these factors affect the basis, they are not able to provide a fully satisfactory explanation of the existence of these pricing anomalies. In particular, these factors play a limited role during the euro area sovereign debt crisis period, when the size

of the basis on average widens and significant differences emerged across countries.

Thus, we focus our attention on the ECB liquidity facilities and collateral policy, using ECB proprietary data and complementing our panel analysis with event study analysis around the introduction of the ECB policy interventions. We expect the liquidity facilities and collateral policy to play a key role in explaining the basis due to the introduction of the fixed-rate full allotment in all liquidity operations for the different maturities in October 2008. The ECB liquidity operations mirror private repos: the ECB provides funds to the counter-parties against eligible collateral where the amount of funding can be as high as the market price of the collateral multiplied by one minus the haircut. The fixed-rate full allotment allows banks to access unlimited ECB liquidity at a fixed rate in return of collateral. As a result, the ECB's balance sheet expands and contracts flexibly depending on the funding needs of the banks.

Our results indicate that the monetary premium is time varying and substantial when the ECB modified its collateral policy and offered loans at longer maturities than otherwise available in the repo market and when the sovereign issuer experienced periods of market stress. We find that the pricing anomaly is due to the lower haircuts applied to EUR-denominated bonds respect to foreign-denominated bonds. On 23 October 2008 the ECB announced that USD-denominated bonds were admitted as collateral, subject to an additional haircut for the exchange rate risk.[1] Interestingly, only some of the USD-denominated bonds in our sample were eligible because they fulfilled all the eligibility criteria and such criteria were not accounted for by market participants.[2] The change in the eligibility criteria reduced the basis by over 20 basis points for bond pairs that include eligible USD-denominated bonds, while we don't find any effect for the pairs that include non-eligible USD-denominated bonds. The impact on the basis is substantial when compared with Ashcraft, Garleanu and Pedersen (2010) who document a temporary decrease of 5 basis points in the yield spread for the eligible Term Asset-Backed Securities Loan Facility (TALF) securities.

Second, the size of the basis for a country is strongly positively related to the amount of sovereign bonds pledged to the ECB, when the credit default swap (CDS) of the same country reaches extreme levels. Our results indicate that the ECB liquidity facility access was priced in the EUR-denominated bonds, widening the basis for these countries in times of increased sovereign credit spreads, such as Italy and Spain over the period August 2011 - May 2012. We have the novelty implication that rising yields due to credit risk premia can be mitigated by the access to the ECB liquidity facility and by pledging the local-currency denominated bond.

[1]The ECB announced the admission of marketable debt instruments denominated in USD and other currencies to be eligible collateral in ECB credit operations. This temporary change was in place until 31 December 2010. Subsequently, the ECB announced the reintroduction of this extension on 6 September 2012.

[2]The ECB publishes the list of eligible assets on a daily basis.

Third, the size of the basis is strongly positively related to the amount of sovereign bonds pledged to the ECB in the context of 3-year Long Term Refinancing Operations (LTROs), that consist of 3-year collateralized loans. Since only EUR-denominated bonds could be pledged to the ECB in exchange of liquidity for a very long horizon that was not available in the private repo market, the widening of the basis reflects the funding premium that EUR-denominated bonds embedded during this non-standard measure. When we study the reaction of the basis at the announcement of the 3−year LTROs, we find a statistically significant increase in the basis by over 60 basis points.

The pricing anomaly, we observe, may reflect the sell-off of USD-denominated bonds by outside euro area investors who are the main holders of this securities type and/or may be affected by the currency swap market liquidity that matters for the implied USD-denominated bond yields. To address these concerns we exclusively look at comparable EUR-denominated bonds that are subject to different regimes of haircuts by the ECB. First, we compare eligible fixed and variable rate coupon bonds issued by Belgium, Finland and Italy. We document that there exist substantial price differences between a long term fixed-rate coupon bond and its synthetic counterpart - a swapped floating rate bond - issued by Italy. The latter one issued by Italy carries a persistent and positive premium over the period where the 3−year LTROs were announced and the CDS of Italy reached extreme values. We argue that this premium reflects the lower haircuts applied by the ECB to floating-rate coupon bonds.[3] Differently, the premium is negligible in the case of Belgium and Finland. Second, we document that also an EUR-denominated fixed-rate coupon bond issued by Italy but not eligible for the ECB liquidity operations always became cheaper than comparable eligible bonds supporting again the existence of the monetary funding premium. Third, we use the basis based on USD- and EUR-denominated bonds issued by Turkey as a control group to further assess the impact of the ECB liquidity facilities on the basis of the euro area countries under study, since Turkish bonds could not be pledged to the ECB in exchange of liquidity. Our results are not affected by this exercise.

Finally, we also evaluate the impact of the Security Market Programme (SMP) activated by the ECB. Since the SMP targeted public and private EUR-denominated debt securities, we expect a widening of the basis around purchases. Our event study findings indicate that the interventions had a large but temporary impact on the price of individual sovereign bonds of the targeted countries, Italy and Spain. Our results are consistent with the recent predictions of the revised preferred habitat theory (see Vayanos and Vila (2009) and Gromb and Vayanos (2012)), suggesting that the open-market purchases by the ECB targeting EUR-denominated securities markets might affect the prices if "EUR-

[3]The ECB collateral policy establishes that the haircut applied to a fixed rate coupon bond depends on the time-to-maturity and the sovereign issuer rating. The longer the time-to-maturity, the higher the margin applied to the fixed-rate coupon bond. Differently, the haircut applied to a bond with variable rate coupons is that applied to the zero-to-one-year maturity bucket for fixed coupon instruments.

denominated" bonds investors benefit from holding these securities above and beyond the bonds' cash flows.

This paper contributes to two streams of literature. The first stream relates to "limits to arbitrage" theories (see Shleifer and Vishny (1997) and Duffie (2010)).[4] Within this literature, there are several recent empirical papers, to whom our paper is related, that document large price anomalies: the CDS-bond basis by Bai and Collin-Dufresne (2013), the US TIPS-Treasury bond puzzle by Fleckenstein, Longstaff and Lustig (2013), the impact of FX market liquidity on arbitrage trading by Mancini, Ranaldo and Wrampelmeyer (2013), and the relative mis-pricing of pairs of emerging market sovereign bonds issued in both dollars and euros by Buraschi, Sener and Menguturk (2014). Our paper is more directly related to the latter one. However, the crucial difference between Buraschi, Sener and Menguturk (2014) paper and our paper is the main findings. Our unique and novel data allows us to directly link the basis evolution with the type and the amount of sovereign debt pledged to the ECB in exchange for liquidity. Finally, our paper contributes to the recent literature on the limits to arbitrage and investors' preferred habitats.[5] In our paper, the preferred habitat corresponds to currencies markets rather than maturities inspired by the recent cross-asset arbitrage theory by Gromb and Vayanos (2012).

We also contribute to the recent literature on the role played by the non-standard monetary policy measures implemented by the central banks through lending facilities and assets purchase programs. Ashcraft, Garleanu and Pedersen (2010) discuss how the central bank's lending facilities lowering margin requirements can increase asset prices in crises by offering loans and easing funding constraints in the banking sector. The results are consistent with the theoretical predictions of Garleanu and Pedersen (2011) who show that margin differences lead to a basis between securities with (nearly) identical cash flows during times of funding illiquidity. Drechsler, Drechsel, Marques-Ibanez and Schnabl (2013) document that European banks, which borrowed heavily, also pledged increasingly risky collateral to the ECB suggesting that the ECB's liquidity facility was used for risk-shifting due to the lower haircuts. Acharya and Steffen (2013) document that under-capitalized banks in the peripheral countries used the ECB's LTROs to increase their exposure to risky domestic bonds, thus tightening the feedback loop between banks and sovereigns. Finally, Nagel, Krishnamurthy and Vissing-Jorgensen (2013) find that ECB actions have been successful in lowering government bond yields, in particular in reducing the solvency risk and in mitigating market segmentation, but they abstract from

[4]Shleifer and Vishny (1997) and Duffie (2010) discuss how limited availability of risk capital by arbitrageurs leads to persistent deviations from the law of one price when an initial price shock occurs. There are several lines of research, that depart from the seminal paper by Shleifer and Vishny (1997), who study different sources of frictions that can cause these deviations as (i) short selling restrictions; (ii) funding cost and collateral margins; (iii) institutional and regulatory frictions; and (iv) trading liquidity.

[5] Greenwood and Vayanos (2010) examine the effect of increases in bond supply across the yield curve for U.S. Treasuries, based on Vayanos and Vila (2009), who assume that different maturities have different clienteles and each type of investor trades only in a certain range of maturities - the preferred habitat.

the role the ECB liquidity facilities and collateral policy played on the euro area sovereign yields. We also shed light on the impact of central banks purchases on the markets for sovereign bonds contributing to a recent and growing literature that has analyzed the effects of SMP on euro area sovereign bond yields (see for example De Pooter, Martin and Pruitt (2013), Eser and Schwaab (2013), Ghysels, Idier, Manganelli and Vergote (2013) and Trebesch and Zettelmeyer (2013))[6] and the effects of the Federal Reserve's Large-Scale Asset Purchase program on U.S. Treasury yields (see for example Gagnon, Raskin, Remacke and Sack (2011), Krishnamurthy and Vissing-Jorgensen (2011) and D'Amico and King (2013)).

The paper is organized as follows. In Section 2, we describe the euro area sovereign pricing anomaly that is the focus of our paper. Section 3 describes the data. Section 4 discusses the empirical strategy, while we study the determinants of the basis and investigate the effects of ECB's policy interventions on the basis in Section 5. Section 6 concludes.

2 Pricing Anomaly

We proceed by first describing the USD- and EUR-denominated bond arbitrage strategy. We study deviations between the yield to maturity of bonds issued by the same Euro area sovereign countries in EUR and in a foreign currency. As foreign-currency bonds issued in USD are relatively common among Euro area countries and are also in general relatively actively traded, we restrict our analysis to USD-denominated fixed-rate coupon bonds exclusively. We select five euro area sovereign countries: Austria, Belgium, Finland, Italy, and Spain. We focus on fixed-rate coupon bonds denominated in USD, issued after 1999. Next, for every single USD-denominated bond we select a comparable EUR-denominated bond in terms of issuer, issue date and maturity and create a list of paired bonds.

In order to exploit the pricing anomaly, we assume traders convert the USD-denominated bond into a synthetic EUR-denominated bond by means of a cross-currency asset swap to exchange the fixed coupons of the USD-denominated bond at the Euribor rate plus a spread, the cross currency spread or cross currency basis, and get into a floating-fixed

[6]De Pooter, Martin and Pruitt (2013) find that weekly ECB purchases had the desired effect of lowering liquidity premia, but such reduction was mainly temporary. Eser and Schwaab (2013) find that SMP purchases have contributed effectively in lowering yields bonds and the impact is stronger in markets which are smaller, less liquid, and where risk premia were higher. Ghysels, Idier, Manganelli and Vergote (2013) analyze the high-frequency dynamics of bond yields and purchases. Their empirical investigation reveals that SMP purchases have contributed to reducing the volatility of targeted bond yields. Trebesch and Zettelmeyer (2013) back out the ECB's purchases of Greek bonds in the SMP in 2010, using the fact that the ECB did not participate in the Greek debt exchange of March 2012. They find that bonds bought by the ECB show a much larger drop in yields after the start of the SMP. Overall, their findings support the view that the interventions had a large local impact on the price of individual sovereign bonds.

interest rate swap to exchange the EUR-denominated stream of floating inflows into a fixed coupon rate. At initiation, the buyer receives the USD-denominated bond in exchange for its cash price valued in EUR at the spot price. Additionally, the trader has to pay/receive an upfront payment to compensate for any premium or discount paid for the USD-denominated bond. This upfront payment ensures that the net position created by the cross currency asset swap package is the same as a USD-denominated bond issued at par. On coupon dates, the buyer pays the coupon of the USD-denominated bond and receives the Euribor rate plus the cross currency spread. By means of the floating-fixed interest rate swap, this floating cash-flow is exchanged with a fixed-rate EUR-denominated coupon. On the maturity date, the buyer pays the redemption amount of the USD-denominated bond and receives the swapped redemption amount in EUR at the spot price. By getting into this strategy, we create a synthetic fixed-rate coupon EUR-denominated bond. We calculate the yield to maturity by applying standard bond valuation techniques.

Subsequently, we estimate the yield to maturity ($\widehat{Y}_{i,t}^{USD->EUR}$) of that synthetic bond belonging to the pair i at time t. To conclude, we define the basis for every matched-pair of bonds as the difference between the yield to maturity of the synthetic bond and the yield to maturity of the bond denominated in EUR ($Y_{i,t}^{EUR}$):

$$Basis_{i,t} = \widehat{Y}_{i,t}^{USD->EUR} - Y_{i,t}^{EUR}. \tag{1}$$

One contribution of this paper is to deal with the mismatch in coupon rates and payment dates between bonds and swaps and to document that other less precise alternatives have a substantial impact on the calculation of the basis affecting the level and the dynamics of the basis itself (see Appendix A).[7] Baba and Sakurai (2011) note that due to the long term horizon in bond cash-flows, cross-currency basis swaps have been used as a tool for converting currencies of the liabilities, particularly by issuers of bonds denominated in foreign currencies. Alternatively, one can use the forward market to hedge each cash-flow. Because forward contracts become less liquid beyond one year, the use of forward market does not appear appropriate, given the length of the cash-flows we are interested in. Moreover, while covered interest parity (CIP), which equates the return on domestic currency with a fully hedged foreign currency return, holds for short term maturities, it is violated for longer maturities. As a result, the difference in the term structure of the credit spreads of two different countries and the currency basis swap are needed in order to hedge foreign currency denominated cash-flows. Alternatively, Tuckman and Porfidio (2003) propose a strategy to create an adjusted forward rate that takes into account violations of the CIP in the long run on the basis of the spot exchange rate, the local and

[7]The existing literature, that applies cross currency swaps, subtracts par swap rates directly from yields of coupon bearing bonds that do not necessarily trade at par.

foreign LIBOR and the cross-currency basis.[8]

Figure 1 depicts the weekly average basis across the bond pairs at a country level from January 2006 to February 2013. At first glance, we observe a large and persistent positive basis that is common across all countries, where the yield of the synthetic EUR-denominated bonds is almost systematically higher than the yield of EUR-denominated bonds. And hence, for most of the sample period we observe that the USD-denominated bonds trade cheaper than the comparable bonds denominated in Euro.

[INSERT FIGURE 1 HERE]

At the beginning of the sample period we observe that the average basis is close to zero. Between the Lehman Brothers collapse and March 2009, the basis generally increases across the five european countries and Turkey. This finding is consistent with Buraschi, Sener and Menguturk (2014), who find that USD-denominated bonds issued by Turkey traded at a cheaper level than the EUR-denominated bonds over the same time period. Over this period, the weekly average basis across the bond pairs for Italy reached 152 basis points, while the basis for Austria, Belgium and Spain reached 68, 56 and 67 basis points respectively.

There are several reasons why one might expect the basis to be positive and to become even more positive during strongly distressed periods. Because the natural buyers of euro area sovereign bonds are European banks, three main factors make holding USD-denominated euro area sovereign bonds unattractive for them. First, at the beginning of the financial crisis, USD-denominated bonds were not accepted as eligible collateral under the terms of the ECB liquidity facilities. On 23 October 2008, in the context of the non-standard monetary policy measures, the list of assets accepted as eligible collateral was extended to ease access to ECB operations in an attempt to reduce asset-side constraints on banks' balance-sheets. In this context, the ECB announced the admission of marketable debt instruments denominated in USD, the pound sterling and the Japanese yen, and issued in the Euro area, as eligible collateral. This temporary change was in place until 31 December 2010.[9] However, foreign-denominated bonds are subject to additional haircut due to the currency risk. Second, under Basel rules, EUR-denominated domestic sovereign bonds have zero capital weightings for domestic banks, while the USD-denominated domestic sovereign bonds do not, so holding these bonds would incur capital charges (see Acharya, Engle and Pierret (2013)). Third, an additional margin is required in a private repo market operation, when European bank finances holdings of

[8]This strategy presents a lot of similarities with the one implemented in this paper, in the sense that both are based on a combination of a currency swap and an interest rate swap. However, this strategy is very costly to implement in our context because we would need to enter in a combination of currency swaps and interest rate swap to discount every single cash-flow of a bond.

[9]Subsequently, the ECB announced the reintroduction of this temporary measure on 6 September 2012.

USD-denominated bonds. An alternative explanation for the large positive basis observed during specific crisis episodes is a sell-off of USD-denominated bonds by outside euro area investors who are the main holders of this securities type. The increasing euro area policy uncertainty may have led outside euro area investors to drop out of this market. However, the USD-denominated bond yields might consistently reflect a segmentation factor because these investors couldn't benefit from access to the ECB liquidity facility and couldn't receive special regulatory treatment.

After that period the basis drops but its level is still above that observed at the beginning of the sample period. At the beginning of 2010, the activation of the SMP by the ECB is seen as the official start of the sovereign debt crisis in the euro area with the Greek debt crisis, which triggered the sovereign debt crisis for Ireland and Portugal and later for Italy and Spain in August 2011. The program was designed to intervene in the secondary markets of public and private EUR-denominated debt securities markets. This period is also characterized by the activation of a set of non-standard measures by the ECB such as the first 3-year LTRO in December 2011 and the second one in February 2012, whose objective was to provide liquidity for a very long horizon that was not available in the private repo market. However, only EUR-denominated bonds could be pledged as collateral to the ECB.

During this period, the sovereign yields of Italy and Spain skyrocketed reaching a peak in December 2011. Hereafter, the yields trended downward. We observe a large and persistent basis in all European countries, but the basis widened for countries with weak fiscal positions, like Italy and Spain. Over the period December 2011 - March 2012 the weekly average basis across the bond pairs for Austria reached 93 basis points, while the basis for Belgium, Italy and Spain reached 199, 152 and 402 basis points. Interestingly, the basis of Turkey remained unaffected by this turmoil. Overall, this supports the idea that the ECB interventions generated asymmetries between those ex-ante comparable bonds.

3 Data and Variables

The datasets for this paper consist of daily sovereign bond quotes collected from Bloomberg and ECB proprietary data on all sovereign bond purchases made by the ECB under the SMP programme and all euro area sovereign collateral pledged to the ECB from 2008 to 2013. Additionally, following the more recent "limits to arbitrage" literature we include in the analysis information on the lending activity and market and political risk factors collected from Data Explorers and Datastream, respectively.

3.1 Bond and Pair Characteristics

We focus on all European Monetary Union (EMU) countries that issue fixed-rate coupon bonds denominated in US Dollars (USD). Using information from the Dealogic database, we select all bonds issued in USD before 1999 and with a maturity date after 2008. For those bonds we find a comparable bond denominated in euro in terms of the same issuer, similar issue date and maturity. We rule out those USD-denominated bonds for which we do not find a comparable EUR-denominated bond.

3.1.1 Bond Data

Bond level information is gathered from Bloomberg. We retrieve daily bid, mid and ask prices and yields (Bloomberg CBBT).[10] When these prices are not available, we use the Bloomberg BGN, a weighted average of the quotes contributed to Bloomberg by a minimum of five brokers and dealers, and as a last source, we use Bloomberg BVAL prices which provide a theoretical price of the bond. The sample covers information about five EMU countries: Austria, Belgium, Finland, Italy, and Spain for which we use 47 fixed-rate coupon bonds of which 25 are USD- and 22 EUR-denominated. As a robustness check, we also construct the basis for the Turkish sovereign bonds using 8 fixed-rate coupon bonds (4 USD- and 4 EUR-denominated). Appendix B reports information about the 55 specific bonds.

To control for the liquidity of the bonds, we define the $Bid - Ask\ Spread_{i,j,t}$ as difference between the bid-ask spread in the USD- and EUR-denominated bonds.

3.1.2 Pair Characteristics

25 different pairs belonging to the five countries under analysis constitute our sample. Table 1 reports the main characteristics of the pairs. The first two columns report the starting and the last day in the sample. In order to avoid systematic convergence in the basis around the maturity date due to the convergence of the price to the face value, we rule out the last year of the bond life. Therefore, a bond that matures in May 2012 is only considered in the sample until May 2011.

[INSERT TABLE 1 HERE]

The third column reports the country that issued the pair under study. Italy comprises 10 out of the 25 pairs in our sample, Spain and Austria have 5 pairs each, followed by Belgium (3) and Finland (2).

The fourth column reports the average basis, which is consistently positive for all pairs and over the whole sample period. Focusing on those pairs that cover most of the

[10] Prices and yields are weighted averages based on the number of sources who price at 2nd and 3rd best pricing levels among the qualifying deals. CBBT requires at least three executable pricing sources with prices and size on both sides of the market. Prices must be within five minutes.

sample we observe that on average Italy, Spain and to a lesser extent Belgium have larger deviations than Austria and Finland, but the bases are on average higher than 25 basis points for all pairs. We also report the relative size of the USD-denominated bond to its EUR-denominated comparable bond in the fifth column. We observe that the outstanding amount of the EUR-denominated bond is significantly larger. However, the minimum size we observe in the sample for a USD-denominated bond is above 600 million which means that although smaller, USD-denominated bonds are still sizable, ranging from 5% to 22% of the EUR-denominated bond outstanding amount.

The last column refers to the governing law of the USD-denominated bonds given that all EUR-denominated bonds are issued under the local law. We observe that Austria, Finland and Spain issue USD-denominated debt under English law and Belgium under local law. Italy is the only country issuing under different regimes. It issues most of the USD-denominated bonds under the New York legislation but some under local and English law. We consider other bond specific covenants such as *negative pledge* and *cross default clauses* which could potentially explain differences across comparable bonds.

3.1.3 Lending Activity

Bond level information is complemented with information about lending activity provided by Data Explorers. Although securitiy lending activity is not a direct measure of short selling activity, it is a proxy commonly used in the limits to arbitrage literature. In fact, to short a bond, an investor must first borrow the bond through a secured loan where the owner of the bond lends the bond to the investor at some market determined rate.

We explore the effect of two variables: *No. of Transactions* and *Fees*. The *No. of Transactions* refers to the number of daily open securities lending transactions on a specific bond. On average, we observe 21 and 14 daily open lending transactions on the EUR- and USD-denominated bonds respectively. The *Fees* denotes the daily average fee for borrowing a specific bond. We observe that the average fee is around 43 (48) basis points for EUR-denominated (USD-denominated) bonds during our sample.

3.2 Currency Swaps

We collect data on USD and euro swap rates and EUR/USD currency swap rates using matching end-of-day Bloomberg data.

3.3 Risk Factors

In order to control for the potential impact of risk factors on the basis we include a set of global and country-specific market risk factors and a news-based policy uncertainty index on the euro area.

Quanto Credit Default Swaps ($Quanto\ CDS_{j,t}$) refers to the differential of CDSs on the same underlying, but quoted in different currencies. According to Ehlers and Shönbucher (2006), the $Quanto\ CDS_{j,t}$ is defined as one minus the ratio between the average EUR-denominated CDS spread and the average USD-denominated CDS spread capturing the expected devaluation of the Euro relative to the USD conditional on the country's default. We consider EUR- and USD-denominated CDS spreads with maturities of 6m, 1y, 2y, 3y, 4y, 5y, 7y, 10y, 20y and 30y to compute the $Quanto\ CDS_{j,t}$. Thus, the $Quanto\ CDS$ captures the correlation between creditworthiness of the euro area sovereign j and the value of euro currency against the dollar.

We use the spread between the sovereign specific Eurepo general collateral rate 3-month and the Overnight Index Swap (OIS) both EUR-denominated ($Eurepo_{j,t} - OIS$) to control for the funding risk, since eurozone funding markets are increasingly dependent on collateralized rather than unsecured loans.[11] Due to the increased riskiness of its sovereign collateral, the repo rates of Italian and Spanish collateral have been diverging from the ones of Germany and France since July 2011. On the other hand, OIS is equivalent to the average of the overnight interest rates expected until maturity and is almost riskless. Thus, the $Eurepo - OIS$ spread over the same term quantifies the premium that banks pay when borrowing collateralized funds for a pre-determined period relative to the expected interest cost from a repeatedly rolling over funding in the overnight market.[12]

To proxy the economic uncertainty at European level we use the Economic Policy Uncertainty index proposed by Baker, Bloom and Davis (2013) (EPI_t). To measure European policy-related economic uncertainty, the authors construct an index from two types of underlying components: newspaper coverage of policy-related economic uncertainty and disagreement among economic forecasters uncertainty.[13]

3.4 ECB Data

3.4.1 *ECB Liquidity Facility and Collateral Management*

In line with central bank practice, the ECB requires counterparties to pledge collateral in exchange for liquidity. The ECB risk control framework establishes collateral eligibility criteria, based on type of assets, credit quality, place of issuance, type of issuer, currency, acceptable markets and other characteristics which are applied uniformly across the Euro area. The ECB collateral management compiles a public list of eligible assets on a daily basis.

USD- and EUR-denominated bonds from the same issuer are treated differently. These differences can be summarized as follows: (i) USD-denominated bonds are not accepted

[11] A repo is a sale of a security coupled with an agreement to repurchase the same security at a specified price in exchange of liquidity that is remunerated at the general collateral rate.

[12] Information on the country specific Eurepo general collateral rate is collected from the European Banking Association (EBA).

[13] This variable is available available at http://www.policyuncertainty.com/index.html.

as collateral during the whole sample period of our study;[14] (ii) USD-denominated bonds are subject to an additional haircut due to currency risk when they are eligible.

The ECB collateral management procedure collects information at bond level from the National Central Banks (NCBs) on a weekly basis. Our data contains the nominal amount and the market value before and after the application of the haircuts of all individual sovereign bonds pledged to the ECB. We compute the total nominal amount of sovereign bonds held by the ECB at country level. We scale these amounts by the total nominal sovereign debt outstanding and eligible by each country ($Sov.\ Collateral_{j,t}$ *to* $Tot.\ Sov.\ Debt_{j,t}$) in order to account for the proportion of the total debt eligible that is actually pledged to the ECB.

3.4.2 *Securities Market Programme (SMP)*

The ECB launched the securities market programme (SMP) in May 2010. This programme consisted of purchasing debt securities in the open market and retaining them on the balance sheet of the ECB up to the payment of all the cash flows of the securities (hold-to-maturity strategy). Some distinctive features of this programme are related in particular to the disclosure of the composition of the portfolio. The ECB did not disclose the total amounts which would be spent, the time frame over which the program would be active, or the set of securities that would be targeted. Data on the outstanding value of the holding portfolio were only published weekly without any reference to the time during the week when the securities had been bought. Moreover, the ECB did not provide a breakdown describing the composition of assets by national origin of issuance. On 21 February 2013, the ECB provided details on securities holdings acquired under the programme revealing a country-by-country breakdown. Italian debt accounts for roughly half of the total: 103 billion Euros ($136 billion) out of 218 billion Euros. Spain ranks second, with 44 billion euros of its debt purchased by the Euro area's central bank, followed by Greece (34 billion Euros), Portugal (23 billion Euros) and Ireland (14 billion Euros).

Figure 2 plots the accumulated book value of the SMP over time. Clearly, purchases are not evenly spread out over time. The largest purchases occurred after the introduction of the SMP on 10 May 2010 in the context of the central bank reactions to the Greek debt crisis and after its reactivation on 8 August 2011 for the Italian and Spanish sovereign bond market. The chart also suggests that there have been long periods during which the SMP has been open but inactive. From the week ending 25 March 2011 until 8 August 2011, the SMP was inactive for 19 weeks. Purchases stopped in January 2012.

[INSERT FIGURE 2 HERE]

[14]The ECB admitted US dollars, pounds sterling or Japanese yen as eligible collateral subject to the fulfillment of the relevant eligibility criteria from the 25th of October 2008 to the 31st of December 2009 and from the 9th of November 2012 onwards.

We include the SMP information in three different ways: we use data on (i) weekly purchases (SMP_t) based on the outstanding value of the holding portfolio; (ii) weekly purchases at country level ($SMP_{j,t}$); and (iii) weekly purchases at pair level ($SMP_{i,j,t}$). The latter two variables are based on ECB proprietary data. Purchases at pair level refer to the weekly purchases of the EUR-denominated bonds given that only EUR-denominated bonds were targeted.

4 Empirical Strategy

Our empirical strategy seeks to identify the main drivers of the basis. We first evaluate to what extent factors established in the "limit to arbitrage" literature help to explain the previously documented basis in Section 2 by means of the following panel regression analysis:

$$\text{Basis}_{i,j,t} = \alpha + \delta_j + \beta_1 \times \text{Bond Factors} + \beta_2 \times \text{Risk Factors} + \varepsilon_{i,j,t}, \tag{2}$$

where the dependent variable is the estimated basis for each pair of bonds i, and j refers to the issuer country. *Bond Factors* is a matrix that contains pair−specific information about the bond liquidity, lending activity and bond covenants. Following the definition of the basis, we construct pair-specific information as the difference between the USD- and the EUR-related variables. *Risk Factors* is a matrix that contains country and global market risk factors and the euro area Economic Policy Uncertainty index. We employ a Prais-Winsten regression with country fixed−effects δ_j and with corrected standard errors (PCSEs) for contemporaneous correlation across panels and serial autocorrelation within panels. The correlation within panels is treated as a first-order autocorrelation AR(1) and the coefficient of this process is common to all the panels.

We divide the period January 2008 - February 2013 into two main subsamples: a *pre* euro area sovereign debt crisis period that starts on 1 January 2008 and ends on 9 May 2010, and a euro area sovereign debt crisis period starting on 10 May 2010. The beginning of the later period coincides with the activation of the SMP.

To assess the impact of the ECB policy actions on the basis we employ information relative to the ECB liquidity facility and collateral management and to the SMP. First, we study to what extent the ECB liquidity facility and collateral management policy explain the time−varying evolution of the basis in the context of the European sovereign debt crisis. We study the impact of those factors individually through the following weekly panel regression analysis:

$$\begin{aligned}\text{Basis}_{i,j,t} = \alpha + \delta_j + \beta_1 \times \text{Bond Factors} + \beta_2 \times \text{Risk Factors} \\ + \beta_3 \times \text{ECB Collateral Factors} + \varepsilon_{i,j,t},\end{aligned} \tag{3}$$

where *ECB Collateral Factors* account for three different factors: (i) changes in eligibility criteria; (ii) the amount of sovereign collateral pledged to the ECB; and (iii) the introduction of the 3−year long term refinancing operations.

Besides panel data estimation, we also use an event study methodology to test for the effect of the ECB intervention over a window of 56 (8 weeks) days before and 56 after the intervention date. Compared to panel data estimation, this method has the advantage of focusing on a time interval in which the effects of the intervention should be less clouded by confounding factors. Thus, we conduct the following daily panel regression analysis:

$$\text{Basis}_{i,j,t} = \alpha + \delta_i + \delta_j + \delta_t + \beta \times \text{Dum. After} + \varepsilon_{i,j,t}, \tag{4}$$

including pair, country and time fixed−effects. *Dum. After* is a matrix that contains four dummy variables. The first one is 1 for a window of two weeks after the event under study and zero otherwise, the second one is 1 from the third to the fourth week and zero otherwise and so on. This decomposition of the after event period allows us to evaluate the size and the persistence of the policy action on the basis.

Finally, we evaluate the impact of the SMP on the basis by means of a panel regression analysis, as in Equation (3),

$$\begin{aligned}\text{Basis}_{i,j,t} = \alpha + \delta_j + \beta_1 \times \text{Bond Factors} + \beta_2 \times \text{Risk Factors} \\ + \beta_3 \times SMP_{.,.,t} + \varepsilon_{i,j,t},\end{aligned} \tag{5}$$

and an event study analysis around the reactivation of the SMP for the Italian and Spanish sovereign market in August 2011.

5 What Drives the Pricing Anomaly?

5.1 Bond and Market Factors

Table 2 reports the estimates of Equation (2). The first column contains the result for the whole sample period while columns (2) and (3) report the results for the *pre* euro area sovereign debt and euro area sovereign debt crisis sub-periods.

[INSERT TABLE 2 HERE]

In general terms, USD-denominated bonds present wider bid-ask spreads (i.e., they are generally more illiquid) and hence, the $Bid - Ask\ Spread_{i,j,t}$ is most of the time positive. We document that as the illiquidity of the EUR-denominated bonds gets closer to the illiquidity of the USD-denominated bond, the basis decreases by 3.457 bps. Thus, differences in the relative illiquidity explain the widening of the basis: the larger the difference in relative illiquidity, the wider the basis. Additionally, this effect is only significant during the pre euro area sovereign debt crisis period.

We next study the role of the lending activities on the basis by means of the $No.\ Transactions_{i,j,t}$ and $Fees_{i,j,t}$ variables. We systematically observe that EUR-denominated bonds are expensive in comparison to the comparable USD-denominated bond, which is consistent with Buraschi, Sener and Menguturk (2014). In order to exploit this anomaly, we expect traders to buy cheap (USD-denominated) and short-sell expensive (EUR-denominated) bonds in such a way that relative increases in the number of transactions or of the lending cost of the EUR-denominated bonds should decrease the basis. However, the empirical results do not support this possible explanation. On the contrary, we find that an increase in the relative number of transactions of the EUR-denominated bonds (i.e., $No.\ Transactions_{i,j,t}$ becomes more negative) significantly widens the basis. Additionally, we observe that this effect is only significant during the euro area sovereign debt crisis period. Interestingly, we were advised in private conversations with practitioners that the increase of lending activity of EUR-denominated bonds is likely to be related to the increasing demand of collateral securities that could be pledged by banks to the ECB in exchange of liquidity. This would support the existence of a monetary funding premium in the EUR-denominated bonds that will be discussed in the next section.

Then, we study whether bond covenants explain the pricing anomaly. We consider two dummies related to the law jurisdictions: $England\ Law_{i,j}$ takes 1 when a USD-denominated bond is issued under the UK law, and $NY\ Law_{i,j}$ takes 1 when a USD-denominated bond is issued under the New York law. In addition, we control for additional covenants in the USD-denominated bond in the dummy called *Additional Clauses*.[15] We expect to have a larger basis for pairs issued under the local law than those issued under international laws, because the sovereign bond issued under international laws should guarantee a higher recovery rate in case of sovereign default. In fact, we find that the basis is on average smaller when the USD-denominated bond is issued under the New York law, in both sub-periods, suggesting that a USD-denominated bond issued under New York law is more attractive than a comparable USD-denominated bond issued under local law.[16] However, this effect is not supported across jurisdictions by the data due to the fact that countries tend to issue under the same law jurisdiction and so it is not possible to disentangle the law and country effect.

We then address the impact of the country and global market factors. The *Quanto CDS* has been used as a proxy of the expected devaluation of the Euro relative to the USD, conditional on the country's default (see Ehlers and Shönbucher (2006)). Thus, buying EUR-denominated CDS is a less attractive hedge, as the value of that protection

[15] *Negative pledge* and *cross default clauses* are two covenants that appear simultaneously in some of the USD-denominated bonds so we control by them in one variable called "Additional Clauses" that takes 1 when the USD-denominated bond is issued under those covenants.

[16] Choi, Gulati and Posner (2011) document that the yield premium of the Greek sovereign debt governed by local law versus foreign law was discernible before November 2009 but then increased, reaching a peak of 400 bps, as the news about Greece's financial state emerged and the probability of a restructuring increased.

is likely to diminish as the referenced sovereign approaches default. According to this definition, we would expect that the *Quanto CDS* has a negative impact on the basis because, as the expected devaluation increases, USD-denominated bonds should become more attractive than EUR-denominated bonds. Nevertheless, we do not find empirical support for this economic intuition. On the contrary, we find a positive and significant effect of the $Quanto\ CDS_{j,t}$. Buraschi, Sener and Menguturk (2014) argue that the Quanto CDS contracts gained great popularity during the 2010 euro area sovereign debt crisis, as market participants feared a substantial devaluation of the euro as a consequence of the default of one of its member countries. Before 2010, however, expected devaluation values were close to zero and the Quanto CDS prices were then trading at only a few basis points. Interestingly, we were advised in private conversations with practitioners that the liquidity in Quanto CDS has been fairly limited and investors' demand for Quanto CDS was the defining factor in Quanto CDS pricing. In particular, the main source of supply stemmed from credit-linked notes, where investors buy government bonds and sell the relevant CDS to enhance the yield. In this instance, having an exact profile match between the currency of the bond and the CDS was preferable for investors.

The development of the secured market funding has dramatically changed during the crisis. According to Hördahl and King (2008), during the first part of the crisis, the Eurepo-OIS spread was marginally affected in the Euro area, and subsequently moved upwards as the crisis progressed due to a combination of factors. In the *pre* euro area sovereign debt crisis period, we observe that increases in the $Eurepo - OIS\ Spread_{j,t}$ significantly widened the basis, suggesting that the shift from unsecured to secured funding made EUR-denominated bonds more attractive than USD denominated bonds, because the latter ones are subject to an additional haircut in repo transactions due to the currency risk. Instead, in the euro area sovereign debt crisis period, we observe that decreases in the Eurepo activity significantly increase the basis. In this period, secured funding in the Euro area was affected by several factors. Large increases were observed of the interest rates on repos, general collateral rates, for countries under market stress affecting the bank funding. In addition, the repo market experienced a large decline in its activity due to the effect of the ECB's 3-year LTROs (see Mancini, Ranaldo and Wrampelmeyer (2013b)).

Finally, we find that the increase of the policy uncertainty index (EPI_t) in the Euro area significantly widens the basis. This finding suggests that increases in the basis are positively correlated with increasing policy uncertainty in the euro area reflecting the sell-off of USD-denominated bonds by outside euro area investors.

Overall, the bond and risk factors affect the basis, but they are not able to provide a fully satisfactory explanation of the existence of these arbitrage opportunities. In particular, these factors play a limited role during the euro area sovereign debt crisis period, when the size of the basis on average widens and significant differences emerged across

the countries. In fact, the R^2 of our regressions drops from 33.8% (*pre* euro area sovereign debt crisis) to 10.5% (euro area sovereign debt crisis).

5.2 Liquidity Facility and Collateral Management of the ECB

In this section we study the impact of the liquidity facility and collateral management of the ECB focusing on three different aspects: (i) changes in the collateral eligibility criteria; (ii) the amount of sovereign debt collateral pledged at the ECB; and (iii) the introduction of the 3-year LTROs. Later, we study the impact of the ECB purchases of EUR-denominated bonds.

5.2.1 Changes in the Eligibility Criteria

Table 3 reports the results for the changes in the collateral eligibility criteria. Column (1) reports the results of Equation (3) where we introduce two dummies which are 1 during the first and the second eligibility windows of USD-denominated bonds ($1st\ Eligibility\ Window_t$ and $2nd\ Eligibility\ Window_t$, respectively). The $1st\ Eligibility\ Window$ refers to the decision announced on 23 October 2008 and implemented on 14 November 2008, which was in place until 31 December 2010. Subsequently, the ECB announced the reintroduction of this temporary measure on 6 September 2012 ($2nd\ Eligibility\ Window$) with effect on 9 November 2012. Additionally, we interact these variables with a dummy that is 1 for those pairs where the USD-denominated bonds fulfill all the eligibility criteria and therefore could be pledged to the ECB.

[INSERT TABLE 3 HERE]

We find that the basis of those eligible pairs is statistically lower than the ones of non-eligible pairs by 11 and 23 basis points during the first and the second eligibility windows, respectively. In addition, Columns (2) and (3) report the results of Equation (4) in which we conduct the event study analysis around the implementation date of the changes in the eligibility criteria. Consistent with the previous findings, we document that the basis of eligible pairs is statistically lower than that of non-eligible pairs after the introduction of the first eligibility window and the impact is persistent over time.

Figure 3 shows the estimated response of the basis to being the USD-denominated bond eligible around the introduction of the changes in the eligibility criteria on 14 November 2008. This figure illustrates our event study estimates by plotting the cross-sectional averages for the eligible USD-denominated pair group (blue solid line) and the non-eligible USD-denominated pair group (green dashed line) minus their respective pre-event average mean over time. The dashed lines indicate the sub-period averages for pre event, 2 weeks after the event, 4 weeks after the event, 6 weeks after the event and 8 weeks after the event. The larger effect is registered after the third week and is persistent. The average

basis for the eligible USD-denominated pair group is lower than the average basis of the non-eligible USD-denominated pair group by more than 20 basis points. It could be due to price pressure associated with the selling of non-eligible USD-denominated bonds by investors who would only hold the bonds if they could pledge the bond to the ECB.

[INSERT FIGURE 3 HERE]

The impact on the yields is substantial when compared with Ashcraft, Garleanu and Pedersen (2010) who examine empirically the impact of the introduction of the TALF lending facility, studying the reaction of market prices by considering the price response to an unpredictable bond rejection from the TALF programme. They measure a temporary decrease of 5 basis points in the yield spread for the eligible TALF securities, but a statistically significant rise in the yield spread by over 20 basis points for the non-eligible assets. Moreover, our results are consistent with the theoretical predictions of Garleanu and Pedersen (2011) who show that margin differences lead to basis between securities with (nearly) identical cash flows during times of funding illiquidity.

However, the impact of the second change in the collateral eligibility criteria (Column (2)) seems to be weaker and non-persistent, probably due to an anticipation effect from the market. The announcement was made on September 2012 but with effect on 9 November 2012. Overall, these findings support the idea that the possibility of being pledged to the ECB in exchange for liquidity is priced in the eligible bonds. So, the fact that only EUR-denominated bonds can be pledged to the ECB in exchange for liquidity generates an asymmetry between EUR- and USD-bond represented in the basis, that is mitigated after the expansion of the list of eligible assets to the USD-denominated bonds.

5.2.2 Sovereign Debt Pledged at the ECB

We next investigate the effect of the sovereign debt collateral pledge at the ECB in exchange for liquidity and how this effect varies depending on the country default risk. To that aim we run the Equation (3) including the variable $Sov.\ Collateral_{j,t}\ to\ Tot.\ Sov.\ Debt_{j,t}$ that captures the proportion of the total outstanding eligible sovereign debt that is actually pledged at the ECB. Results are reported in Table 4. We find that during non-distress periods the level of sovereign collateral pledged at the ECB does not play a significant role. To investigate the effect during distress periods, we interact this variable with a dummy that takes 1 when the CDS of the same country reaches extreme levels (the CDS is above the $90th$ percentile of its distribution over the full-sample period). We find that an increase of a 1% of the sovereign debt collateral pledged at the ECB divided by the nominal total outstanding amount of the sovereign debt during distress periods widens the basis approximately by 2.95 basis points. The fact that the $Sov.\ Collateral_{j,t}\ to\ Tot.\ Sov\ Debt_{j,t} \times Dum.\ High\ CDS_{j,t}$ variable has positive and significant coefficient supports the idea that the ECB liquidity facility was priced on the EUR-denominated

bonds widening the basis for the countries in strong distress, like Italy and Spain. Thus, our result provide the novelty implication that the credit risk premium and the monetary funding premium are not independent, but they are negatively correlated, because rising yields due to solvency concerns can be mitigated by the ECB liquidity facility access.

[INSERT TABLE 4 HERE]

Thus, we study the impact of the 3−year LTROs that the ECB launched in order to provide longer-term refinancing to the banking sector. Concretely, the 3−year LTROs provided EUR 489 billion on 21 December 2011 in three years loans and EUR 523 billion on 29 February 2012, aiming to supporting the provision of bank lending to the economy and reducing banks' funding risk. In line with the findings on the eligibility criteria we expect the 3−year LTRO to have an impact on the basis because of the unique opportunity provided by the ECB to get liquidity under more favourable conditions than those that prevail on the market.

Column (2) of Table 4 reports the estimation of Equation (3), where in order to capture the difference in the spirit of the regular operations and the 3−year LTRO, we interact the $Sov.\ Collateral\ to\ Tot.\ Sov.\ Debt_{j,t}$ variable with a dummy variable that is 1 in the implementation weeks of the 3−year LTROs. We find that an increase of a 1% of the sovereign debt collateral pledged at the ECB during 3−year LTROs divided by the nominal total outstanding amount of the sovereign debt widens the basis approximately by 3.09 basis points. The fact that the $Sov.\ Collateral_{j,t}\ to\ Tot.\ Sov\ Debt_{j,t} \times Dum.\ 3y - LTRO_t$ variable obtains a positive and significant effect reflects the funding premium that the EUR-denominated bonds embedded during the implementation of the non-standard measures. Additionally, Column (3) of the same Table reports the results of the event study analysis around the announcement date of the 3−year LTROs. In line with the previous findings, we document a positive and significant effect of the announcement of the 3−year LTRO which persists over time.

5.2.3 Robustness

In this subsection, we consider three types of robustness checks: (i) verifying whether the large positive basis, we observe during specific crisis episodes, reflects the sell-off of USD-denominated bonds by outside euro area investors who are the main holders of this securities type; (ii) verifying whether the basis is affected by the currency and interest swap market liquidity that matters for the implied USD-denominated bond yields; and (iii) verifying the impact of the market risk factors and of the ECB liquidity facility and collateral policy.

To address the first two points, we exclusively look at EUR-denominated bonds that are subject to different regimes of haircuts by the ECB. First, we compare EUR-denominated fixed and variable rate coupon bonds issued by Belgium, Finland and Italy

where the main holders of this securities type are euro area investors. All the bonds we consider are eligible for the ECB liquidity operations. The ECB collateral policy establishes that the haircut applied to a fixed rate coupon bonds depends on the time-to-maturity and the sovereign issuer rating. The longer the time-to-maturity, the higher the margin is applied to the fixed-rate coupon bond. Differently, the haircut applied to a bond with variable rate coupons is that applied to the zero-to-one-year maturity bucket for fixed coupon instruments. We expect price differences between a long term fixed-rate coupon bond and its synthetic counterpart - a swapped floating rate bond, issued by the same euro area country, due the differential in haircuts during the crisis episodes we discussed. We focus on floating-rate coupon bonds that are linked to the Euribor and are daily traded on euro area stock exchanges. Following the same approach for creating USD-EUR pairs, we select a comparable fixed-rate coupon bond in terms of maturity for every single floating-rate coupon bonds. Our sample is composed of 8 pairs: 5 for Italy, 2 for Belgium and 1 for Finland.

Figure 4 depicts the weekly average basis for the pair with the longest maturity for each country. The pair issued by Italy expires in 2026, while the one issued by Belgium and Finland in 2016 and 2020 respectively. The haircut differential is of 5% (= 6%(fixed-rate) − 1%(floating-rate)) for Italy. Before July 2011 the average basis for this pair is around −20 basis points. Over the period August 2011 - April 2012 the basis is positive, large and persistent reaching more than 50 basis points when the 3−year LTROs (see time line) were announced and when the CDS of Italy reaches extreme levels. Differently, the basis is negligible in the case of Belgium and Finland.

[INSERT FIGURE 4 HERE]

Second, we identified an EUR-denominated fixed-rate coupon bond issued by Italy, expiring in 2026 and not eligible for the ECB liquidity operations. We select a comparable and eligible fixed-rate coupon bond issued by Italy. Figure 5 depicts the basis for this pair starting in April 2008. At the beginning of the crisis, the non-eligible EUR-denominated bond was always cheaper (higher yield-to-maturity) than the comparable eligible bond. The basis is positive, large and persistent over the entire sample. Moreover, it reaches more than 80 basis points during the introduction of the 3−year LTROs supporting again the existence of the monetary funding premium.

[INSERT FIGURE 5 HERE]

Finally, in order to highlight the impact of the ECB liquidity facilities on the basis we estimate Equation (3) using as dependent variable the difference between the estimated basis of each pair and the average basis of Turkey, $Basis_{i,j,t} - \overline{BasisTurkey}_t$. Since sovereign bonds issued by Turkey cannot be pledge to the ECB in exchange of liquidity, this difference allows us to control for factors that affected all bonds at the same time.

Table 5 reports the results. Column (1) reports the estimates on the collateral eligibility, Column (2) on the amounts of sovereign collateral pledged to the ECB and Column (3) reports the impact of the 3-year LTROs. The results are consistent with the ones reported in the baseline specification. So, our findings support the existence of the funding liquidity premium that is priced during period of special distress.

[INSERT TABLE 5 HERE]

5.3 Securities Market Programme (SMP)

As discussed in Section 4.4.2, we consider the SMP information in three different ways: we use data on (1) weekly public available purchases (SMP_t); (2) weekly purchases at country level ($SMP_{j,t}$); and (3) weekly purchases at pair level ($SMP_{i,j,t}$). The sample starts in May 2010 coinciding with the launch of the programme. Since the SMP targeted public and private EUR-denominated debt securities, we expect a widening of the basis around purchases. Thus, the panel regression analysis is conducted on the euro area debt crisis period (May 2011 - February 2013), while the event study analysis focuses on the reactivation of the programme for the targeted countries, Italy and Spain.

Columns $(1) - (3)$ of Table 6 report the estimates of Equation (5) using the SMP information at different disaggregate levels. We find that over time a Euro 1 billion of bond purchases on average widens the basis of 2.41 basis points (see Column (2)). Interestingly, when we estimate the same specification using information on individual bond purchases, we find that over time individual bond purchases on average widens the basis of 25.65 basis points (see Column (3)). Our results indicate that SMP purchases of the targeted EUR-denominated sovereign bonds significantly widen the basis, in particular when the EUR-denominated bonds targeted by the program belong to the bond pairs of our analysis. This finding suggests that the interventions had a large impact on the price of individual sovereign bonds.

[INSERT TABLE 6 HERE]

Then, we conduct an event study analysis around the reactivation of the SMP in August 2011 in order to disentangle the impact on the targeted countries. The announcement date is 7 August 2011 when an ECBs press release stated "*The Governing Council of the European Central Bank (ECB) welcomes the announcements made by the governments of Italy and Spain concerning new measures and reforms in the areas of fiscal and structural policies. ... It is on the basis of the above assessments that the ECB will actively implement its Securities Markets Programme. This programme has been designed to help restoring a better transmission of our monetary policy decisions taking account of dysfunctional market segments and therefore to ensure price stability in the euro area.*"

We estimate the event study Equation (4) adding the dummy variable Dum. Target Countries that is 1 when the country j is Italy or Spain. In line with the previous findings (see Column (4) of Table 6), we document a positive and significant impact of the SMP on the basis of the targeted countries which persists over time during the subsequent purchases in the following weeks.

Figure 6 shows the estimated response of the basis of the targeted countries, Italy and Spain, around the reactivation of the SMP on 8 August 2011 (see Column (4) of Table 6). This figure illustrates our event study estimates by plotting the cross-sectional averages for the target pair group (red solid line) and the no target pair group (blue dot-dashed line) minus their respective pre-event average mean over time. The dashed lines indicate the sub-period averages for pre event, 2 weeks after the event, 4 weeks after the event, 6 weeks after the event and 8 weeks after the event.

[INSERT FIGURE 6 HERE]

6 Conclusions

In this paper, we document a large pricing anomaly in the euro area sovereign bond market between $2008 - 2013$. A large yield spread, a basis, developed between EUR- and USD-denominated comparable bonds issued by the same country. USD-denominated bonds became substantially cheaper (higher yield-to-maturity) than those denominated in euro, once the foreign exchange rate risk is hedged in the USD-EUR currency swap market.

The existence of these large and persistent pricing anomalies are not fully explained by the traditional channels used in the limits-to arbitrage literature such as time-varying funding costs affecting capital, short selling constraints and liquidity risk. Apart from these factors, we find that country specific factors help to explain cross-sectional differences in the basis.

Overall, our results suggest that the ECB liquidity facilities and non-standard monetary policy measures play a key role in explaining the basis. Because EUR-denominated bonds could be used as collateral for liquidity operations with the ECB at lower haircuts, a monetary funding premium is embedded in these bonds yields. Moreover, this funding premium might also vary over time, depending on credit spreads of sovereign issuer, on the one hand, and the collateral policy and the liquidity supply conditions determined by the ECB policy stance, on the other.

Further investigation is needed to shed light on the role played by the ECB liquidity facilities and non-standard monetary policy measures. A thorough analysis of the impact of these actions would also require detailed information on banks' collateral policy. In fact, the monetary funding premium might also depend on banks' funding needs.

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Figures

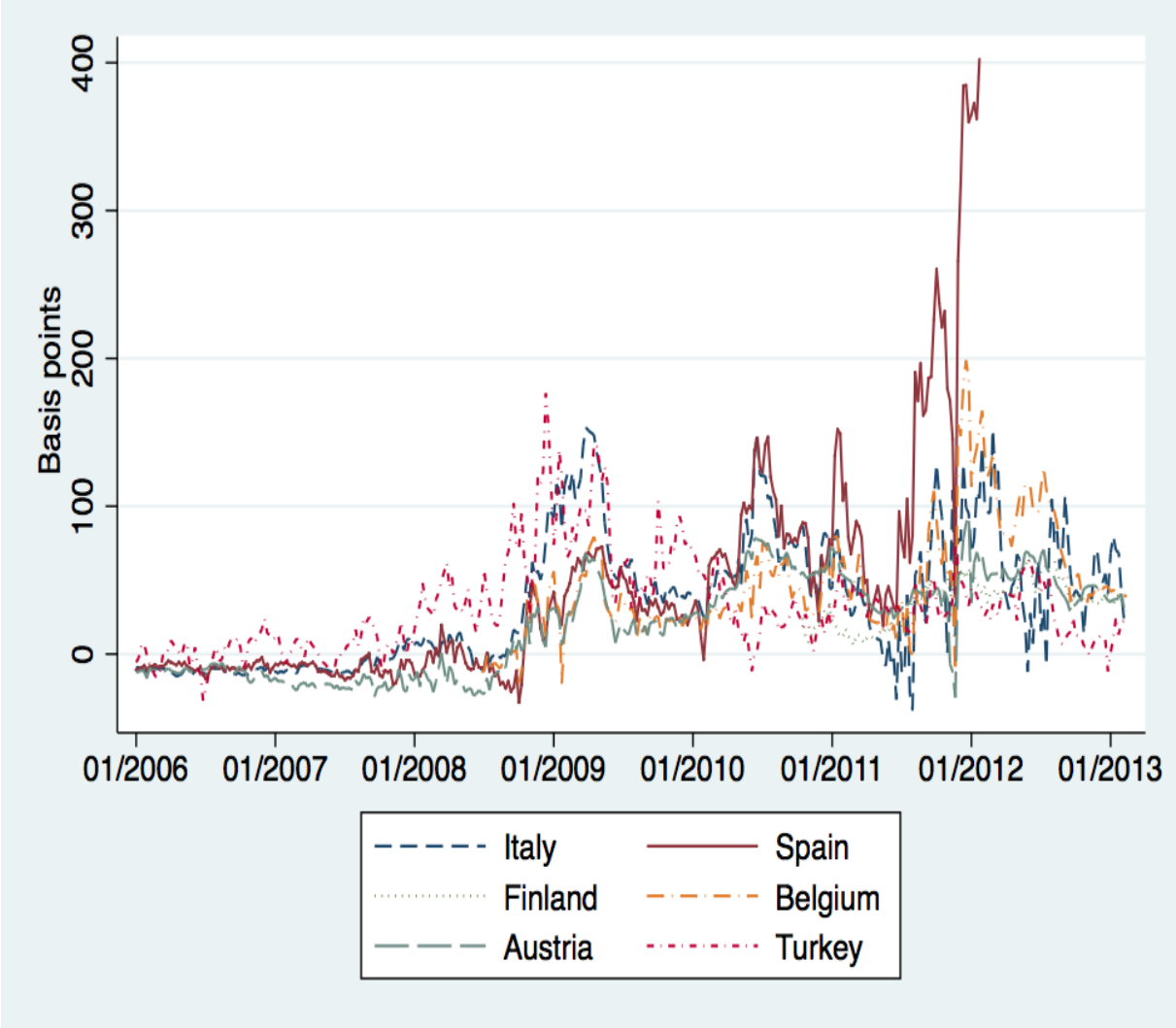


Figure 1: This figure depicts the average basis across pair bonds of the five considered countries: Austria, Belgium, Finland, Italy, Spain and Turkey. For every bond pair, the basis is defined as the difference between the yield to maturity of the USD-denominated bond after the conversion of the bond cash flows from USD to Euro ($\widehat{Y}_{i,t}^{USD->EUR}$) and that of the EUR-denominated bond ($Y_{i,t}^{EUR}$). The sample spans from January 2006 to February 2013. Bases are reported on a weekly basis and measured in basis points.

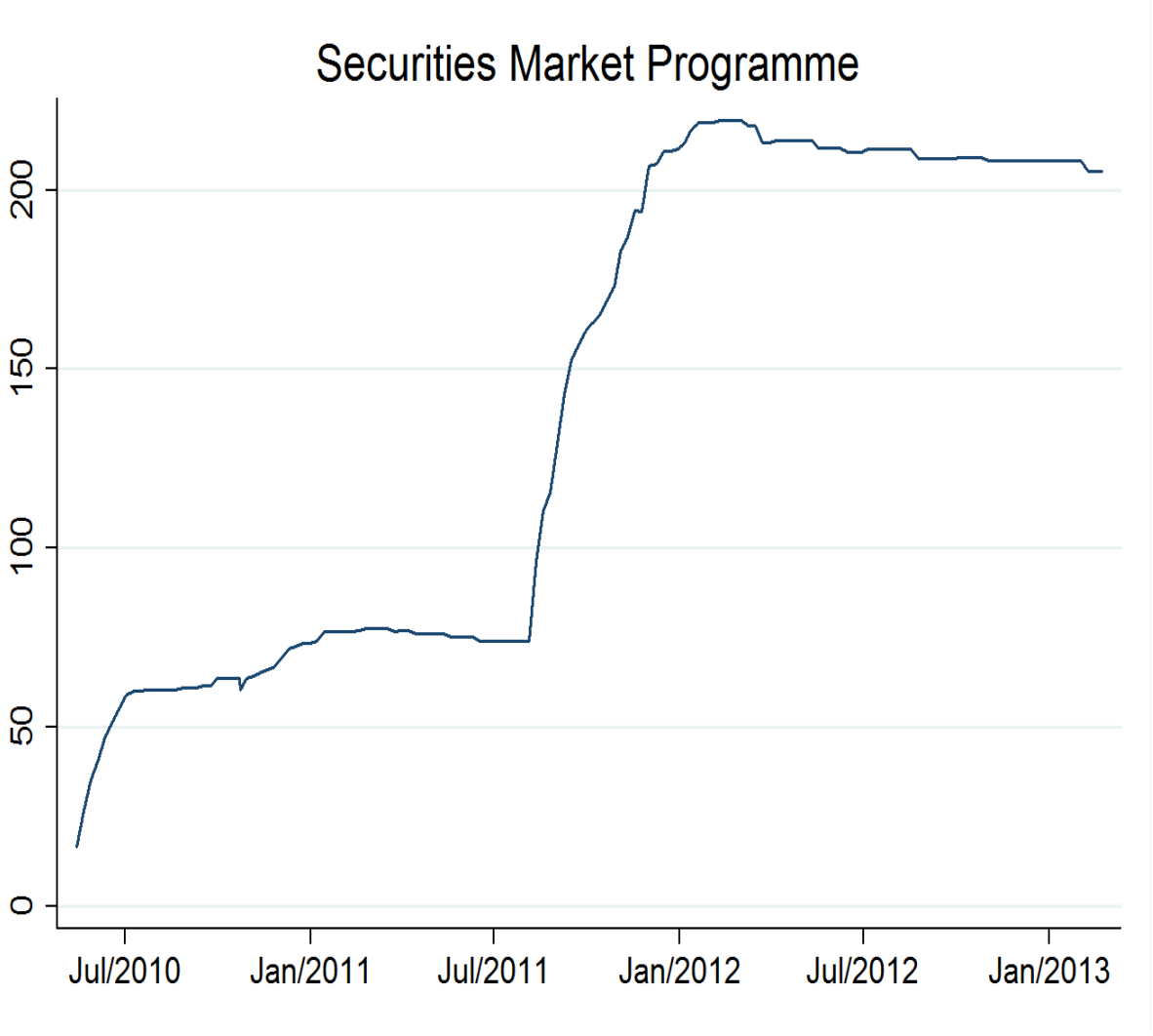


Figure 2: This figure depicts the publicly available information of the Securities Market Programme (SMP). It contains the accumulated book value in EUR billion corresponding to the SMP.

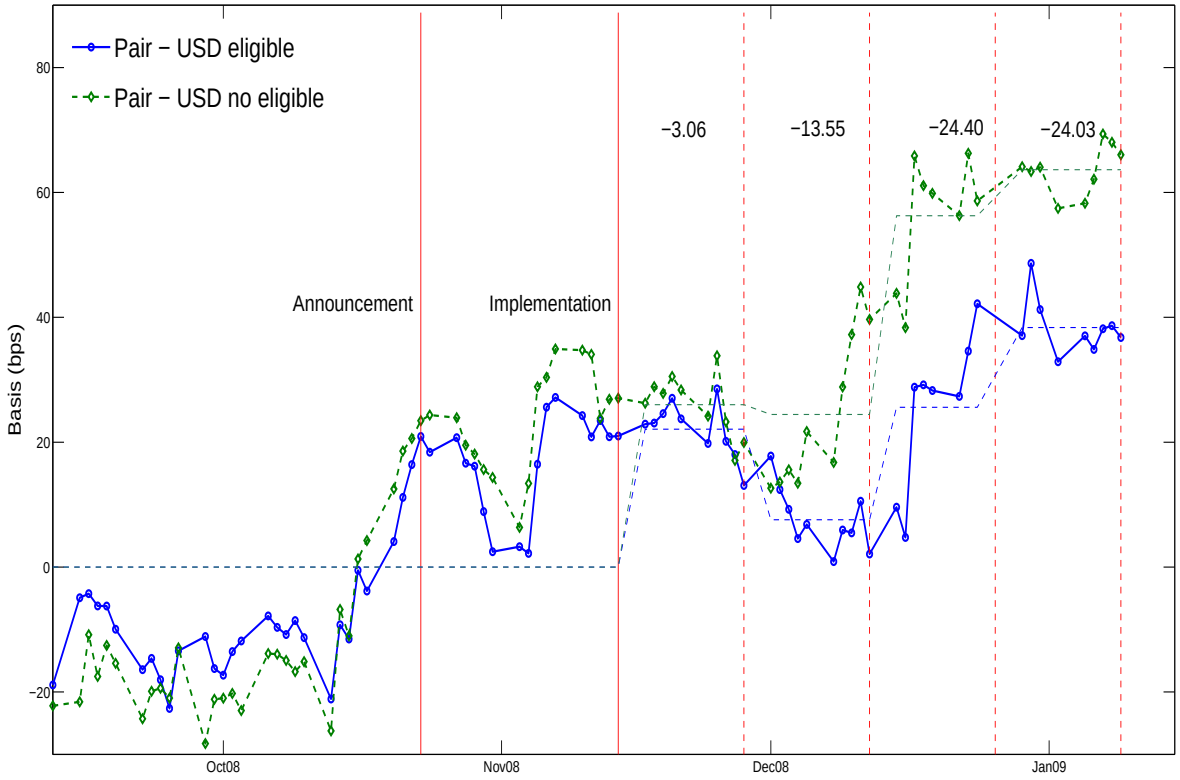


Figure 3: This figure illustrates our event study estimates by plotting the cross-sectional averages for the eligible USD-denominated pair group (blue line) and the non-eligible USD-denominated pair group (green line) minus their respective pre-event average mean over time. The dashed lines indicate the sub-period averages for pre event, 2 weeks after the event, 4 weeks after the event, 6 weeks after the event and 8 weeks after the event. We report the coefficient estimates "Dum. After$_t$ x Eligible Pairs$_{i,j}$" in the graph.

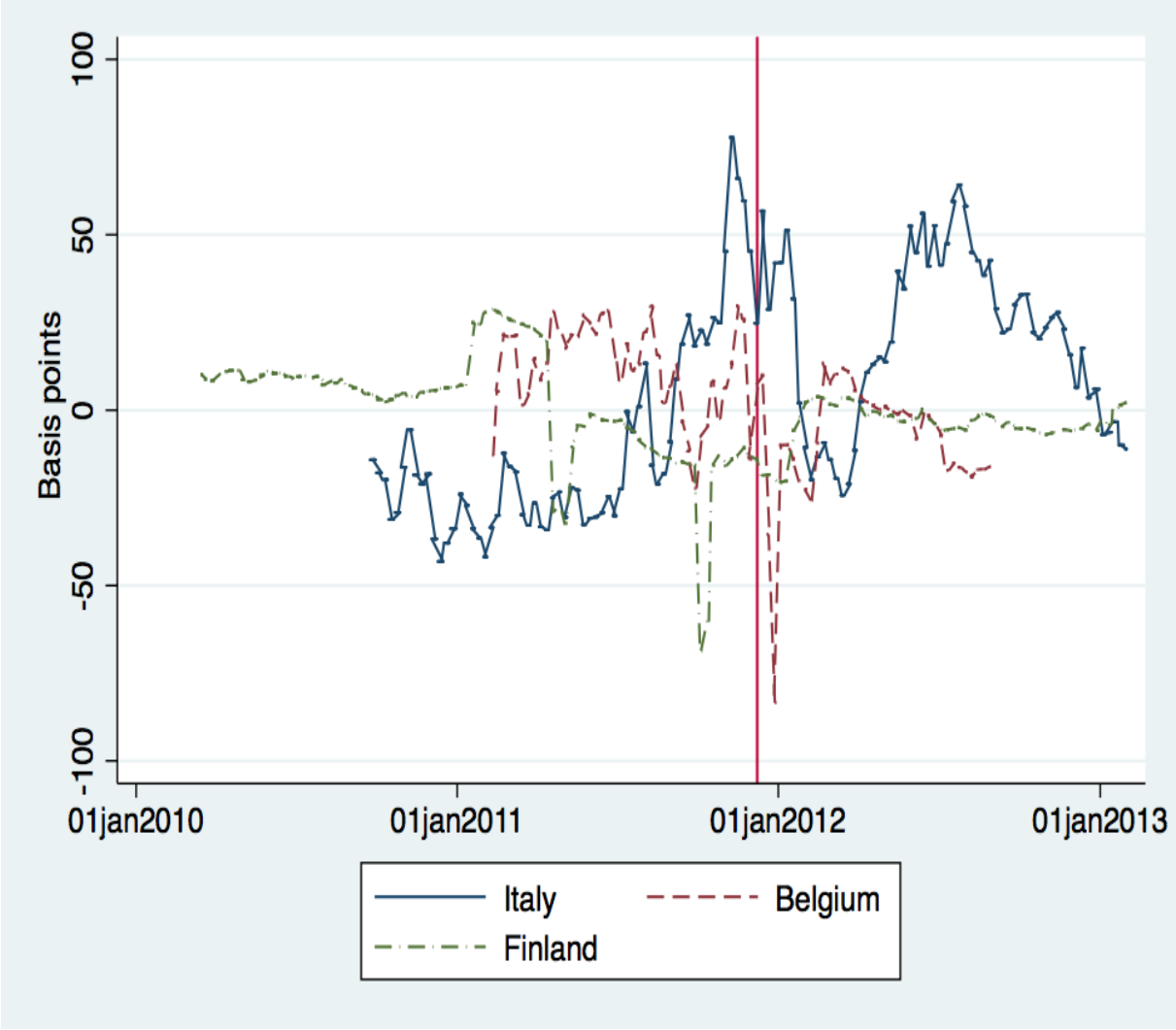


Figure 4: This figure depicts the basis of bond pairs issued by Belgium, Finland and Italy. For every bond pair, the basis is defined as the difference between the yield to maturity of the EUR-denominated fixed-rate coupon bond and the equivalent yield to maturity of the EUR-denominated floating-rate coupon bond. The equivalent yield to maturity is calculated daily by means of an asset swap. Bases are reported on weekly average basis and measured in basis points. The vertical line refers to the announcement of the 3−year LTROs (8th December 2011).

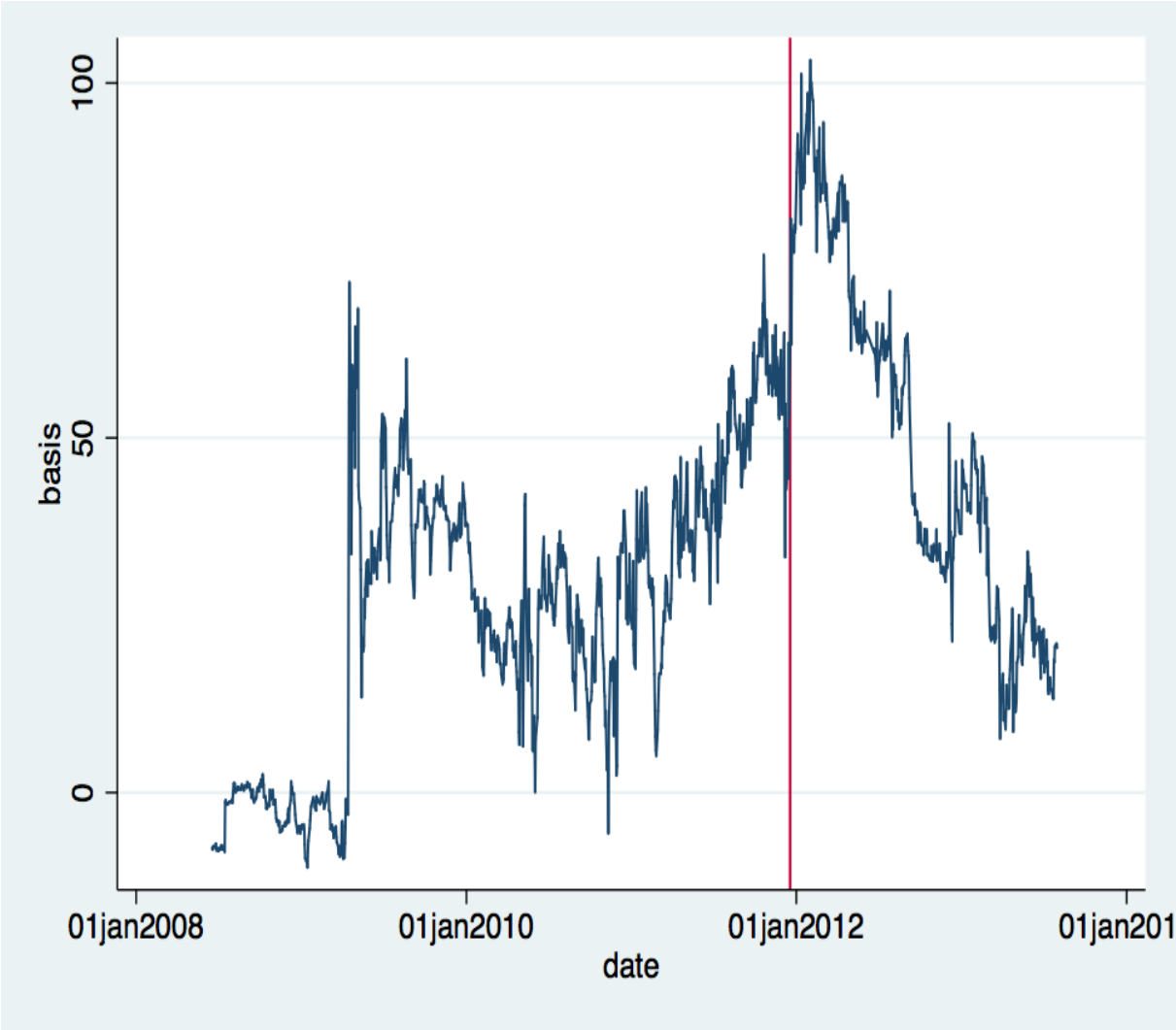


Figure 5: This figure depicts the basis of a bond pair issued by Italy. The basis is defined as the difference between the yield to maturity of the no eligible EUR-denominated fixed-rate coupon bond and the yield to maturity of the eligible and comparable EUR-denominated fixed-rate coupon bond. The basis is reported on daily basis and measured on basis points. The vertical line refers to the announcement of the 3−year LTROs (8th December 2011).

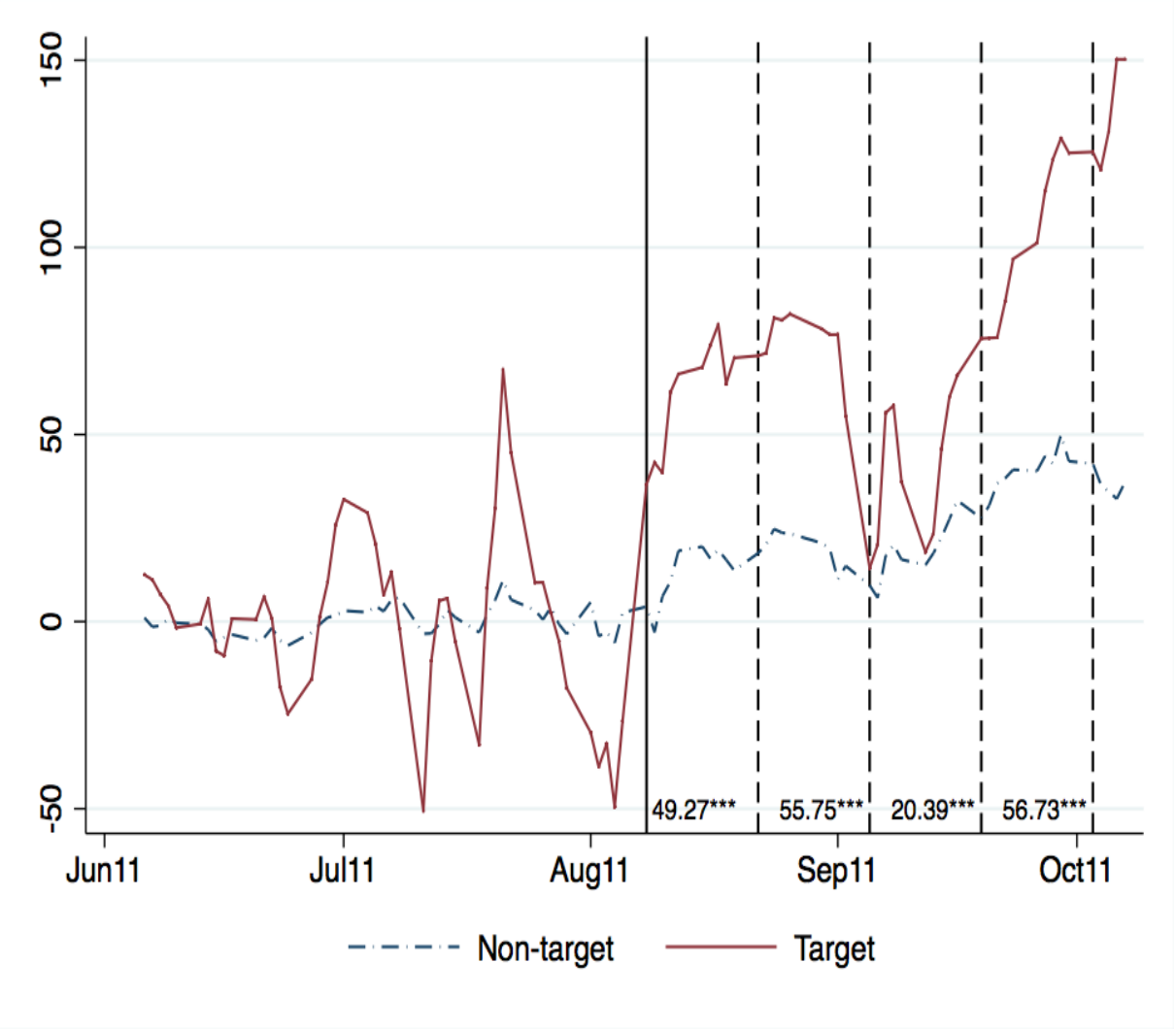


Figure 6: The figure shows the estimated response of the basis of the targeted countries, Italy and Spain, around the reactivation of the SMP on 8 August 2011 (see Column (4) of Table 6). It illustrates the event study estimates by plotting the cross-sectional averages for the target pair group (red solid line) and the no target pair group (blue dot-dashed line) minus their respective pre-event average mean over time. The dashed lines indicate the sub-period averages for pre event, 2 weeks after the event, 4 weeks after the event, 6 weeks after the event and 8 weeks after the event.

Tables

Table 1: This table reports the main descriptive statistics at pair bond level. We report the starting and ending date in sample, country, mean basis during the sample period, the ratio between the amount outstanding in USD- and EUR-denominated bonds and the governing law of the USD-denominated (bonds EUR-denominated are issued under the local law).

Starting	*End*	*Country*	*Mean Basis*	*Ration Am. Out*	*Gov. Law USD*
11/Jul/08	31/Aug/12	Belgium	39.07	0.10	Local
18/Sep/09	15/Feb/13	Belgium	96.38	0.05	Local
9/Apr/10	15/Feb/13	Belgium	37.43	0.15	Local
18/May/07	17/Jul/09	Spain	18.35	0.05	England
16/May/08	27/Jan/12	Spain	79.84	0.09	England
22/May/09	30/Apr/10	Spain	41.28	0.08	England
13/Mar/09	4/Mar/11	Spain	53.34	0.07	England
8/Jan/10	16/Sep/11	Spain	8.59	0.11	England
18/May/07	22/Jun/12	Austria	25.76	0.20	England
18/May/07	15/Feb/13	Austria	31.34	0.10	England
18/May/07	25/Mar/11	Austria	21.81	0.09	England
25/Sep/09	15/Jul/11	Austria	50.98	0.10	England
24/Jun/11	15/Feb/13	Austria	24.17	0.07	England
22/Oct/10	15/Feb/13	Finland	33.90	0.22	England
18/Mar/11	15/Feb/13	Finland	40.14	0.22	England
3/Sep/10	4/Feb/11	Italy	100.95	0.12	New York
18/May/07	15/Jun/12	Italy	27.32	0.08	New York
18/May/07	15/Feb/13	Italy	37.21	0.14	New York
18/May/07	15/Feb/13	Italy	73.05	0.06	New York
18/May/07	15/Feb/13	Italy	60.72	0.09	Local
15/Jun/07	15/Feb/13	Italy	75.85	0.06	England
12/Sep/08	16/Jul/10	Italy	37.46	0.09	New York
22/Jan/10	7/Oct/11	Italy	30.56	0.09	New York
5/Feb/10	15/Feb/13	Italy	26.35	0.09	New York
26/Nov/10	14/Sep/12	Italy	4.89	0.09	New York

Table 2: This table reports the estimation of Equation (2) in which we study the impact of the Bond Information and Market Factors on the basis. We employ a Prais-Winsten regression with country fixed-effects, correlated panel, corrected standard errors and robust to heterokedasticity and contemporaneous correlation across panels and serial autocorrelation within panels. The correlation within panels is treated as a first-order autocorrelation AR(1) and the coefficient of this process (ρ) is common to all the panels. Bond Information refers pair-specific information about the bond liquidity (Bid-Ask Spread), lending activity (Fees and No. Transaction) and bond covenants (Dum. England Law, Dum. NY Law and Dum. Additional Clauses). Following the definition of the basis, we construct pair-specific information as the difference between the USD- and the EUR-related variables. Market Factors refers to the Quanto CDS, Euro-OIS Spread, and the European Policy Uncertainty (EPI). The sample spans from January 2008 to February 2013 and it is composed of 25 pairs of bonds that belong to 5 European countries. Column (1) refers to the whole sample. Columns (2) and (3) refer to the "Pre European Sovereign Debt" and "European Sovereign Debt" crisis period, respectively. j denotes country specific variable and i denotes pair specific variable. The regression is conducted on weekly basis.

	(1)	(2)	(3)
Bid-Ask Spread$_{i,j,t}$	3.457**	13.389***	2.337
	(1.461)	(3.247)	(1.822)
Indicative Fee$_{i,j,t}$	-33.373	114.240	-47.157
	(128.774)	(99.292)	(176.088)
No. Transactions$_{i,j,t}$	-0.180***	-0.020	-0.237***
	(0.057)	(0.053)	(0.084)
Dum. England Law$_{i,j}$	19.351*	12.252	26.088*
	(10.130)	(9.007)	(14.622)
Dum. NY Law$_{i,j}$	-24.517***	-18.410***	-25.667**
	(8.449)	(7.128)	(11.864)
Dum. Additional Clauses$_{i,j}$	1.204	-1.539	-0.849
	(7.418)	(5.623)	(10.625)
Quanto CDS$_{j,t}$	82.663***	67.617***	85.785***
	(6.787)	(8.371)	(9.893)
Eurepo-OIS$_{j,t}$	-0.762	53.466***	-73.990***
	(8.961)	(7.798)	(15.255)
EPI$_t$	0.502***	0.507***	0.498***
	(0.039)	(0.038)	(0.058)
Dum. Belgium$_{j,t}$	38.336***	22.986**	44.016***
	(11.513)	(10.445)	(16.087)
Dum. Finland$_{j,t}$	-10.222**		-13.872***
	(4.002)		(4.302)
Dum. Italy$_{j,t}$	59.140***	56.341***	55.235***
	(7.828)	(7.497)	(11.258)
Dum. Spain$_{j,t}$	26.968***	14.942**	46.038***
	(9.289)	(7.182)	(15.546)
Constant	-76.664***	-66.501***	-88.056***
	(11.974)	(10.905)	(17.680)
ρ	0.836	0.843	0.807
Num. Obs.	3763	1470	2293
R^2	0.105	0.324	0.088

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3: This table shows the impact of changes in the eligibility criteria. Column (1) reports the estimation of Equation (3) where we conduct a panel regression analysis using the whole sample period on weekly basis. 1st Eligibility Window and 2nd Eligibility Window are two dummies that take 1 during the first and the second eligibility windows. Eligible Pair is a dummy that takes 1 for those pairs where the USD-denominated bonds are eligible. Columns (2) and (3) report the estimation of Equation (4) where we conduct an event study around the first and second implementation dates of the changes in the eligibility respectively. We consider a window of 8 weeks before and after the event. We break down the after period in four dummies that takes 1 in windows of two weeks. The regression is conducted on daily basis. We employ a Prais-Winsten regression correlated panel, corrected standard errors and robust to heterokedasticity and contemporaneous correlation across panels and serial autocorrelation within panels. The correlation within panels is treated as AR(1) and the coefficient of this process (ρ) is common to all the panels. j denotes country specific variable and i denotes pair specific variable.

	(1)	(2)	(3)
1st Eligibitity Window$_t$	20.561***		
	(4.002)		
2nd Eligibitity Window$_t$	19.882***		
	(6.504)		
Eligible Pair$_{i,j}$	22.900***	45.447***	10.488***
	(7.776)	(4.540)	(1.943)
1st Eligibitity Window$_t$ x Eligible Pair$_{i,j}$	-11.545**		
	(4.878)		
2nd Eligibitity Window$_t$ x Eligible Pair$_{i,j}$	-22.990**		
	(9.453)		
Dum. After 1w-2w$_t$		1.058	-11.179***
		(5.508)	(4.287)
Dum. After 3w-4w$_t$		-1.497	5.346
		(5.572)	(4.305)
Dum. After 5w-6w$_t$		31.776***	-3.846
		(5.638)	(4.308)
Dum. After 7w-8w$_t$		43.187***	5.401
		(5.738)	(4.303)
Dum. After 1w-2w$_t$ x Eligible Pair$_{i,j}$		-3.066	4.895*
		(3.116)	(2.641)
Dum. After 3w-4w$_t$ x Eligible Pair$_{i,j}$		-13.351***	-4.932*
		(3.472)	(2.778)
Dum. After 5w-6w$_t$ x Eligible Pair$_{i,j}$		-24.406***	-3.349
		(3.806)	(2.798)
Dum. After 7w-8w$_t$ x Eligible Pair$_{i,j}$		-24.038***	-2.856
		(4.268)	(2.764)
Constant	-105.933***	-8.719	40.842***
	(13.791)	(6.199)	(3.106)
Country FE	Yes	Yes	Yes
Time FE	No	No	Yes
Pair FE	No	Yes	Yes
Other Control Variables	Yes	No	No
ρ	0.823	0.791	0.639
Num. Obs.	3763	1078	850
R^2	0.128	0.726	0.861

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: This table shows the impact of the amount of sovereign debt collateral pledge at the ECB in exchange of liquidity. Columns (1) and (2) report the estimation of Equation (3) where we conduct a panel regression analysis using the whole sample period on weekly basis. Sov. Collateral to Tot Sov. refers to the of the sovereign debt collateral pledged over the total nominal sovereign debt outstanding by each country. Dum. High CDS is a dummy that takes 1 when the CDS of the same country reaches extreme levels (i.e., the CDS is above the 90th percentile). Dum. 3y-LTROs is a dummy variable that takes value 1 in the implementation dates of the 3−year LTROs. The regression is conducted on weekly basis. Column (3) reports the estimation of Equation (4) where we conduct an event study around the announcement date of the 3y-LTROs. We consider a window of 8 weeks before and after the event. We break down the after period in four dummies that takes 1 in windows of two weeks. The regression is conducted on daily basis. The analysis is conducted on weekly basis using a Prais-Winsten regression correlated panel, corrected standard errors and robust to heterokedasticity and contemporaneous correlation across panels and serial autocorrelation within panels. The correlation within panels is treated as AR(1) and the coefficient of this process (ρ) is common to all the panels. j denotes country specific variable and i denotes pair specific variable

	(1)	(2)	(3)
Sov. Collateral to Tot. Sov Debt$_{j,t}$	-37.407	-71.551	
	(68.105)	(67.235)	
Sov. Collateral to Tot. Sov Debt$_{j,t}$ x Dum. High CDS$_{j,t}$	295.968**		
	(122.770)		
Dum. High CDS$_{j,t}$	-33.046***		
	(6.217)		
Sov. Collateral to Tot. Sov Debt$_{j,t}$ x Dum. 3y-LTROs$_{j,t}$		309.958**	
		(131.899)	
Dum. 3y-LTROs$_{j,t}$		0.102	
		(4.760)	
Dum. After 1w-2w$_t$			28.127**
			(12.379)
Dum. After 3w-4w$_t$			45.728***
			(12.379)
Dum. After 5w-6w$_t$			5.985
			(12.379)
Dum. After 7w-8w$_t$			39.376***
			(12.379)
Constant	-79.438***	-78.388***	-9.356
	(11.784)	(11.497)	(9.739)
Country FE	Yes	Yes	Yes
Time FE	No	No	Yes
Pair FE	No	No	Yes
Other Control Variables	Yes	Yes	No
ρ	0.829	0.826	0.796
Num. Obs.	3763	3763	1231
R^2	0.128	0.116	0.708

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: This table reports the estimates of Equation (5) in which we study the ECB facilities and collateral management on the new basis defined as the difference between the estimated basis of each pair and the average basis of Turkey. We employ a Prais-Winsten regression with country fixed-effects, correlated panel, corrected standard errors and robust to heterokedasticity and contemporaneous correlation across panels and serial autocorrelation within panels. The correlation within panels is treated as a first-order autocorrelation AR(1) and the coefficient of this process (ρ) is common to all the panels. The sample spans from January 2008 to February 2013 and it is composed of 25 pairs of bonds that belong to 5 European countries. Column (1) reports the impact of changes in the eligibility criteria. 1st Eligibility Window and 2nd Eligibility Window are two dummies that take 1 during the first and the second eligibility windows. Eligible Pair is a dummy that takes 1 for those pairs where the USD bonds are eligible. Column (2) reports the effect of the sovereign debt collateral pledged at the ECB. Sov. Collateral to Tot Sov. refers to the of the sovereign debt collateral pledged over the total nominal sovereign debt outstanding by each country. Dum. High CDS is a dummy that takes 1 when the CDS of the same country reaches extreme levels (i.e., the CDS is above the 90th percentile). Column (3) reports the effect of the 3y-LTRO. Dum. 3y-LTROs is a dummy variable that takes value 1 in the implementation dates of the 3y-LTROs. j denotes country specific variable and i denotes pair specific variable. The regression is conducted on weekly basis.

	(1)	(2)	(3)
1st Eligibitity Window$_t$	11.286***		
	(4.366)		
2nd Eligibitity Window$_t$	26.602***		
	(6.953)		
Eligible Pair$_{i,j}$	13.180		
	(10.807)		
1st Eligibitity Window$_t$ x Eligible Pair$_{i,j}$	-10.957*		
	(5.861)		
2nd Eligibitity Window$_t$ x Eligible Pair$_{i,j}$	-23.668**		
	(10.648)		
Sov. Collateral to Tot. Sov Debt$_{j,t}$		-141.717*	-159.235**
		(80.043)	(78.683)
Sov. Collateral to Tot. Sov Debt$_{j,t}$ x Dum. High CDS$_{j,t}$		405.487***	
		(131.656)	
Dum. High CDS$_{j,t}$		-39.891***	
		(6.665)	
Sov. Collateral to Tot. Sov Debt$_{j,t}$ x Dum. 3y-LTRO$_t$			297.494**
			(146.528)
Dum. 3y-LTROs$_{j,t}$			-3.348
			(5.759)
Constant	-151.062***	-135.501***	-133.845***
	(16.556)	(13.325)	(13.073)
Country FE	Yes	Yes	Yes
Control Variables	Yes	Yes	Yes
ρ	0.818	0.832	0.829
Num. Obs.	3763	3763	3763
R^2	0.115	0.118	0.108

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

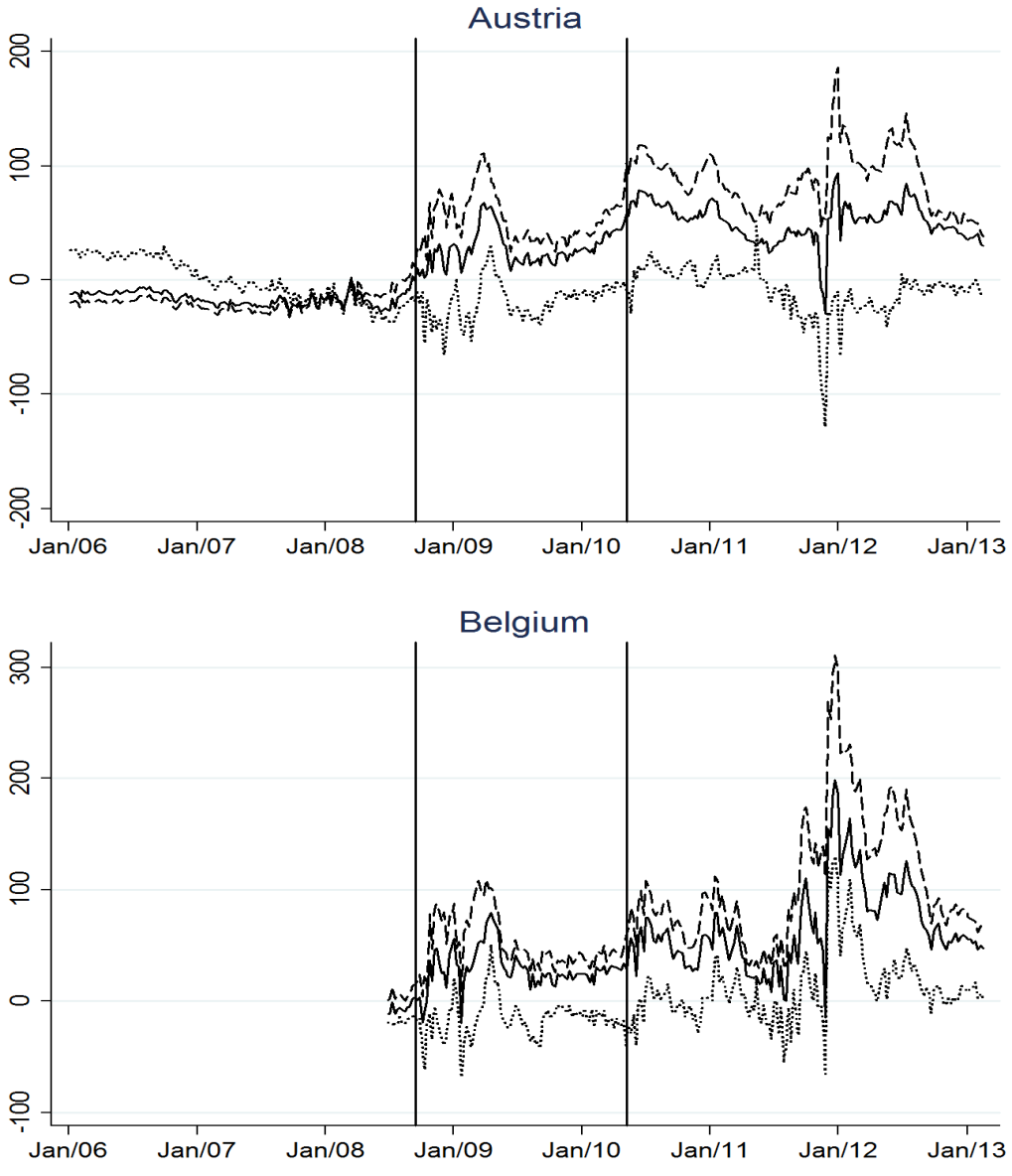
Table 6: This table reports the impact of the Securities Market Programme (SMP). Columns (1) − (3) reports the estimates of Equation (3) where we conduct a panel regression analysis on the euro area sovereign debt crisis period (from May 2010 to February 2013). Column (1) reports the results using the weekly public available SMP purchases; column (2) reports the results using weekly purchases at country level; and column (3) reports the results using weekly purchases at pair level. The regressions are conducted on weekly basis. Column (4) reports the estimates of Equation (4) where we conduct an event study around the reactivation of the SMP in August 2011. We consider a window of 8 weeks before and after the event. We break down the after period in four dummies that takes 1 in windows of two weeks. Target Countries is a dummy that takes 1 for Italy and Spain and zero otherwise. The regression is conducted on daily basis. In the estimations we employ a Prais-Winsten regression correlated panel, corrected standard errors and robust to heterokedasticity and contemporaneous correlation across panels and serial autocorrelation within panels. The correlation within panels is treated as AR(1) and the coefficient of this process (ρ) is common to all the panels. j denotes country specific variable and i denotes pair specific variable.

Panel A	(1)	(2)	(3)	(4)
SMP_t	1.690***			
	(0.169)			
$SMP_{j,t}$		2.414***		
		(0.371)		
$SMP_{i,j,t}$			25.654**	
			(11.401)	
Dum. After 1w-2w$_t$				37.413***
				(5.930)
Dum. After 3w-4w$_t$				36.177***
				(5.944)
Dum. After 5w-6w$_t$				20.458***
				(5.930)
Dum. After 7w-8w$_t$				56.019***
				(5.980)
Dum. After 1w-2w$_t$ x Target Countries$_j$				49.266***
				(4.955)
Dum. After 3w-4w$_t$ x Target Countries$_j$				55.745***
				(5.040)
Dum. After 5w-6w$_t$ x Target Countries$_j$				20.388***
				(4.955)
Dum. After 7w-8w$_t$ x Target Countries$_j$				56.727***
				(5.111)
Target Countries$_j$				-99.275***
				(6.111)
Constant	-83.757***	-90.952***	-88.713***	18.668***
	(17.457)	(17.233)	(17.633)	(6.391)
Country FE	Yes	Yes	Yes	Yes
Time FE	No	No	No	Yes
Pair FE	No	No	No	Yes
Other control variables	Yes	Yes	Yes	No
ρ	0.811	0.806	0.808	0.780
Num. Obs.	2293	2293	2293	1436
R^2	0.127	0.111	0.091	0.768

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix A

These figures show the average basis using three different approaches to convert the USD-denominated cash flows in EUR. The solid line depicts the trading strategy considered in the paper. It involves buying a cross currency asset swap package to exchange the fixed coupon of the USD-denominated bond at the Euribor rate plus a spread and getting into a floating-fixed interest rate swap to exchange that EUR-denominated stream of floating inflow into a fixed coupon rate. The dashed line depicts the Tuckman and Porfidio's (2003) strategy to create an adjusted forward rate that takes into account violations of the covered interest parity in the long run. The dotted line depicts the trading strategy that involves the use of forward contracts to convert the USD-denominated cash flows. The sample spans from January 2006 to February 2013 and the y-axis in measure in basis points. Vertical lines refer to the Lehman Brothers collapse (September 2008) and the starting date of the Securities Market Programme (May 2010)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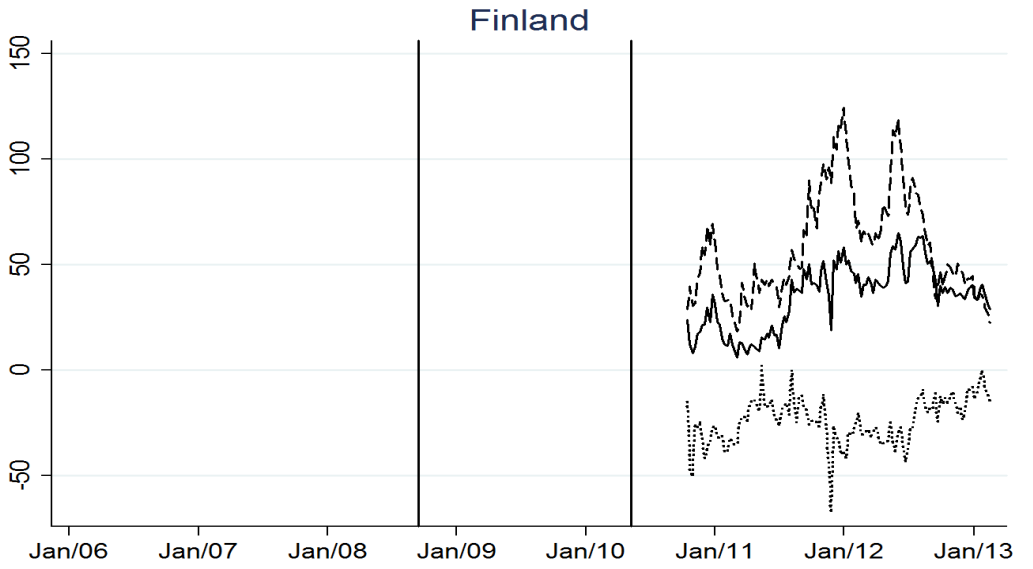
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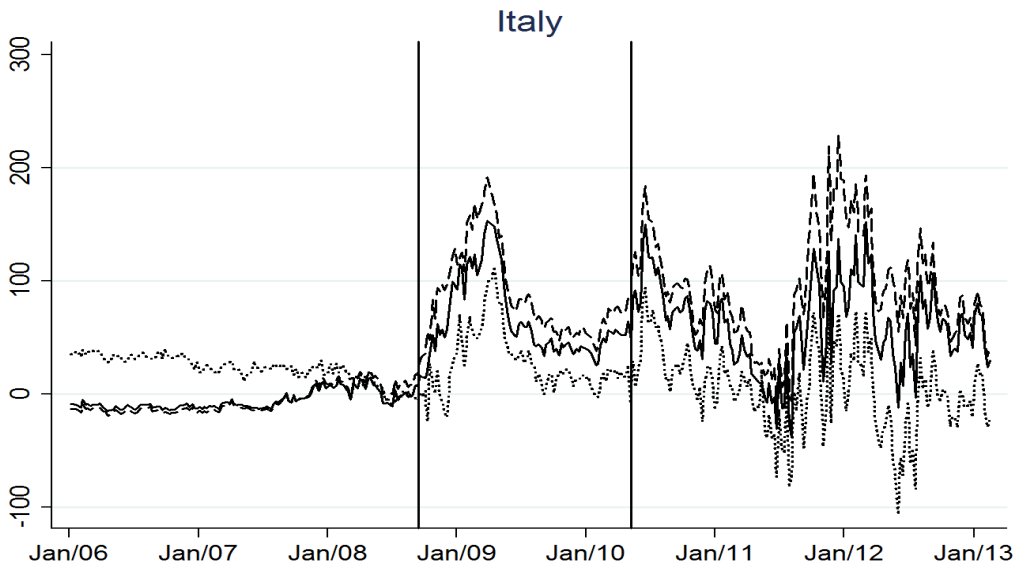
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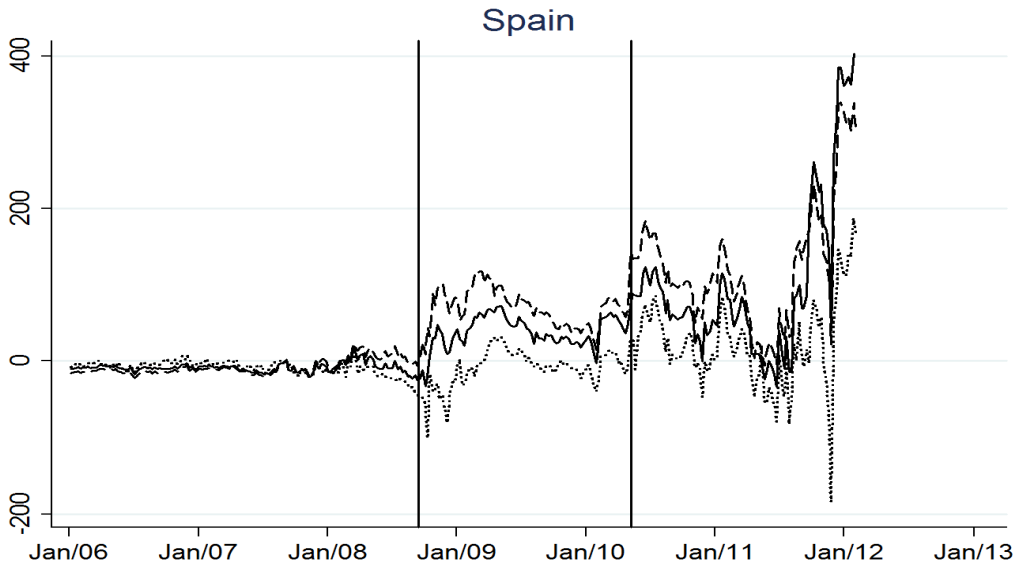
Spain
400
200
0
-200
Jan/06
Jan/07
Jan/08
Jan/09
Jan/10
Jan/11
Jan/12
Jan/13

Appendix B

Table 7: Bond descriptive statistics. This table reports the main descriptive statistics at bond level. We report the ISIN, issuer country, settlement and maturity dates, coupon (all bonds are fixed rate), currency, and outstanding amount in millions of EUR (for those bonds USD-denominated we apply the spot exchange rate of the settlement date).

ISIN	*Country*	*Settlement Date*	*Maturity Date*	*Coupon*	*Currency*	*Amount Out.*
AT0000385356	Austria	15/Jan/02	15/Jul/12	5	EUR	10000
AT0000385992	Austria	28/May/03	20/Oct/13	3.8	EUR	13127
XS0170724479	Austria	25/Jun/03	25/Jun/13	3.25	USD	2687
AT0000386073	Austria	15/Jan/04	15/Jul/14	4.3	EUR	9560
XS0192781150	Austria	19/May/04	19/May/14	5	USD	998
XS0211055891	Austria	26/Jan/05	30/Mar/12	4	USD	918
XS0453795824	Austria	23/Sep/09	15/Nov/12	2	USD	1018
AT0000A0GLY4	Austria	15/Jan/10	20/Feb/17	3.2	EUR	9877
XS0638878461	Austria	17/Jun/11	17/Jun/16	1.75	USD	699
BE0000314238	Belgium	24/Apr/08	28/Mar/14	4	EUR	13000
BE0934531337	Belgium	1/Jul/08	3/Sep/13	4.25	USD	1266
BE6000356335	Belgium	15/Sep/09	15/Sep/14	2.875	USD	682
BE6000673598	Belgium	5/Mar/10	5/Mar/15	2.75	USD	1468
BE0000319286	Belgium	16/Mar/10	28/Mar/16	2.75	EUR	9594
FI4000018049	Finland	21/Sep/10	15/Apr/16	1.75	EUR	6500
XS0550739535	Finland	19/Oct/10	19/Oct/15	1.25	USD	1448
XS0605995561	Finland	17/Mar/11	17/Mar/16	2.25	USD	1426
IT0003190912	Italy	1/Feb/02	1/Feb/12	5	EUR	28303
XS0144129649	Italy	1/Mar/02	15/Jun/12	5.625	USD	3467
US465410BF43	Italy	27/Feb/03	15/Jun/13	4.375	USD	1861
IT0003472336	Italy	2/May/03	1/Aug/13	4.25	EUR	24696
IT0003719918	Italy	1/Sep/04	1/Feb/15	4.25	EUR	21350
US465410BN76	Italy	21/Jan/05	21/Jan/15	4.5	USD	3075
IT0003844534	Italy	2/May/05	1/Aug/15	3.75	EUR	25809
US465410BQ08	Italy	25/Jan/06	25/Jan/16	4.75	USD	1634
IT0004019581	Italy	1/Mar/06	1/Aug/16	3.75	EUR	26738
US465410BR80	Italy	20/Sep/06	20/Sep/16	5.25	USD	2364
IT0004164775	Italy	2/Jan/07	1/Feb/17	4	EUR	25598
US465410BS63	Italy	12/Jun/07	12/Jun/17	5.375	USD	1503
US465410BT47	Italy	4/Jun/08	15/Jul/11	3.5	USD	1621
IT0004404973	Italy	1/Sep/08	1/Sep/11	4.25	EUR	18199
US465410BU10	Italy	5/Oct/09	5/Oct/12	2.125	USD	1706
IT0004564636	Italy	4/Jan/10	15/Dec/12	2	EUR	18686
IT0004568272	Italy	15/Jan/10	15/Apr/15	3	EUR	20404
US465410BV92	Italy	26/Jan/10	26/Jan/15	3.125	USD	1776
US465410BW75	Italy	16/Sep/10	16/Sep/13	2.125	USD	1530
IT0004653108	Italy	1/Nov/10	1/Nov/13	2.25	EUR	17819
ES00000120E9	Spain	12/Apr/05	30/Jul/10	3.25	EUR	16183
XS0225226710	Spain	20/Jul/05	20/Jul/10	4.125	USD	823
ES00000120Z4	Spain	15/Jan/08	30/Apr/11	4.1	EUR	15542
ES0000011660	Spain	8/Apr/08	31/Jan/13	6.15	EUR	13606
XS0363874081	Spain	14/May/08	17/Jun/13	3.625	USD	1292
XS0376589288	Spain	16/Jul/08	18/Jul/11	3.375	USD	1264
ES0000121I8	Spain	13/Jan/09	30/Apr/12	2.75	EUR	11939
XS0416150950	Spain	5/Mar/09	5/Mar/12	2.75	USD	797
XS0452149072	Spain	17/Sep/09	17/Sep/12	2	USD	1696
ES00000121T5	Spain	6/Oct/09	30/Apr/13	2.3	EUR	14894
US900123AS92	Turkey	24/Sep/03	15/Jan/14	9.5	USD	1523
DE000A0AU933	Turkey	10/Feb/04	10/Feb/14	6.5	EUR	788
XS0245387450	Turkey	1/Mar/06	1/Mar/16	5	EUR	629
US900123AZ36	Turkey	26/Sep/06	26/Sep/16	7	USD	1577
XS0285127329	Turkey	2/Feb/07	2/Apr/19	5.875	EUR	965
US900123BA75	Turkey	3/Oct/07	3/Apr/18	6.75	USD	1597
US900123BH29	Turkey	18/Mar/10	30/Mar/21	5.625	USD	1470
XS0503454166	Turkey	22/Apr/10	18/May/20	5.125	EUR	1505