

Lender of Last Resort versus Buyer of Last Resort — Evidence from the European Sovereign Debt Crisis[☆]

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Abstract

We assess from a financial stability standpoint the effectiveness of two significant interventions of the European Central Bank (ECB) during the sovereign debt crisis. By being the lender of last resort via the long-term refinancing operations (LTROs), the ECB temporarily reduced funding pressure for banks, but did not address solvency concerns. Banks in the peripheral countries became excessively dependent on public funds and increased their exposure to risky domestic debt. In contrast, the ECB's announcement of being a potential buyer of last resort via the Outright Monetary Transaction (OMT) program increased sovereign bond prices, permanently improving solvency conditions for eurozone banks. Nevertheless, banks in the peripheral countries remained weak and heavily dependent on public funds.

Keywords: Money market funds, repos, bank risk, sovereign debt, ECB

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“The Governing Council of the European Central Bank (ECB) has today decided on additional enhanced credit support measures to support bank lending and liquidity in the eurozone money market.” (European Central Bank press release, December 8, 2011.)

“Within our mandate, the ECB is ready to do whatever it takes to preserve the euro. And believe me, it will be enough. (...) The short-term challenges in our view relate mostly to the financial fragmentation that has taken place in the eurozone.” (Speech by Mario Draghi, President of the European Central Bank at the Global Investment Conference in London, July 26, 2012.)

1. Introduction

Europe has been in an extraordinary period of banking and sovereign stress since 2009. The sovereign debt crisis that started in 2009-10 affected peripheral countries due to high sovereign or private sector debt and intimate sovereign-bank linkages (Acharya and Steffen, 2015). This caused substantial instability in the European financial sector; the solvency risk of banks increased, which in turn had immediate consequences on their funding liquidity. Funding liquidity risk peaked in the summer of 2011, when short-term investors “ran” from European banks by massively withdrawing short-term funding. In particular, U.S. money market funds (MMFs) were the first group of investors to withdraw from banks in the eurozone; U.S. prime MMFs holdings of eurozone banks fell from 30% of their assets in May 2011 to 11% by December 2011 (Investment Company Institute, 2013).

The European Central Bank (ECB) reacted with a series of non-standard measures to deal with the sovereign debt crisis, such as engaging in the three-year Long-Term Refinancing Operation (LTRO) liquidity injections in December 2011 and February 2012, and announcing the Outright Monetary Transactions (OMT) program in the summer of 2012. An important dimension along which these programs differed is whether the ECB acted as *lender of last resort* (LOLR) or *buyer of last resort* (BOLR). When acting as a LOLR (e.g., in the LTROs), the ECB provided banks with funding liquidity in exchange for eligible collateral. When acting as a BOLR (e.g., in the OMT), the ECB purchased or announced commitment to

purchase eurozone government bonds.

While a LOLR provides banks with liquidity, the risk of moral hazard may increase if banks can use the public funds to increase their exposure to risky but eligible collateral because of, for example, gambling incentives (Acharya and Tuckman, 2014). In the context of the European sovereign debt crisis, under-capitalized banks would have incentives to increase their holdings of risky domestic sovereign debt (Crosignani, 2015), especially once they are eligible collateral at the central bank at attractive haircuts (Drechsler et al., 2015; Hoshi and Kashyap, 2015; Nyborg, 2015). Such response could segment the market for eligible collateral by making domestic banks the dominant holder of these assets, further strengthening the bank-sovereign nexus. While banks may be able to temporarily raise funding against eligible collateral, an increase in the riskiness of collateral (e.g., due to further sovereign stress) could aggravate funding risk due to the increased holdings of risky collateral.

In contrast, purchasing assets directly from the market does not segment the market preferentially towards banks. To unfreeze asset and credit markets, Diamond and Rajan (2011) show that the central bank should implement an intervention that moves the risky assets from weak banks into safer hands. The credibility of asset purchases in future periods of stress can attract even non-bank financial firms to the market, allowing banks to delever by selling the risky assets and reducing the risk of fire sales. In the context of the European sovereign debt crisis, this would imply taking on some of the risks associated with sovereign debt holdings and providing liquidity to the markets at large, in turn weakening the domestic bank-sovereign nexus. By doing so, the asset purchases by the central bank could result in restoring the private funding for banks in a sustainable manner.

We study the effects of the two ECB policy measures — LTRO and OMT — in stabilizing sovereign debt markets and funding markets for banks. In particular, we ask the following questions: In response to these unconventional ECB interventions, how did the markets for sovereign debt react? How did the banks adjust their sovereign bond holdings? How did

ECB interventions affect bank access to short-term funding? And, were different central bank measures (LOLR versus BOLR) equally effective?

In a first step, we analyze how the ECB interventions affected sovereign and bank risk in the eurozone since 2011. We investigate the impact of ECB interventions on (i) sovereign bond yields and sovereign credit default swap (CDS) spreads, (ii) banks' holdings of sovereign bonds, and (iii) bank equity prices and bank CDS spreads. We distinguish between (i) the peripheral countries of Greece, Ireland, Italy, Portugal and Spain (GIIPS), with a specific focus on Italy and Spain as the largest economies in the eurozone periphery; (ii) non-GIIPS eurozone countries; and (iii) non-eurozone European countries. The last group is a control group where eurozone-specific risks should be less relevant.

Using an event study methodology, we find that the LTRO liquidity injections did not affect the sovereign risk of GIIPS countries to any great extent. We do not find a significant reduction in sovereign yields around the announcement dates and allotment dates of the LTROs, consistent with the results of Krishnamurthy, Nagel, and Vissing-Jorgensen (2015). Moreover, sovereign bond yields did not stabilize after the LTRO liquidity injections. In fact, average GIIPS sovereign CDS spreads increased to their highest levels after the second LTRO. For example, sovereign CDS spreads of Spain and Italy increased, on average, by 48% between February 2012 and July 2012.¹

Banks from the peripheral countries used the LTRO allotments to purchase domestic sovereign bonds. Italian and Spanish banks, for example, increased their domestic sovereign bond holdings by € 49 billion in the time period between the announcements of the LTRO and OMT programs, increasing the domestic share in their sovereign bond portfolios from 79% to 83%. The LTRO liquidity injections thus entrenched GIIPS sovereign bonds to GIIPS

¹In the spring of 2012, attention shifted to Italy and Spain amid a worsening situation across the eurozone due to high levels of public debt and the economic problems of these countries. Borrowing costs rose substantially and in June 2012, Spain asked for bailout funds from the European Stability Mechanism (ESM) for its banking sector.

banks' balance sheets. In contrast, non-GIIPS eurozone banks' balance sheets were stronger, thus these banks did not have the same incentives to purchase risky sovereign bonds.² In other words, sovereign risk in the eurozone became more concentrated in the portfolios of peripheral banks while non-GIIPS eurozone banks continued to reduce their GIIPS sovereign exposures.

Due to the elevated sovereign-bank linkages in the GIIPS countries, the increase in sovereign risk and sovereign bond yields following the three-year LTRO liquidity injections worsened the financial health of their domestic banks. The average five-year CDS spread of Italian and Spanish banks, for example, increased by 47% in the time period between the second LTRO in February 2012 and the OMT program in the summer of 2012. But despite the rotation of sovereign risk from core to peripheral European banks, the LTRO liquidity injections did not make the worsening of the sovereign debt crisis less of a pan-European problem. In fact, non-GIIPS banks' CDS spreads substantially increased after the second LTRO allotment. The five-year CDS spreads of non-GIIPS eurozone banks increased by 23%. At the same time, the average equity prices of GIIPS banks and non-GIIPS eurozone banks dropped by 60% and 36%, respectively.

In striking contrast with the LTRO liquidity injections, we find that the announcement of the OMT program (introduced by Mario Draghi's "Whatever it takes" speech on July 26, 2012) significantly reduced the sovereign yields and CDS spreads of Italy and Spain. Our event study results show a larger abnormal two-day reduction of 5-year CDS spreads of Italy and Spain around the announcement of the details of the OMT program in September 2012 (-49 bps and -73 bps, respectively), compared to the abnormal reduction in Italian and Spanish CDS spreads around Draghi's speech in July 2012 (-39 bps and -54 bps, respectively). Compared to previous BOLR actions of the ECB (e.g., the securities markets program in

²Acharya and Steffen (2015) identify the risk shifting or "carry trade" incentives of under-capitalized GIIPS banks as the primary motive for sovereign bond purchases.

May 2010 and August 2011), the OMT program established strict and effective conditionality for countries to enter the program ruling out an additional ECB intervention without reform efforts from sovereigns. The OMT program eventually increased the demand of GIIPS sovereign bonds from non-GIIPS investors. Non-GIIPS banks and non-bank financial institutions started buying GIIPS sovereign bonds again following the announcement of the OMT program, reducing the GIIPS bank-sovereign nexus, and sovereign bond prices surged.

The announcement of the possibility of asset purchases stabilized sovereign bond prices, consequently, we find increasing equity prices, as well as decreasing CDS spreads of all eurozone banks following the announcement of the OMT program in the summer of 2012. The average five-year CDS spreads of GIIPS and non-GIIPS eurozone banks fell by 27% and 45%, respectively, between July 2012 and December 2012. Over the same period, the average equity prices of GIIPS and euro non-GIIPS banks increased by 36% and 41%, respectively. However, the announcement effect of the OMT program is only significant for GIIPS banks; the average cumulative abnormal CDS changes of GIIPS banks are significantly negative surrounding the announcement of the details of the OMT program. As discussed above, the GIIPS banks purchased a substantial amount of domestic sovereign bonds at low prices/high yields with LTRO money. The OMT program brought about an increase in the value of these bonds and helped to improve the financial health of GIIPS banks in particular, as the main holder of these bonds.

For our analysis of bank funding markets, we employ monthly data on U.S. MMF investments in European banks. We begin our sample period in November 2010, when the regulatory requirement of U.S. MMFs to report their portfolio composition started, and collected their data until August 2014. Before analyzing the impact of the ECB interventions on funding risk, we document the “run” of U.S. MMFs on European banks before the interventions. In the summer of 2011, European banks lost about 50% of their U.S. dollar unsecured funding (\$ -300 billion) via MMFs. We argue that the reduction in U.S. dollar

funding for European banks was not caused by a lower demand from European banks for U.S. dollar liquidity but reflects a reduction in the supply of liquidity by U.S. MMFs and provide various pieces of evidence to support this. First, U.S. MMFs exposed to eurozone banks experienced redemptions from their investors during that period (Chernenko and Sunderam, 2014), and became increasingly sensitive to eurozone risk. Second, the cost of alternative sources of U.S. dollar funding for European banks also increased (Ivashina, Scharfstein, and Stein, 2015). Third, we find the largest MMF outflows from GIIPS banks, and almost no outflows at non-eurozone European banks during that period. Similarly, MMF outflows are the largest for banks with large GIIPS sovereign debt exposures. Finally, the MMF outflows are predictive of the demand for LTRO liquidity.

The ECB LTRO liquidity injections initially helped stop the MMF run and even prompted U.S. MMF flows from non-eurozone banks to non-GIIPS eurozone banks. However, the moral hazard behavior of GIIPS banks to load on risky domestic sovereign debt, which deepened the sovereign-bank linkages in the peripheral countries, also increased the risk for the eurozone as a whole. Consequently, the run by U.S. MMFs on GIIPS and non-GIIPS eurozone banks intensified after the second LTRO allotment in February 2012.

The OMT program led to the reversal of the unsecured MMF flows, but only for non-GIIPS banks. Between July and December 2012, U.S. MMFs increased their unsecured funding of non-GIIPS eurozone banks by 89% and of non-eurozone European banks by 8%. Specifically, we find that MMF investors returned to the banks holding GIIPS sovereign bonds as the OMT program provided insurance for these bonds. Our results suggest that the non-GIIPS eurozone banks exposed to GIIPS sovereign debt were better able to recover access to U.S. MMFs, and that their funding risk — measured by the probability of losing access to U.S. MMFs — did not increase when holding GIIPS sovereign bonds in the post-OMT period. In contrast, GIIPS banks remained heavily dependent on public funds from the ECB. In spite of the improved solvency conditions, GIIPS banks remain weak in terms

of an absolute level of capitalization, e.g. based on book and market leverage ratios.

In summary, while both LOLR and BOLR interventions induced the temporary easing of bank funding risk, only the BOLR intervention improved the prices of sovereign bonds. The first sentence of the LTRO announcement on December 8, 2011 specifies that the LTRO is intended to address a funding liquidity problem at banks. The LTRO affected the liability side of banks and reduced immediate funding liquidity risk, but did not address solvency concerns. In contrast, the introductory quote of Mario Draghi from his speech of July 26, 2012 (announcing the OMT program) refers to the fragmentation of financial markets in the eurozone as the prevailing short-term challenge. The ECB dealt with financial fragmentation with the announcement of the OMT program. Without purchasing any asset under this program, the ECB's announcement of being a potential BOLR to the sovereign bond markets under the OMT program did improve the asset side of eurozone banks by stabilizing the prices of their assets. In turn, only the buyer of last resort intervention reduced the solvency risk of eurozone banks. This led to a sustained improvement in bank funding conditions for non-GIIPS eurozone banks, but GIIPS banks remained dependent on public funds.

The rest of the paper proceeds as follows. In Section 2, we relate our paper to the literature and describe the institutional background, as well as data used in our analyses. In Section 3, we investigate how ECB interventions affected sovereign bond prices. We focus on effects on bank risk in Section 4. In Section 5, we investigate the MMF flows. We conclude in Section 6 with policy implications.

2. Literature, Institutional Background, and Data

In this section, we review the literature related to the bank-sovereign nexus, ECB interventions, and funding liquidity in the European financial sector. We also describe the institutional background of ECB interventions (LTROs and OMT program), as well as data used in our analyses.

2.1. Related literature

Our paper is related to the literature on the bank-sovereign nexus. Acharya, Drechsler, and Schnabl (2014a) model the interaction between sovereign and bank credit risk. Using CDS data, they show that bank bailouts were followed by increasing sovereign risk and increasing co-movements between sovereign CDS and bank CDS spreads. In the model of Crosignani (2015), under-capitalized banks act as buyers of last resort for home public debt as they gamble for resurrection. Farhi and Tirole (2015) model the feedback loop between banks and sovereigns that allows for both domestic bank bailouts by the government and sovereign debt forgiveness. Gennaioli, Martin, and Rossi (2014) present a model where government defaults should lead to declines in private credit, even more for countries where banks hold more government bonds. In addition, De Marco and Macchiavelli (2016) and Ongena, Popov, and Van Horen (2016) focus on moral suasion as a channel that leads to an increase in home bias during the European sovereign debt crisis.

Our paper is related to the literature on the effect of monetary policy interventions by the ECB on sovereign bond yields. The evidence in some of these papers suggests that the OMT program announcement significantly lowered sovereign bond spreads (Altavilla, Giannone, and Lenza, 2014; Krishnamurthy, Nagel, and Vissing-Jorgensen, 2015; Saka, Fuertes, and Kalotychou, 2015; Szczerbowicz, 2015). Szczerbowicz (2015) finds that the OMT program led to a lowering of covered bond spreads and GIIPS sovereign yields. Krishnamurthy, Nagel, and Vissing-Jorgensen (2015) investigate the channels causing the reduction in sovereign bond yields around the Securities Markets Program (SMP), the LTRO liquidity injections, and the OMT program. They find evidence consistent with a reduction in default risk, segmentation, and redenomination risk among GIIPS countries. Saka, Fuertes, and Kalotychou (2015) find that the perceived commonality in default risk among peripheral and non-GIIPS eurozone sovereigns increased after Mario Draghi's "Whatever it takes" speech. Finally, Crosignani, Faria-e Castro, and Fonseca (2015) find that the yield curve for the Portuguese sovereign

bonds steepens after the LTRO announcement as Portuguese banks increased their domestic holdings of shorter maturities.

Our paper is also related to the literature on funding liquidity in the European banking sector. Mancini, Ranaldo, and Wrampelmeyer (2015) show that the central counterparty-based euro interbank repo market stabilized funding markets during the sovereign debt crisis because of its market design and high-quality collateral. In other words, there was no run on euro repo markets as there was in the U.S. in the summer of 2007 (Gorton and Metrick, 2012). Repo rates were however higher for GIIPS counterparties at the peak of the European sovereign debt crisis in 2011 (Boissel et al., 2015). Perignon, Thesmar, and Vuillemeys (2016) study the European market for certificates of deposits and find a reallocation of funds towards higher quality banks during periods of stress. Garcia de Andoain et al. (2016) also find that rates dropped on unsecured interbank markets with ECB excess liquidity only in stressed economies like those in Italy and Spain.

Relative to this literature, we highlight the differential effect of LOLR versus BOLR policies in the context of the European sovereign debt crisis. While providing liquidity to European banks, we find that the LTRO allotments did not mitigate sovereign risk but instead further entrenched sovereign debt to peripheral banks' balance sheets. In contrast, the possibility to buy sovereign debt outright in the OMT program substantially reduced sovereign risk. We show how these ECB interventions affect bank risk through sovereign-bank linkages. Importantly, we show the effect of LOLR and BOLR policies on the behavior of short-term wholesale investors (U.S. MMFs) that are not protected by deposit insurance and particularly sensitive to banks exposure to sovereign risk. We do not, however, analyze whether non-standard policy measures by the ECB affected bank lending and the real sector.³

³Analyzing the implications of the introduction of the full allotment concept (and the first LOLR liquidity injection by the ECB) in October 2008, Acharya et al. (2015) find that the intervention reduced funding risk for all banks; however, it did not result in better lending terms for all firms. Under-capitalized banks did not reduce loan spreads to the same extent compared to well-capitalized banks, resulting in lower asset

2.2. ECB interventions

Since 2010, the ECB has implemented a series of unconventional policy measures in an attempt to provide support for a “dysfunctional market” and repair the monetary policy transmission mechanism. Our sample period starts in November 2010 with the disclosure regulation for U.S. MMFs and ends in August 2014, and, therefore, we examine ECB interventions during this period.

2.2.1. LTROs

The ECB announced that it would conduct three-year LTRO liquidity injections on December 8, 2011 as an additional measure to enhance bank lending and liquidity in the eurozone money markets. In this announcement, the ECB stated it would conduct two three-year LTRO allotments on December 21, 2011 (LTRO 1) and February 29, 2012 (LTRO 2). The ECB allotted € 489 billion to 523 banks in LTRO 1, and € 530 billion to 800 banks in LTRO 2. The banks had to post collateral in exchange for funding under the LTRO programs and the interest on the funds was tied to the ECB policy rate.

The ECB switched to full allotment in its regular main refinancing operations (MRO) in October 2008, for which banks paid the same interest rate as for the LTROs. Rolling over weekly MROs is thus similar to borrowing under the LTROs. The latter, however, removes the uncertainty that the ECB switches back to fixed quantity allotment in its MROs. In LTRO 1, banks were also allowed to shift all of the outstanding amounts received in the one-year LTRO allotted on October 6, 2011 into the first three-year LTRO allotted on December

growth and capital expenditures by the borrowers of these banks. These results suggest that a LOLR policy that provides liquidity is less effective when the banking sector is weak. Acharya et al. (2016) and Ferrando, Popov, and Udell (2015) investigate the effects of the OMT program on the extension of credit to European borrowers. Ferrando, Popov, and Udell (2015) find using survey data that small- and medium-sized enterprises (SMEs) in Europe are less likely to be credit constrained after the announcement of the OMT program. Acharya et al. (2016) document that banks that remained under-capitalized after the OMT program engage in “zombie lending”, i.e., subsidized credit to weak firm relationships, to delay recognizing loan losses.

21, 2011. Most banks therefore switched from one type of public finances (MROs or one-year LTRO) to the three-year LTROs such that about € 0.5 trillion of net liquidity was injected into the eurozone banks with the two three-year LTRO liquidity injections.

The intention of the ECB to conduct longer term LTROs was first revealed by Mario Draghi before a plenary of the European Parliament on December 1, 2011. He mentioned that “*options include three-year ECB loans to banks and broadening the pool of assets that can be provided as collateral.*”⁴ However, this speech does not only mention credit support measures to the banks, but rather focuses on fiscal measures: “*What I believe our economic and monetary union needs is a new fiscal compact (...) it is definitely the most important element to start restoring credibility.*” One week later (December 8, 2011) the details of the three-year LTROs were announced.

2.2.2. OMT program

In response to the worsening of the sovereign debt crisis, Mario Draghi declared on July 26, 2012, during a conference in London: “*Within our mandate, the ECB is ready to do whatever it takes to preserve the euro. And believe me, it will be enough.*” Mario Draghi focused his speech on financial fragmentation as the main short-term challenge for restoring the transmission of ECB monetary policy. A few days later, on August 2, 2012, the ECB announced outright purchases of sovereign debt in secondary bond markets. On September 6, 2012, the ECB introduced and announced the key parameters of the OMT program. Under the program, the ECB could purchase unlimited amounts of eurozone government bonds with maturities of one to three years, provided that the country the ECB would buy bonds from met key conditions.

The country had to receive financial support from the European Stability Mechanism (ESM). The government had to comply with the reform efforts required by the respective

⁴“Draghi hints at eurozone aid plan” (*Financial Times*, December 1, 2011).

ESM program. Moreover, the OMT program could only be activated if the country had regained complete access to private lending markets. Finally, the country's government bond yields had to be higher than what could be justified by the fundamental economic data.

The ECB implemented other BOLR actions in the previous months: the Securities Markets Program (SMP) was announced in May 2010, and its extension to buy sovereign bonds of Italy and Spain in August 2011. Under the SMP program, the ECB holdings of GIIPS sovereign bonds amounted to € 218 billion in December 2012 (including € 103 billion of Italian sovereign bonds and € 44 billion of Spanish sovereign bonds). The SMP program was terminated with the announcement of the OMT program details in September 2012.

As of the end of 2015, the OMT program had not been used (i.e., the ECB did not purchase any sovereign bonds under the program), yet the OMT program could be qualified as an unprecedented BOLR measure of the ECB. The OMT program differed from other programs first of all due to its conditionality. While “promises” of fiscal and structural reforms were almost sufficient to benefit from ECB purchases in the SMP, the introductory statement about the OMT details of Mario Draghi establishes strict and effective conditionality for countries to enter the OMT program. Second, the ECB would improve transparency and publish the OMT holdings, the duration, the issuer, and the market value. Third, the duration of purchased assets is different. Fourth, the ECB did not make itself a senior claimant under the OMT program. If the ECB purchased sovereign bonds under the OMT program, it would absorb the liquidity by auctioning off an equal amount of one-week deposits at the ECB. Finally, although no clear limits to ECB holdings were announced under the SMP, the ECB stated that unlimited amounts of sovereign bonds could be purchased under the OMT program in order to reach its objectives.

2.2.3. LOLR versus BOLR

An important dimension along which LTRO and OMT interventions differed is whether the ECB acted as a LOLR or a BOLR. As a LOLR, the ECB injected liquidity to the banks against eligible collateral. As a BOLR, the ECB purchased or announced the possibility to purchase assets outright in secondary markets. Providing liquidity might prevent inefficient fire sales and help banks to deleverage and sell risky assets. However, it might also increase moral hazard as banks could use the liquidity to increase their exposure to risky assets because of, for example, gambling incentives. Purchasing assets directly reduces the discretion of banks and thus moral hazard incentives (Acharya and Tuckman, 2014). Moreover, the conditionality associated with the OMT program also reduced the moral hazard incentives of governments, which effectively reduced the default risk of sovereign bonds (Krishnamurthy, Nagel, and Vissing-Jorgensen, 2015). This in turn might have increased demand by non-bank investors and reduced the bank-sovereign nexus.

2.3. Data sources

In this subsection, we discuss the data sources we used in our analysis of the consequences of ECB interventions. Our analysis starts with event studies, linking those interventions with sovereign bond prices, sovereign bond CDS prices, and equity and CDS prices of European banks. All asset prices are collected from Bloomberg from January 2010 until June 2013. We also collected data on the sovereign bond holdings of European banks as disclosed by the European Banking Authority (EBA) in its stress tests and capitalization exercises on eight different dates from March 2010 until December 2013.

In our analysis of the access of European banks to U.S. money market funds, we start with a sample of 63 European banks that received funding from U.S. MMFs (see Table C.7 in Appendix). The 63 banks cover 15 European countries; 10 are countries in the eurozone (including three GIIPS countries).

Monthly information on U.S. MMF investments at European banks is collected from the regulatory reports of U.S. MMFs available from the iMoneyNet database. As a consequence of the 2007-2009 global financial crisis, the U.S. Securities and Exchange Commission (SEC) approved changes to Rule 2a-7 of the Investment Company Act of 1940 in 2010 and took other actions to strengthen the regulatory framework that governs MMFs. Following the revised SEC rules, U.S. MMFs have to report monthly mark-to-market net asset value (NAV) per share of their portfolios on Form N-MFP, which is then published by the SEC.

From the N-MFP forms downloaded from iMoneyNet, we collect data on the principal amounts, maturities, and yields of 15 different types of MMF securities (including CDs, repos, and financial CPs) from November 2010 until August 2014 (46 months). The MMF data are collected for approximately 13,000 issuer names in the European banking industry and aggregated at the bank holding company level (63 banks).

We match MMF data for these 63 European banks with financial information (assets, capitalization, etc.) collected from SNL, market data (stock prices, market cap) from Bloomberg for the 31 banks that are publicly traded, five-year CDS prices available for 34 banks, and EBA sovereign bond holdings available for 32 banks.

3. Sovereign Risk

The ECB undertook a series of unconventional measures to restore financial stability in the European financial sector. We discuss that the effectiveness of ECB interventions in restoring financial stability depends on whether the type of intervention we consider effectively reduced sovereign risk. In this section, we investigate the impact of ECB interventions on euro-denominated government bond yields and government bond CDS spreads.

The European sovereign debt crisis has been characterized by a widening of the spread between the yields of German bunds and the yields of the sovereign bonds of the peripheral countries of the eurozone (the so-called GIIPS countries). We illustrate this difference

in yields in Panel A of Figure 1, where we plot the average yields of five-year government bonds of GIIPS countries, together with the average corresponding yield of non-GIIPS eurozone countries (or “core” eurozone countries like Austria, Belgium, Germany, France, and the Netherlands), and the average corresponding yield of non-eurozone European countries (Denmark, Norway, Sweden, and the U.K.).

In Panel A of Figure 1, a reduction of GIIPS sovereign bond yields appears after Mario Draghi’s speech in July 2012 and the announcement of the OMT program in September 2012. We observe a similar pattern with the five-year sovereign bond CDS prices in Panel B of Figure 1. We find in Table 1 (Panel A) that the average CDS spread of GIIPS countries decreases by 59% following Draghi’s speech. Not only the GIIPS countries benefited from the ECB acting as a BOLR, the average CDS spreads of non-GIIPS eurozone countries and non-eurozone countries decrease by 64% and 59%, respectively, from July 2012 until December 2012. In contrast, the two three-year LTRO liquidity injections in December 2011 and February 2012 do not appear to have a significant impact on eurozone sovereign yields or CDS prices. The risk of Italian and Spanish bonds even increases following the LTROs. Between the LTRO 2 allotment in February 2012 and Draghi’s speech in July 2012, the average CDS spread of Italy and Spain increases by 48%. In addition, we do not observe any significant variation in the volatility (not reported in the table) of those asset prices for all regions in the three different periods.

To confirm the differential effect of LOLR and BOLR interventions on sovereign risk, we implement an event study analysis of sovereign bond yields and sovereign CDS spreads around ECB intervention dates. We calculate cumulative abnormal changes (CARs) of five-year sovereign bond yields for Spain, Italy, and Germany around seven events that are reported in Table 2 (Panel A): (1) the preliminary announcement of the three-year LTROs (12-01-2011), (2) the official announcement of the three-year LTROs (12-08-2011), (3) the allotment of the first LTRO liquidity injection (12-21-2011), (4) the allotment of

the second LTRO liquidity injection (2-29-2012), (5) “Draghi’s speech” (7-26-2012), (6) the preliminary OMT program announcement (8-02-2012), and (7) the announcement of the OMT program details (9-06-2012). Abnormal changes are derived from a market model adjusted for autocorrelation. We use the JPM EU Sovereign Bond Index as the benchmark bond market index, and the Markit iTraxx SovX Western Europe Index as the benchmark sovereign CDS market index in computing abnormal sovereign yield changes and abnormal sovereign CDS changes, respectively. The methodology we employ for deriving abnormal changes and their variance is described in Campbell, Lo, and MacKinlay (1997).⁵

Consistent with what we observe graphically, the € 0.5 trillion of net liquidity injected into the financial system in both LTRO allotments did not have a major effect on sovereign bond yields. This finding also coincides with the findings of Krishnamurthy, Nagel, and Vissing-Jorgensen (2015). Only the preliminary LTRO announcement in Draghi’s hearing of December 1, 2011 appears to be accompanied by a positive market reaction. We find a significant reduction in Spanish sovereign yields around this date. However, as pointed out above, this speech was essentially focused on fiscal actions. It is therefore difficult to attribute this market reaction to the announcement of liquidity injections.

Following BOLR announcements, we find a significant reduction of Spanish and Italian sovereign yields around Draghi’s speech of July 2012, as well as a significant reduction of the Spanish sovereign yields after the OMT announcement.⁶ For example, the two-day CAR of Spanish sovereign yields around Draghi’s speech is -0.58%, and is significant at the 1% level. The abnormal reduction in Italian sovereign yields is more modest (-0.41%). We find similar results for the event study on five-year sovereign CDS spreads in Table 2 (Panel B);

⁵The abnormal changes (resp. returns) in the market model adjusted for autocorrelation are derived from $AR_{iT+h} = r_{iT+h} - [\hat{\alpha}_i + \hat{\beta}_i r_{mT+h} + \hat{\varphi}_i r_{iT+h-1}]$, where r_{it} is the yield or spread change (resp. log-return) of asset i , and r_{mt} is the yield or spread change (resp. log-return) of the market index.

⁶We find similar results on ten-year sovereign bond yields and two-year sovereign bond yield (see Appendix A). We find that the sovereign CARs of Italy and Spain tend to be more significantly negative around the OMT program announcement than after Draghi’s speech for the long end of the yield curve.

we observe an abnormal reduction of Spanish and Italian sovereign risk following Draghi's speech and the OMT details announcement (with, again, a more pronounced impact on Spanish CDS spreads).

The more pronounced impact of BOLR interventions on Spanish CDS spreads compared to Italian CDS spreads suggests the presence of a reduction of redenomination risk following the BOLR action announcements. This differential effect would come from the fact that the CDS contracts of G7 countries (including Italy) do not cover losses from redenomination risk, whereas those of non-G7 countries like Spain do (Krishnamurthy, Nagel, and Vissing-Jorgensen, 2015).

Interestingly, the abnormal reductions in CDS spreads of Italy and Spain are the largest around the announcement of the OMT program details (-73 bps and -49 bps, respectively), compared to Draghi's speech in July 2012 and the announcement of asset purchases in August 2012.⁷ This result suggests that market participants also positively reacted to the announcement of a conditionality attached to the OMT program, improving their expectations about future solvency conditions of eurozone peripheral countries.

Overall, the results in this section help us to draw an important distinction between the effects of LOLR versus BOLR interventions of the ECB; while the LOLR interventions have almost no impact on sovereign risk, the BOLR interventions significantly reduced the sovereign risk of Italy and Spain. Moreover, a larger reduction of CDS spreads of Italy and Spain around the announcement of the OMT details compared to the reduction around Draghi's speech suggests that a reduction of default risk in these countries (due to the conditionality attached to the OMT program) was an important channel explaining the reduction in sovereign risk.

⁷The announcement effect of the OMT program details is also larger than the effect of the announcement of the extension of the SMP program in August 2011 (see Appendix Table B.3), despite the fact that Italian and Spanish bonds were actually purchased by the ECB under the SMP program.

4. Solvency Risk

In this section, we assess the effectiveness of ECB interventions (LTROs and OMT program) in reducing the solvency risk of European banks. We start the analysis of solvency risk by examining the evolution of the sovereign bond portfolios of European banks and other groups of financial institutions in Subsection 4.1. We document the evolution of bank capitalization in Subsection 4.2. In Subsection 4.3, we measure the effect of ECB interventions on bank asset prices (i.e., bank equity and bank CDS prices).

4.1. Sovereign bond holdings

ECB interventions gave incentives for banks to adjust their portfolios of sovereign bonds. This information is available from the several EBA disclosures on sovereign bond holdings of European banks from March 2010 until December 2013. We show this reallocation of the sovereign bond portfolio of European banks between different EBA disclosures in Table 3.

In Panel A of Table 3, we report the aggregate change (in € billion) in the domestic sovereign exposure (home exposure) of GIIPS, Italian and Spanish banks, as well as the aggregate change in the GIIPS sovereign exposure of non-GIIPS eurozone banks and non-eurozone European banks. Between the LTROs and the OMT program (between December 2011 and June 2012), the home exposure of GIIPS banks increased by € 55 billion while non-GIIPS banks (eurozone and non-eurozone) decreased their exposure to GIIPS sovereign debt by € 15 billion. In particular, Italy and Spain increase their home exposure by € 49 billion following the LTRO liquidity injections.

The trend is different following the OMT program announcement (after June 2012), where all banks increase their exposure to GIIPS sovereign debt. During the three months following the OMT program announcement, GIIPS banks increase their home exposure by € 12 billion. More importantly, non-GIIPS eurozone banks stop reducing their exposure to GIIPS sovereign debt and start buying GIIPS sovereign bonds again; we find that non-GIIPS

eurozone banks increase their exposure to GIIPS sovereign debt by € 4 billion following the announcement of the OMT program.

In Panels B and C of Table 3, we split the evolution of banks' sovereign bond exposures by maturity of their sovereign bond holdings. Panel B shows the evolution of sovereign bond holdings of short maturity (between one and three years), while Panel C shows the evolution of longer-term bond holdings (maturity above three years). We observe that purchases by GIIPS banks of GIIPS sovereign bonds were concentrated in the 1-3 year maturities following the LTRO liquidity injections, which is precisely the maturity of LTROs suggesting that GIIPS banks used the LTRO funds to increase their home exposure.

From December 2011 until June 2012, the total outstanding amount of government debt of Italy and Spain remained almost constant (increased by \$ 18 billion), as we can see in Figure 3 (Panel A). Therefore, the sovereign bond movements that we observe can be characterized as a rotation of these bonds from non-GIIPS bank investors to GIIPS banks. After June 2012, Italy and Spain issued a significant amount of government securities, increasing the outstanding amount of government debt by \$ 189 billion in these countries, and indicating that more players were buying Italian and Spanish sovereign bonds. Similarly, in Figure 3 (Panel B), we find that French banks only increase their exposure to Italian and Spanish official sectors after the OMT program announcement, while Italy and Spain were increasing their home exposure after both LTRO liquidity injections and OMT program announcements.

We provide some evidence of other (non-bank) investors investing again in GIIPS sovereign bonds in Table 4. The table reports the estimation results of the following regression:

$$\begin{aligned}
 r_{it} = & \alpha + \alpha_{LTRO}d_{LTRO} + \alpha_{OMT}d_{OMT} + \varphi r_{it-1} + \beta r_{mt} + \beta_{Germany}dy_{Germany,t} \\
 & + \beta_{GIIPS}dy_{GIIPS,t} + \beta_{GIIPS,LTRO} (dy_{GIIPS,t} * d_{LTRO}) + \beta_{GIIPS,OMT} (dy_{GIIPS,t} * d_{OMT}) + \epsilon_{it},
 \end{aligned}
 \tag{1}$$

where r_{it} is the daily return on an equity index for different financial institution groups,

$dy_{Germany,t}$ is the daily change in the yield of five-year German bunds, $dy_{GIIPS,t}$ is the daily change in average yield of five-year GIIPS bonds, r_{mt} is the market return, d_{LTRO} and d_{OMT} are dummy variables equal to one during the post-LTRO allotment period (12-08-2011 - 7-25-2012), and during the post-OMT program period (7-26-2012 - 6-25-2013), respectively. We construct equity indexes for GIIPS, non-GIIPS eurozone, non-eurozone European, and U.S. banks using weights given by the banks' market capitalizations in 2011. We also use the HFRX Global Hedge Fund Index and the Stoxx Europe 600 Insurance Index as indexes for non-bank financial institutions. Since we have yield changes as independent variables, a negative $\beta_{Germany}$ indicates a long exposure in German bunds. For example, we find that eurozone banks and insurance companies had a short exposure in German bunds during our sample period, while hedge funds maintained a long exposure in those bonds.

The estimation sample starts with the beginning of the sovereign debt crisis (June 2011) and ends at the end of the post-OMT program period (December 2012). The regression of equation (1) is specified such that the parameter β_{GIIPS} captures the exposure to GIIPS bonds during the sovereign debt crisis, and the parameter $\beta_{GIIPS,LTRO}$ (resp. $\beta_{GIIPS,OMT}$) captures a variation in GIIPS exposure in the post-LTRO allotment (resp. post-OMT program) period compared to the sovereign debt crisis period. During the summer of 2011, we find that all European banks (including non-eurozone banks) and insurance companies have a significant long exposure in GIIPS bonds.

We do not find any significant change in the GIIPS exposure in the post-LTRO allotment period. However, we find a significant increase in the GIIPS exposure of hedge funds in the post-OMT program period. While hedge funds had a short exposure during the sovereign debt crisis, they significantly invest in GIIPS bonds in the post-OMT program period and turn their GIIPS exposure into a long exposure. We also find that GIIPS banks increase their domestic exposure, while non-eurozone European banks reduce their GIIPS exposure

following the OMT program announcement.⁸

Overall, the results of this section show a distinctive pattern in the evolution of GIIPS sovereign bond holdings following the LOLR and BOLR interventions. Following the LTRO liquidity injections (ECB acting as LOLR), we observe a rotation of GIIPS sovereign bonds from non-GIIPS banks to GIIPS banks (i.e., an increase in home bias). Because the risk of GIIPS sovereign bonds is not reduced following the LTRO interventions, what we observe is a rotation of risky assets from low-risk to high-risk banks. Risky banks used the LTRO liquidity provided by the ECB to increase their exposure to risky illiquid assets.⁹ The LTRO liquidity injections therefore contributed to more fragmented sovereign bond markets and increasing bank-sovereign nexus in GIIPS countries.

Following the OMT program (ECB acting as BOLR), all eurozone banks and hedge funds increased their exposure to GIIPS sovereign debt motivated by the reduction of the sovereign bond yields and sovereign CDS of Italy and Spain in particular. The entry of new investors contributed to a reduction in the financial fragmentation of sovereign debt markets and the GIIPS bank-sovereign nexus.¹⁰

4.2. Bank capitalization

European banks were severely undercapitalized particularly because of their exposure to risky sovereign debt that was not funded with equity due to the zero regulatory capital requirement for these exposures (zero risk weights). To address banks' solvency concerns, the EBA launched a capitalization exercise among European banks in September 2011 requiring both, more capital to fund risk-weighted assets (9% instead of 5% of bank risk-weighted

⁸We find similar results for the domestic exposure of Italian and Spanish banks in Appendix Table B.4. We also find an increase of hedge funds' exposure to Italy and Spain following the OMT program.

⁹Evidence of Italian and Spanish banks loading up more on the three-year LTRO liquidity compared to other eurozone banks can be found in the BIS Quarterly Review of March 2012 (Graph 3, p. 4).

¹⁰Additional evidence of a reduction in financial fragmentation (or an increase in financial integration) following the OMT announcement can be found in the ECB report on "Financial Integration in Europe," April 2014 (Chart 2, p. 9).

assets) and an additional capital buffer for eurozone sovereign debt exposures. Overall, this exercise revealed a capital shortfall of about € 115 billion (including € 30 billion for Greek banks). Several facts, however, suggest that this exercise fell short of adequately recapitalizing the banks and the GIIPS banks in particular.

First, Acharya, Engle, and Pierret, 2014b find evidence consistent with the interpretation that the required recapitalization of banks was insufficient even though the capitalization exercise introduced sovereign risk weights and a sovereign buffer. They find that some of the most undercapitalized banks as assessed by market participants (based on a market leverage ratio) were not required to raise additional capital under the EBA capital exercise. The difference in measures of capitalization (market capital shortfall versus EBA capital shortfall) arises from the reliance on book values and regulatory risk weights to derive capital shortfalls in the capital exercise.

Second, we document that GIIPS banks raised substantially less capital relative to non-GIIPS eurozone and non-eurozone banks. Non-GIIPS eurozone banks (with an estimated capital shortfall of € 5 billion) raised € 26 billion of capital and non-eurozone banks (with zero capital shortfall) raised an additional € 22 billion. In contrast, GIIPS banks raised exactly the additional € 20 billion capital buffer until June 2012 that was required by the EBA to fund their risky sovereign bond exposures as of December 2011. Importantly, GIIPS banks also increased their domestic sovereign bond exposure by € 55 billion at the same time. We find that the amount of capital raised would only cover an additional 5% of home exposures of GIIPS banks as of June 2012. We conjecture that GIIPS banks did not build sufficient capital buffers to withstand a sovereign shock in June 2012. In particular, Italian banks were the most undercapitalized banks in December 2011 with a capital shortfall of € 10.4 billion. Italian banks raised € 9 billion of capital in the post LTRO period, while increasing their home exposure by € 36 billion.

Third, consistent with Acharya and Steffen (2015) we find that the most undercapitalized

banks increased their GIIPS exposure following the LTRO liquidity injections. The correlation between the regulatory capital ratio in December 2011 and the percentage change in GIIPS exposure in the post LTRO period is -0.12, and increases to -0.22 for GIIPS banks only, consistent with moral hazard risk shifting incentives of GIIPS banks. The GIIPS exposure increase is uncorrelated with the capital increase between December 2011 and June 2012, emphasizing again that GIIPS banks remained undercapitalized, also relative to non-GIIPS eurozone and non-eurozone banks.

4.3. Bank equity and CDS prices

In this subsection, we assess the effect of the ECB interventions on the equity prices and CDS prices of European banks. We continue to differentiate between the effects of LOLR type versus BOLR type interventions. We start by examining the evolution of the average bank equity prices in Panel A of Figure 2, and the evolution of the average bank CDS prices in Panel B of Figure 2 from October 2010 until June 2013. We observe that the pre-intervention trend is characterized by falling stock prices and increasing CDS spreads. While CDS spreads are the largest for GIIPS banks, the largest drop in equity prices takes place for non-GIIPS eurozone banks in the summer of 2011 (-72% between May and December).¹¹

Following an effective central bank intervention, we expect to see CDS prices (bank risk) fall and a stabilization of stock prices (bank performance). The three-year LTRO generates this outcome for a couple of months only. The effect is then reversed and the situation of the banking sector worsened after the second LTRO liquidity injection. We document this reversal in Table 5 (Panel C), where average equity prices of GIIPS banks increase by 15% after LTRO 1, but decrease by -60% after LTRO 2. Similarly, the average five-year

¹¹Note that Greek banks are excluded from GIIPS banks, and Dexia is excluded from non-GIIPS eurozone banks. Greek banks had their own interventions, and were treated separately in the 2011/2012 EBA Capital exercise in order not to conflict with pre-agreed arrangements under the EU/IMF program. Dexia was bailed out and restructured in October 2011.

CDS spread of GIIPS banks (Panel A) decreases following LTRO 1 (-20%), and increases between LTRO 2 and Draghi's speech (25%). The effects on three-year CDS spreads (Panel B) are similar, albeit larger in magnitude due to the higher sensitivity of short-term CDS spreads. We find an even more pronounced reversal of the trend of CDS spreads for Italian and Spanish banks following LTRO 2.

The effects of the LTRO liquidity injections only lasted until full allotment of LTRO money in February 2012. Once these funds were allocated to banks, the stability of the European banking sector started to be compromised again due to uncertainty about future (public or private) short-term funding flows and strong GIIPS bank-sovereign nexus. The increased bank-sovereign nexus in GIIPS countries not only amplified the risk of GIIPS banks and GIIPS sovereign bonds; it also had negative effects on non-GIIPS eurozone banks. We obtain similar trends in CDS and equity prices of non-GIIPS eurozone banks to the ones observed for GIIPS banks. Average equity prices of non-GIIPS eurozone banks decrease by -36% between LTRO 2 and Draghi's speech, and their average five-year CDS prices increase by 23% over the same period.

Only BOLR actions (Draghi's speech and OMT program announcement) led to a permanent stabilization of bank risk. We observe this permanent effect in Panel B of Figure 2 and in Table 5. The average equity return is 36% for GIIPS banks and 41% for non-GIIPS eurozone banks between Draghi's speech (July 2012) and December 2012. The reduction of five-year CDS prices during the same period is -27% and -45% for GIIPS and non-GIIPS eurozone banks, respectively.

The event study results in Table 6 show a similar picture. In this table, we show the average cumulative abnormal equity returns (Panel A) and the average cumulative abnormal CDS changes (Panel B) of GIIPS, non-GIIPS eurozone, and non-eurozone European public banks around the same events as in Section 3. The event study methodology of bank equity returns (or bank CDS changes) is similar to the methodology in Section 3, where we simply

replace the sovereign yield changes of a country by the returns on the equally weighted bank equity (or bank CDS) portfolio. This methodology allows accounting for cross-sectional dependence in bank abnormal returns since the events we study are common to all banks, and therefore overlapping. Average CARs are derived from a market model adjusted for autocorrelation in the portfolio returns. We use the Euro Stoxx Index as the benchmark stock market index, and the Markit iTraxx Europe Crossover Index on the most liquid sub-investment grade European corporate entities as the benchmark CDS market index in computing abnormal bank equity returns and abnormal bank CDS changes, respectively.

We do not find any significant abnormal equity returns for GIIPS, non-GIIPS eurozone or non-eurozone banks following the different ECB interventions (including both LOLR and BOLR type interventions), except for Draghi's speech on December 1, 2011 about the new fiscal compact. The two-day cumulative abnormal average equity returns of GIIPS banks of 8.5% are significant at the 5% level, while those of non-GIIPS eurozone banks of 10.7% are significant at the 10% level around this date.¹² Markets seem to have been disappointed by the LTRO announcement that followed on December 8, 2011; we observe (non-significant) negative abnormal equity returns around that date. The cumulative abnormal equity returns are positive for the other intervention announcements.

Concerning bank risk, we find a significant abnormal reduction of CDS spreads for all European banks around Draghi's speech on December 1, 2011, but a significant increase in the CDS spreads of non-GIIPS eurozone banks around the LTRO announcement date (December 8, 2011). Market reaction seems again to be negative around the LTRO announcement; the abnormal average five-year CDS spread and three-year CDS spread increase are 12.9 bps and

¹²It is however difficult to attribute this reaction solely to the December 1, 2011 speech. A central bank intervention the day before (November 30, 2011) helped lower the cost of U.S. dollar liquidity for eurozone banks. In the December 1, 2011 speech: *"Yesterday, in a globally coordinated action with the Federal Reserve, the Bank of Japan, the Bank of England, the Bank of Canada and the Swiss National Bank, we have agreed to lower the price on U.S. dollar provision in other constituencies including the eurozone."*

12.33 bps respectively, and are significant at the 5% level. Abnormal CDS spreads are not significant at the 5% level around other intervention dates until the announcement of the OMT program details. Around the announcement of the OMT program, we find significant negative abnormal CDS spread changes for GIIPS banks. The two-day cumulative abnormal change in the average five-year CDS spread of GIIPS banks is -35.66 bps, significant at the 1% level. The largest reduction in bank risk is observed for the average three-year CDS spreads of GIIPS banks; the two-day CARs around the OMT program is about -38.42 bps.

In Table 7, we report the results of cross-sectional regressions of CDS CARs on bank characteristics, including their holdings of GIIPS and non-GIIPS eurozone sovereign bonds scaled by the banks' total assets. We find a significant reduction of the two-day CDS CARs at banks with a larger exposure to GIIPS sovereign debt following both Draghi's speeches (December 1, 2011 and July 26, 2012) and the announcement of the OMT program details. Similarly, we find a significant negative correlation between the two-day CDS CARs and banks' GIIPS exposure around those dates, and find that this correlation is significant at the 10% level on a restricted sample of non-GIIPS eurozone banks only around Draghi's speech on July 26, 2012 (see Appendix Table B.5).

Moreover, we highlight the sovereign default risk channel as driving the reduction of bank CDS CARs around BOLR interventions.¹³ In Appendix Table B.6, we show that the sovereign GIIPS exposure remains significant at the 5% level when we control for the GIIPS exposure of banks in other asset classes (measured by the total GIIPS exposure at default scaled by the banks' total assets). While we have some evidence of a reduction in redenomination risk following BOLR interventions [see Section 3, and Krishnamurthy, Nagel, and Vissing-Jorgensen (2015)], it does not appear to be the main driver of a reduction in

¹³Krishnamurthy, Nagel, and Vissing-Jorgensen (2015) identify default risk as one of the main channels affecting the bond yields of Italy and Spain around the OMT program. The reduction of default risk in Italy and Spain could be associated with the conditions attached to the OMT program that would have affected the countries fiscal policies.

bank risk around those dates. Redenomination risk would not only affect sovereign bond prices, but also the prices of all securities issued in the GIIPS countries and would therefore be reflected in the total GIIPS exposure (not only the sovereign one) of a bank. Our results in Appendix B show that the total exposure at default in GIIPS countries of a bank is not a significant determinant of CDS CARs while the GIIPS sovereign exposure is significant at the 5% level.

Overall, the results are consistent with a stabilization of the risk of all banks holding GIIPS sovereign bonds due to a reduction of GIIPS sovereign default risk with the OMT program announcement. Increasing GIIPS bond prices lead to a recapitalization of banks holding these bonds. GIIPS banks in particular benefit from a reduction of the GIIPS bank-sovereign nexus following the announcement of the OMT program.

5. Funding Flows

In this section, we assess the effectiveness of ECB interventions (LTROs and OMT program) in restoring a permanent access to private funding for European banks. Specifically, we study the access of European banks to funding from U.S. MMFs. The SEC defines U.S. MMFs as “an option for investors to purchase a pool of securities that generally provided higher returns than interest-bearing bank accounts.” U.S. MMFs are typically low-risk investments with higher returns than U.S. deposits since unlike deposits, they are not insured by the Federal Deposit Insurance Corporation (FDIC) and are therefore subject to runs. Moreover, U.S. MMFs have incentives to closely monitor eurozone banks and their exposure to eurozone sovereign risk since they do bear the downside risk of investing in eurozone risky banks (Ivashina, Scharfstein, and Stein, 2015).¹⁴ In Subsection 5.1, we review descriptive statistics of U.S. MMF investments at European banks. We document the run of U.S.

¹⁴They are also subject to stricter regulations regarding the risk of their portfolio since 2010 (following the run on U.S. MMFs during the financial crisis of 2008-2009).

MMFs on European banks in Subsection 5.2 and provide evidence that reduced money market funding is caused by a reduction of liquidity supply by U.S. MMFs. In Subsection 5.3, we investigate the impact of ECB interventions (LTROs and OMT program) on U.S. MMF investments.

5.1. Descriptive statistics of U.S. MMF investments at European banks

The four most important types of securities in terms of outstanding amounts invested by U.S. MMFs at European bank include certificates of deposits (CDs), financial company commercial papers (Fin CPs), government agency repurchase agreements (Gvt repos), and Treasury repurchase agreements (Treasury repos).¹⁵ These four types of securities amount to 75%-86% of all securities invested at 63 European banks through U.S. MMFs between 2010 and 2014. U.S. MMFs constitute the largest source of U.S. dollar lending for European banks and their subsidiaries. U.S. MMF repos are secured by U.S. collateral, in particular U.S. government agency collateral for government agency repos and U.S. Treasuries for Treasury repos. In the rest of the paper, we will refer to unsecured funding for CDs and financial CPs, and secured funding for government repos, Treasury repos, and other repos.

MMF investments at European banks decreased from \$ 993 billion to \$ 686 billion over the sample period, with a minimum of \$ 529 billion in June 2014 (see Figure 4, Panel A). A strong end-of-quarter seasonality is driven by secured funding. Munyan (2015) shows that the seasonality in repo investments is driven by the broker-dealer subsidiaries of non-U.S. banks rather than their repo lenders as banks practice “window dressing” to appear safer at regulatory reporting dates.

In Panel B of Figure 4, we show the evolution of unsecured and secured funding invested at European banks from November 2010 until August 2014. A “run” appears on unsecured

¹⁵We report some descriptive statistics of the principal amounts, maturities, and yields of MMF securities invested at European banks in Appendix Table C.8.

funding starting in April 2011, then CDs and financial CPs start flowing back to European banks in the summer of 2012. We will therefore focus the rest of our analyses on unsecured funding flows; the run during summer 2011 and the fly back following ECB interventions.¹⁶

5.2. The unsecured “run” on eurozone banks: demand versus supply

U.S. MMFs were the first group of investors to withdraw funding from European banks in 2011.¹⁷ In the previous section, we document a funding shock in the unsecured funding in U.S. dollar of European banks in the summer of 2011. This funding shock could be a demand shock for European banks willing to reduce their exposure to “flighty” short-term debt, or a supply shock as U.S. MMFs started to worry about sovereign risk in the eurozone. The results in this section and in the literature support the view that the unsecured MMF funding shock was a supply shock for the banks, and that this shock was particularly instrumental in precipitating severe funding liquidity problems in the eurozone financial sector. First, European banks were not able to completely substitute unsecured MMF funds with alternative funding sources to finance their assets in U.S. dollars. Second, U.S. MMFs experienced redemptions during that period and became increasingly sensitive to eurozone risk. Third, the run of U.S. MMFs is predictive of the demand for LTRO liquidity; European banks that experienced unsecured outflows via MMFs in the summer of 2011 became more reliant on ECB liquidity injections via the LTROs starting in December 2011.

¹⁶The trend in secured funding (repos) is reversed; some banks increased their secured funding from April 2011 until June 2012. However, it does not appear that banks were substituting unsecured funding for secured funding via U.S. MMFs due to the restricted collateral eligible to receive MMF secured funding; only 13 European banks have access to U.S. MMF repos, as these repos require high-quality U.S. collateral (U.S. government agency collateral and U.S. Treasuries). Therefore, the flight-to-secured funding we observe reflects a flight-to-quality toward safe U.S. collateral. This flight-to-secured funding is reduced following the OMT announcement when eurozone sovereign risk declined.

¹⁷“US money market funds warm to eurozone” (*Financial Times*, February 28, 2013)

5.2.1. U.S. MMFs and other sources of funding

The U.S. MMF flows to European banks are correlated with other short-term funding flows, as shown in Appendix Table C.9. In particular, we show that one-month lagged U.S. MMF unsecured funding flows are correlated with the flows in all debt securities with residual maturity of one year invested at the 28 largest banks in the European Union.¹⁸ In contrast, secured MMF funding flows are not significant to be predictive of the evolution of all short-term debt securities flows. The results in this table suggest that the run of unsecured MMF funding and the recovery following ECB interventions is also present in other sources of short-term funding at European banks.¹⁹ It does not appear that the European banking sector was able to tap into another source of short-term funding in order to become less reliant on unsecured MMF funding.

In addition, alternative ways for European banks to finance assets in U.S. dollars did not become cheaper during that period. According to the Bank for International Settlements (BIS), an increase in U.S. dollar net position (i.e. U.S. dollar assets minus U.S. dollar liabilities) of non-US banks indicate an increase in the demand for U.S. dollar funding through foreign exchange (FX) swaps. From BIS data, we find that U.S. dollar net position of German banks peaked at \$ 70 billions at the end of 2011.²⁰ At the same time, Ivashina, Scharfstein, and Stein (2015) document an increase in the cost of synthetic U.S. dollar borrowing (i.e. when banks borrow in euros to buy U.S. dollars and hedge out the FX risk by buying euros on a forward basis), and that this U.S. dollar funding strain lead eurozone banks to reduce lending in U.S. dollars to both U.S. and European firms.

¹⁸Banks' short-term debt includes commercial papers, CDs and short-term notes with a maximum maturity of 12 months. Source: ESRB.

¹⁹The Granger-causal relationship of MMF unsecured funding on one-year debt securities is robust to controlling for two-year maturity debt flows at EU-28 banks (since a fraction of the two-year residual maturity debt will become one-year debt the next month).

²⁰Source: BIS consolidated banking statistics. Data for other European banks are not available during that period.

5.2.2. U.S. MMFs and bank risk

The unsecured run of U.S. MMFs from European banks is a run on eurozone banks, while non-eurozone banks are able to maintain their unsecured funding. In particular, GIIPS banks completely lose access to unsecured funding via U.S. MMFs following the deterioration of the sovereign bond yields of Italy and Spain in the first half of 2012.²¹ We show the total principal amount of unsecured funding invested in GIIPS banks, non-GIIPS eurozone banks, and non-eurozone banks in Figure 5.

As shown in Subsection 5.4, MMFs are sensitive to bank risk. Our results are therefore consistent with larger private funding outflows at insolvent banks. Ivashina, Scharfstein, and Stein (2015) indicate that U.S. prime MMFs sharply reduced their funding to eurozone banks due to concerns about the credit quality of these banks, in particular after Moody’s put the French banks BNP Paribas, Credit Agricole and Societe Generale on notice for possible downgrades on June 15, 2011.

In the context of the European sovereign debt crisis, insolvency is correlated to the exposure of a bank to risky sovereign bonds. The consequence of banks increasing their exposure to their domestic debt (home bias) is a geographical segmentation over bank insolvency. In line with observed differences in sovereign risk in Figure 1 and assuming home bias, our results are also consistent with funding risk segmentation (i.e., GIIPS banks lose more funding than non-GIIPS eurozone banks, while eurozone banks lose more funding than non-eurozone banks).

The MMF run that we observe is a consequence of money market investors withdrawing their funds from U.S. MMFs, in particular MMFs exposed to eurozone banks (Chernenko and Sunderam, 2014). U.S. MMFs also experienced a funding shock; net outflows at U.S. MMFs exposed to European banks — measured by the difference between subscriptions and

²¹The average MMF flows at GIIPS banks, non-GIIPS eurozone banks, and non-eurozone banks reported in Appendix Table C.10 confirm these observations.

redemptions to the funds — reach \$ - 75 billion from May 2011 until August 2011. At the same time, U.S. MMFs reduced the principal amount invested at eurozone banks by \$ - 119 billion. It appears that some unsecured MMF funding outflows from eurozone banks were preemptive to investors withdrawing from U.S. MMFs. For example, we do not find that lagged net outflows from U.S MMF investors explain the unsecured outflows at eurozone banks when we control for bank risk. The evidence suggests that U.S. MMFs ran from risky eurozone banks as a precautionary measure to avoid additional redemptions from their investors.

5.2.3. U.S. MMFs and the demand for LTRO liquidity

Focusing on the sovereign debt crisis period, we also show that unsecured funding outflows in U.S. MMFs prompted a LOLR intervention from the ECB; banks that experienced U.S. dollar outflows through U.S. MMFs during the crisis become more reliant on ECB secured funding through Long-Term Refinancing Operations. The negative correlation between the six-month U.S. MMF unsecured funding flows during the crisis (from June 2011 until December 2011) and the LTRO amount (including the two LTRO liquidity injections) a bank received is illustrated in Panel A of Figure 6.²²

In Table 8, we show that unsecured MMF outflows during the sovereign debt crisis are predictive of the probability of receiving LTRO funding (probit analysis), as well as the amount of LTRO liquidity received (OLS analysis). Unsecured U.S. dollar outflows at a bank during the crisis increase the probability of the bank receiving LTRO funding. We measure this effect with the following probit regression:

$$P(LTRO_i = 1|X) = \Phi(\alpha + \beta_F dF_{i,crisis}), \quad (2)$$

²²The amount of LTRO funding a bank received is hand collected from press articles. The LTRO numbers collected are consistent with results of Morgan Stanley LTRO survey of March 1, 2012.

where $LTRO_i$ is a binary variable equal to one if bank i received LTRO funding (LTRO 1 + LTRO 2), X comprises all explaining variables included in the regression, and $\Phi(\cdot)$ is the standard normal c.d.f. The marginal effect of unsecured funding outflows on the probability of receiving LTRO funding is given by $-\phi(\beta_F * dF_{i,crisis} + \alpha) * \beta_F$, where $\phi(\cdot)$ denotes the standard normal p.d.f., and $dF_{i,crisis}$ is the six-month unsecured funding flow at bank i before the LTROs.

For the median bank (i.e., the bank with $dF_{i,crisis}$ equal to the median of all banks unsecured crisis flows), the results in column (1) of Table 8 indicate that the probability of receiving LTRO funding increases by 0.7% with an additional 1% outflow in the six months preceding LTRO 1. This effect does not appear to be large but it is conditional on the value of median unsecured funding outflows during the crisis that are already 73%. Therefore, the probability of a bank to get access to LTRO funding increases by 0.7% with one additional percent outflow when the bank already lost 73% of its unsecured funding in the last six months. The marginal effect of unsecured funding outflows is still significant and of similar magnitude (0.6%) when we control for the change in the non-deposit liabilities of the bank in column (2) of Table 8. Finally, LTRO funding is also related to the risk of the bank through its CDS spread and its exposure to GIIPS sovereign debt (columns (3) and (4), respectively); the LTRO funding probability of the median bank increases by 26% with a 100 bps CDS spread increase, and by 16% with an increase of 0.01% of the ratio of GIIPS exposure to total assets.²³

Ultimately, ECB liquidity injected through the LTROs helped stop the run in U.S. MMFs: In Panel B of Figure 6, we observe that the aggregate unsecured funding outflow at European banks stops when the ECB started injecting liquidity through LTRO 1 in December 2011.

²³These variables are however not jointly significant to be predictive of LTRO funding as they are highly correlated (e.g., the correlation between unsecured outflows and GIIPS exposure is 0.87).

5.3. LOLR interventions and MMF flows

Following LTRO 1, private short-term funding starts flowing back into non-GIIPS eurozone banks, and flowing out of non-eurozone banks. We report the unsecured U.S. MMF flows by region after the LTRO 1 and 2 allotments in Panel A of Table 9. This table shows that U.S. MMFs invest an additional \$ 14 billion (+19%) in unsecured securities at non-GIIPS eurozone banks between LTRO 1 and LTRO 2 (December 2011 to February 2012), while \$ 27 billion (-16%) of unsecured funding flows out of non-eurozone European banks during the same period. GIIPS banks, however, continue to lose access to U.S. MMFs. GIIPS banks do not recover access to U.S. MMFs during our sample period due to their lack of capitalization documented in Subsection 4.2. Banco Santander is the only GIIPS bank that kept access to unsecured funding at the time of the LTRO 1 allotment. The bank loses access after the LTRO 2 allotment, and is the only GIIPS bank to recover access to U.S. MMFs during our sample period.

The reversal of fund flows at non-GIIPS eurozone banks was short-lived. After the LTRO 2 allotment in February 2012, all banks (non-GIIPS eurozone and non-eurozone banks) experience a further loss in unsecured funding, following the deterioration of bank CDS spreads. Eurozone and non-eurozone banks lose \$ 19 billion (-21%) and \$ 28 billion (-19%) in unsecured funding, respectively, between February 2012 (LTRO 2 allotment) and July 2012.

While non-GIIPS eurozone banks shift away from GIIPS sovereign bond markets in the post-LTRO period, we find that they increase their holdings of U.S. high quality collateral as indicated by a shift toward *secured* funding during this period (between LTRO 2 and OMT). Panel C of Table 9 indicates seasonality-adjusted inflows of \$ 3 billion at non-GIIPS eurozone banks following the LTRO 2 allotment. Secured funding flows to European banks are then reversed after the OMT program announcement.

5.4. BOLR interventions and MMF flows

In this subsection, we investigate U.S. MMF flows to eurozone banks after BOLR interventions. It is a testable hypothesis that the increase in GIIPS sovereign bond prices and subsequent reduction of banks' solvency risk also increases the willingness of U.S. MMFs to increase their exposure to eurozone banks.

5.4.1. Descriptive evidence on MMF flows

Figure 5 shows that a permanent reversal of U.S. MMF flows to non-GIIPS eurozone banks starts in July 2012, following Mario Draghi's speech. Between July and December 2012, U.S. MMFs invested \$ 61 billion unsecured at non-GIIPS eurozone banks (and an additional \$ 1 billion at Banco Santander), increasing the unsecured principal amount invested at eurozone banks by 89%. Importantly, the short-term investments at eurozone banks are not a reallocation of U.S. MMF portfolios from non-eurozone banks to non-GIIPS eurozone banks; unsecured funding also increases at non-eurozone banks by \$ 11 billion (+8%).

Repo outflows also indicate that the flight-to-quality towards U.S. collateral is reduced after the OMT program is announced. Repo investments by U.S. MMFs are reduced by \$ -10 billion (-6%) at eurozone banks, and by \$ -72 billion (-40%) at non-eurozone banks from July 2012 until December 2012. Repo outflows at European banks are consistent with a reduction of sovereign risk in the eurozone, and banks increasing their exposure to GIIPS and other eurozone sovereign debt.

5.4.2. The effect of bank risk

Following the OMT program, the impact of risk on funding is reversed as risky banks recover part of their secured and unsecured funding. Our results suggest that the reversal of fund flows to risky banks is the consequence of increasing sovereign bond prices following the OMT program announcement.

To measure the incremental effect of bank risk on funding flows, we use the cross-sectional information from bank CDS prices and bank sovereign exposures:

$$dF_{it} = \varphi dF_{it-1} + \sum_{\tau} \left[\beta_{1\tau} CDS_{i,\tau} + \beta_{2\tau} \frac{GIIPS\ holding_{i,\tau}}{TA_{i,\tau}} + \alpha_{\tau} \right] d_{\tau} + \epsilon_{it}, \quad (3)$$

where $dF_{it} = (MMF_{it} - MMF_{it-1}) / MMF_{it-1}$; MMF_{it} is the average MMF principal amount invested at bank i over a three-month window $[t - 1, t + 1]$; d_{τ} is a dummy variable where τ refers to pre-crisis (from November 2010 until May 2011), crisis (from June 2011 until December 2011), post-LTRO (from January 2012 until September 2012), and post-OMT (from October 2012 until August 2014) periods. $CDS_{i,\tau}$, $GIIPS\ holding_{i,\tau}$, and $TA_{i,\tau}$ are respectively the last available five-year CDS price, GIIPS sovereign gross direct exposure, and total assets of bank i before the period τ starts. We report the estimation results of this regression in Table 10.

Without controlling for the GIIPS exposure in column (1) of Table 10, we find that the impact of risk, as measured by CDS spreads, is negative and significant for unsecured funding before and during the sovereign debt crisis, not significant during the LTROs, and positive after the announcement of the OMT program.²⁴ Banks with higher CDS prices experience larger outflows on their unsecured funding during the crisis; a widening of 100 bps of the CDS spread produces an incremental monthly outflow of -17%. After the OMT program, the impact of risk on unsecured funding flows becomes significantly positive; the incremental unsecured inflow is 2% for a 100 bps CDS spread increase.

Part of the risk information contained in the cross-section of CDS spreads explaining funding flows comes from the exposure of banks to risky sovereign debt. Holding the CDS spread fixed (column (3)), we find that a 1% increase in the ratio of the bank's GIIPS

²⁴We also find that *secured* funding is not sensitive to risk during the crisis as U.S. MMF repos are secured by U.S. collateral, but risk has a positive impact on repo flows following the OMT program.

sovereign bond holdings to its assets ($GIIPS\ holdings_{i,\tau}/TA_{i,\tau}$) produces an incremental average monthly outflow of -3% during the sovereign debt crisis.

After the OMT program, inflows to risky banks are positively correlated with the exposure of a bank to GIIPS sovereign debt. Without controlling for the CDS spread (column (2)), monthly unsecured funding flows increase by 5%, with a 1% increase of the ratio measuring the GIIPS exposure of a bank. The positive post-OMT program impact of CDS spreads becomes insignificant when we include the GIIPS exposure of a bank in the regression (column (3)), as these two measures are highly correlated. We conclude that the information about banks' GIIPS exposure contained in bank CDS spreads provides significant explanatory power for funding inflows following the announcement of the OMT program.

5.4.3. Extensions and robustness

Most of the results we find in Subsection 5.4.2 hold when we reproduce the results on non-GIIPS eurozone banks only (see Appendix Table D.11). This allows us to highlight the impact of GIIPS sovereign bond holdings of non-GIIPS eurozone banks in determining access to U.S. MMFs following ECB interventions. Out of the 63 European banks with access to U.S. MMFs, 26 banks raised € 54 billion additional capital under the 2011/2012 EBA capital exercise between December 2011 and June 2012. The post-OMT effect of GIIPS exposure on funding flows is robust to controlling for regulatory capital ratios and capital raised under the EBA capital exercise (see Appendix Tables D.12 and D.13). We also explore other risk measures like market leverage (Lvg), or the Tier 1 capital ratio (T1CR) in Appendix Table D.14. In particular, we find that bank leverage was another important fundamental (next to banks' GIIPS exposure) guiding unsecured outflows during the sovereign debt crisis.

The positive post-OMT program effect of risk on funding remains significant when we control for the crisis unsecured outflows in the regression. Therefore, the MMF unsecured funding inflow following the OMT program is not only an endogenous return to risky banks.

Similarly, we show that the positive impact of bank risk on unsecured funding following the OMT program announcement is robust to country fixed effects, common factors (Appendix Table D.15), and the interaction between country and period fixed effects.

In Appendix E, we show that MMF investors considerably reduced the horizon of their investments at risky banks (or banks exposed to GIIPS sovereign debt) compared to low-risk banks, increasing the cost of risk-taking through shorter maturities and larger yields. Low-risk banks are rewarded by longer maturities for their new unsecured funding securities without a corresponding increase in yields. The gap in maturities between new securities invested at low-risk vs. high-risk banks widens, suggesting that MMF investors only return short-term to high-risk banks. Our results therefore do not suggest a weakening of market discipline in wholesale funding markets as an unintended consequence of the OMT program.

5.4.4. *Funding risk following BOLR interventions*

The unsecured outflows we observe at eurozone banks during the sovereign debt crisis are the result of banks losing access to some money market funds for their unsecured funding in U.S. dollars. We further explore access to U.S. MMFs in Table 11, looking at (i) the probability of completely losing access to U.S. MMF unsecured funding, and (ii) the probability of losing access to one fund.²⁵

Some banks completely lose access to U.S. money market funds during the sovereign debt crisis. In Table 11, we show the results of a probit regression we use to examine the probability of a bank losing access to unsecured U.S. MMFs.²⁶ The dependent variable is equal to one at date t if the bank had access to unsecured funding in month $t - 1$ and lost its access to unsecured funding during month t .

²⁵In addition, we study the number of securities invested at a bank, and its probability of *gaining* access to U.S. MMFs. We present the results in Appendix Tables D.16 and D.17.

²⁶Since only 13 banks have access to secured funding and since these banks never completely lose access to repos, we concentrate on banks losing access to unsecured funding via U.S. MMFs.

The results in Table 11 show that the probability of completely losing access to U.S. MMF unsecured funding within a month ($P(\textit{losing access to all funds})$) is the highest for GIIPS banks (15%) during the sovereign debt crisis, compared to non-GIIPS eurozone banks (8%) or non-eurozone banks (1.8%). Indeed, most GIIPS banks lose access to unsecured funding before LTRO 1. The probability of non-GIIPS eurozone banks losing access to unsecured U.S. MMFs is 6% in the post-LTRO period, and reduces to its lowest level (1.8%) following the announcement of the OMT program. All of these probabilities are significantly different from a probability of 50% at the 1% level.

The probability of losing access to a particular fund in month t when the bank had access to this fund in month $t - 1$ ($P(\textit{losing access to one fund})$) is always larger than the probability of completely losing access to U.S. MMFs ($P(\textit{losing access to all funds})$). The probit regression describing access to a fund is:

$$P(Y_{ijt} = 1|X) = \Phi \left(\sum_{\tau} [\alpha_{GIIPS,\tau} d_{GIIPS} + \alpha_{core,\tau} d_{core} + \alpha_{nonEuro,\tau} d_{nonEuro}] d_{\tau} \right), \quad (4)$$

where Y_{ijt} is a binary variable equal to one if fund j invested unsecured funds in bank i in month $t - 1$ and ceased investing in that bank in month t ; d_{GIIPS} denotes GIIPS banks, d_{core} denotes non-GIIPS eurozone banks, $d_{nonEuro}$ denotes non-eurozone banks, X comprises all explaining variables included in the regression, and $\Phi(\cdot)$ is the standard normal c.d.f.

During the sovereign debt crisis, the probability $P(Y_{ijt} = 1|X)$ is the highest for GIIPS banks (35%), compared to non-GIIPS eurozone and non-eurozone banks (21% and 12%, respectively). After the LTROs, the probability of losing access to one fund for a GIIPS bank is not significantly different from 50%, while this probability is 6% for non-GIIPS eurozone banks and 0.74% for non-eurozone banks. The probability of a GIIPS bank (i.e., Banco Santander) losing access to one fund is the lowest (5%) following the announcement of the OMT program, which is lower than the probability of non-GIIPS eurozone banks and

non-eurozone banks (11% and 9%, respectively).

We derive the marginal effect of an increase in the GIIPS exposure for the “median bank” (i.e., a bank that holds the cross-sectional median exposure to GIIPS sovereign debt) on its probability of losing access to unsecured funding. While increasing the GIIPS exposure has the largest positive impact on the probability of losing access to U.S. MMFs following the LTROs, this marginal effect of the bank GIIPS exposure on losing access to unsecured funding is not significantly different from zero following the OMT program announcement. This conclusion holds for both the probability of losing access to one fund and the probability of losing access to all U.S. MMFs.

Overall, our results suggest that non-GIIPS banks holding GIIPS sovereign bonds on their balance sheet are able to recover access to unsecured funding.²⁷ GIIPS banks, on the other hand, do not regain access to U.S. MMFs and remain dependent on central bank funding. A possible explanation is the lack of capital of GIIPS banks relative to non-GIIPS eurozone and non-eurozone banks as described above. Despite the increase in market value of their domestic sovereign bonds after the OMT program announcement, solvency concerns of GIIPS banks remained eventually excluding them from private short-term funding markets.

6. Conclusion

We assess the effectiveness of the unconventional interventions of the European Central Bank (ECB) in restoring financial stability in the eurozone following the peak of the European sovereign debt crisis in the summer of 2011. Our central result is that how the ECB intervened mattered. In particular, whether the ECB acted as lender of last resort (e.g., LTRO liquidity injections in December 2011 and February 2012) or buyer of last resort (e.g.,

²⁷Not only do these banks experience larger unsecured inflows, we also find that their funding risk (measured by the probability of losing access to U.S. MMFs) does not increase when holding GIIPS sovereign bonds following the announcement of the OMT program.

OMT program in the summer of 2012).

While the LTRO liquidity injections did not affect the sovereign risk of GIIPS countries, the OMT program significantly reduced the sovereign yields and sovereign credit default swap spreads of Italy and Spain. Moreover, while the LTRO liquidity injections did reduce the immediate funding risk for banks, we show that it aggravated the bank-sovereign nexus by giving incentives to GIIPS banks to increase their holdings of domestic sovereign bonds. Consequently, when sovereign risk increased again in the peripheral countries after the LTROs, the financial health of eurozone banks worsened and the run of short-term private creditors intensified. In contrast, the OMT program led to a reduction in the domestic bank-sovereign nexus. By effectively increasing the market prices of sovereign bonds, the OMT program provided incentives for all banks to buy these bonds and improved the asset side of banks exposed to GIIPS sovereign debt. The consequence was a permanent reversal of private funding flows towards eurozone non-GIIPS banks following the announcement of the OMT program. GIIPS banks, however, did not benefit from a reversal of private fund flows due to more severe solvency concerns.

Overall, our findings suggest that the effectiveness of unconventional central bank interventions should not only be assessed in terms of a reduction of immediate funding risk for banks. Instead, we should also carefully assess the effects of these interventions on the asset side of banks. Central bank interventions can aggravate a crisis situation when they increase moral hazard by giving banks incentives to hold onto or expand their holdings of troubled assets. Specifically, without an adequate recapitalization of distressed banks, the lender of last resort interventions can entrench banks with risky assets making them more vulnerable to runs if risky assets worsen in quality. In contrast, buyer of last resort interventions provide liquidity to the market at large and can credibly improve bank fundamentals and stabilize their short-term funding. This was the case for ECB's OMT program, at least in terms of its impact on non-GIIPS eurozone banks.

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Table 1: **Impact of ECB interventions on sovereign CDS spreads and sovereign yields**

This table reports the percentage change in average five-year sovereign CDS spread (Panel A), average five-year sovereign bond yield (Panel B), average ten-year sovereign bond yield (Panel C), and average two-year sovereign bond yield (Panel D), following LTRO 1 (12-21-2011), LTRO 2 (2-29-2012), and OMT (7-26-2012). Note that “OMT” corresponds to the date of Mario Draghi’s speech. IS stands for Italy and Spain. GIIPS excludes Greece.

Panel A: Change in average 5-yr sovereign CDS (%)			
	GIIPS (IS)	Euro non-GIIPS	non-Euro
LTRO 1 - LTRO 2	-8 (-13)	-17	-23
LTRO 2 - OMT	-1 (48)	-12	-7
Post OMT	-59 (-55)	-64	-49

Panel B: Change in average 5-yr sovereign yield (%)			
	GIIPS (IS)	Euro non-GIIPS	non-Euro
LTRO 1 - LTRO 2	-19 (-33)	-24	-16
LTRO 2 - OMT	4 (56)	-50	-49
Post OMT	-58 (-49)	-54	12

Panel C: Change in average 10-yr sovereign yield (%)			
	GIIPS (IS)	Euro non-GIIPS	non-Euro
LTRO 1 - LTRO 2	-5 (-15)	-8	1
LTRO 2 - OMT	6 (29)	-29	-36
Post OMT	-26 (-29)	-15	12

Panel D: Change in average 2-yr sovereign yield (%)			
	GIIPS (IS)	Euro non-GIIPS	non-Euro
LTRO 1 - LTRO 2	-39 (-58)	-54	18
LTRO 2 - OMT	6 (84)	-93	-45
Post OMT	-71 (-67)	-122	12

Table 2: **Sovereign event study**

This table reports in Panel A the two-day [-1;1] cumulative abnormal changes (CARs) in five-year bond yields of Spain, Italy, and Germany surrounding various interventions from the European Central Bank (ECB). In Panel B, we report the two-day [-1;1] cumulative abnormal changes in five-year sovereign CDS spreads of Spanish bonds, Italian bonds, and German bunds surrounding various ECB interventions. These are the LTRO preliminary announcement (12-01-2011), the LTRO announcement (12-08-2011), LTRO 1 (12-21-2011), LTRO 2 (2-29-2012), Draghi's speech (7-26-2012), the preliminary OMT program announcement (8-02-2012), and the announcement of the OMT program details (9-06-2012). The evidence in Panel A is based on a market model and autocorrelation adjusted abnormal bond yield changes. We use the JPM EU Sovereign Bond Index as the benchmark bond market index in computing these abnormal changes. The evidence in Panel B is based on the market model and autocorrelation adjusted abnormal CDS changes. We use the Markit iTraxx SovX Western Europe index as the benchmark CDS market index in computing these abnormal changes. T-statistics are in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	Panel A: CAR of 5-yr Sovereign Yields			Panel B: CAR of 5-yr Sovereign CDS		
	Spain	Italy	Germany	Spain	Italy	Germany
LTRO prelim. 12-01-2011	-36.028*** (-2.329)	-25.211 (-1.315)	5.369 (0.551)	-13.295 (-1.044)	-12.494 (-0.853)	0.106 (0.033)
LTRO 12-08-2011	19.069 (1.199)	25.935 (1.304)	-4.226 (-0.445)	19.345 (1.468)	37.984** (2.519)	-1.373 (-0.418)
LTRO 1 12-21-2011	13.778 (0.856)	18.024 (0.891)	-0.821 (-0.087)	8.206 (0.593)	-14.052 (-0.894)	-1.060 (-0.313)
LTRO 2 2-29-2012	-4.559 (-0.270)	-41.345* (-1.921)	11.351 (1.231)	-3.636 (-0.256)	-20.430 (-1.257)	-2.815 (-0.820)
Draghi's speech 7-26-2012	-58.060*** (-2.728)	-40.585* (-1.765)	15.444* (1.753)	-54.407*** (-2.900)	-38.906* (-1.869)	-2.981 (-0.729)
OMT prelim. 8-02-2012	-30.504 (-1.477)	-21.485 (-0.951)	9.091 (1.069)	7.895 (0.431)	-9.801 (-0.480)	-1.433 (-0.361)
OMT 9-06-2012	-50.905** (-2.349)	-24.485 (-1.097)	7.990 (0.965)	-72.709*** (-3.751)	-48.643** (-2.356)	0.703 (0.177)

Table 3: Sovereign bond holdings of banks

This table reports the change (in € billion) in overall sovereign bond holdings of banks in Panel A, the change in the sovereign bond holdings of short maturity (between one and three years) in Panel B, and the change in the sovereign bond holdings of long maturity (above three years) in Panel C. GIIPS excludes Greece. Sample: Public banks that participated in all EBA stress tests (excludes Dexia, Greek, and Cypriot banks).

Panel A: Change in sovereign bond holdings (€ billion)

	Change in home exposure			Change in GIIPS exposure	
	GIIPS	Italy	Spain	Euro non-GIIPS	non-Euro
Dec 2010 - Dec 2011	-17	-16	1	-59	-18
Dec 2011 - Jun 2012 (post LTRO)	55	36	13	-9	-6
Jun 2012 - Dec 2012 (post OMT)	12	14	-3	4	-1
Dec 2012 - Dec 2013	-8	11	-18	13	-1

Panel B: Change in sovereign bond holdings (between 1 and 3-yr maturity)

	change in GIIPS exp		change in Italian exp		change in Spanish exp	
	GIIPS	non-GIIPS	Italian	non-Italian	Spanish	non-Spanish
Dec 2010 - Dec 2011	-35	-30	-22	-18	-10	-7
Dec 2011 - Jun 2012 (post LTRO)	37	-1	29	4	6	-1
Jun 2012 - Dec 2012 (post OMT)	17	1	8	-1	-7	2
Dec 2012 - Dec 2013	-1	8	15	4	-11	3

Panel C: Change in sovereign bond holdings (above 3-yr maturity)

	change in GIIPS exp		change in Italian exp		change in Spanish exp	
	GIIPS	non-GIIPS	Italian	non-Italian	Spanish	non-Spanish
Dec 2010 - Dec 2011	16	-29	6	-21	11	-5
Dec 2011 - Jun 2012 (post LTRO)	15	-8	8	-1	7	0
Jun 2012 - Dec 2012 (post OMT)	22	3	6	6	4	-2
Dec 2012 - Dec 2013	-14	5	-4	5	-7	1

Table 4: Investor groups' exposure to sovereign bonds

This table presents the results of the regression of several financial institutions group index returns on average five-year sovereign bond yield changes of GIIPS countries and Germany. Bank indexes include value-weighted indexes of EBA non-GIIPS eurozone banks (non-GIIPS), of EBA GIIPS banks (GIIPS), of EBA non-eurozone banks (non-Euro), and of U.S. banks (U.S.). Non-bank indexes include the macro HFRX hedge funds index (Hedge funds), and the Stoxx Europe 600 Insurance index. Crisis period: 6-01-2011 - 12-07-2011. Post-LTRO period: 12-08-2011 - 7-25-2012. Post-OMT period: 7-26-2012 - 6-25-2013. Estimation period: 6-01-2011 - 6-25-2013. All regressions include an autoregressive term, the market index return, crisis, post-LTRO, and post-OMT program constants. As for market return, we include the Euro Stoxx 600 for European indexes, the MSCI World for the global index, and the S&P 500 for the U.S. index. T-statistics based on Newey-West standard errors are in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	Regression of stock returns on sovereign yield changes					
	GIIPS	non-GIIPS	non-Euro	U.S.	Hedge funds	Insurance
GIIPS	-0.015*** (-4.610)	-0.019*** (-3.160)	-0.006*** (-3.010)	-0.001 (-0.569)	0.043 (0.490)	-0.007*** (-3.440)
GIIPS post LTRO	-0.006 (-0.658)	-0.001 (-0.146)	0.002 (0.582)	-0.005 (-1.350)	-0.023 (-0.142)	0.001 (0.181)
GIIPS post OMT	-0.061*** (-4.940)	-0.018 (-1.470)	0.017*** (2.860)	0.008* (1.680)	-0.756*** (-2.940)	0.002 (0.521)
Germany	0.108*** (8.000)	0.093*** (6.860)	0.001 (0.079)	0.022 (3.090)	-1.328*** (-4.690)	0.037*** (6.140)
Adj. R ² (%)	64.77	75.00	84.75	81.90	7.82	89.24
F	108***	175***	323***	295***	7***	552***
Observations	465	465	465	520	522	532

Table 5: Impact of ECB interventions on banks

This table reports the percentage change in average bank CDS spread and average bank equity price following LTRO 1 (12-21-2011), LTRO 2 (2-29-2012), and OMT (7-26-2012). Panel A reports the percentage change in average five-year bank CDS spread. Panel B reports the percentage change in average three-year bank CDS spread. Panel C reports the percentage change in average bank equity prices. Note that “OMT” corresponds to the date of Mario Draghi’s speech. IS stands for Italy and Spain. GIIPS excludes Greece. Sample: Public banks that participated in all EBA stress tests (excludes Dexia, Greek and Cypriot banks).

Panel A: Change in average bank 5-yr CDS (%)

	GIIPS (IS)	Euro non-GIIPS	non-Euro
LTRO 1 - LTRO 2	-20 (-30)	-24	-19
LTRO 2 - OMT	25 (47)	23	18
Post OMT	-27 (-39)	-45	-55

Panel B: Change in average bank 3-yr CDS (%)

	GIIPS (IS)	Euro non-GIIPS	non-Euro
LTRO 1 - LTRO 2	-31 (-42)	-33	-20
LTRO 2 - OMT	22 (55)	25	14
Post OMT	-39 (-54)	-69	-59

Panel C: Change in average bank equity prices (%)

	GIIPS (IS)	Euro non-GIIPS	non-Euro
LTRO 1 - LTRO 2	15 (8)	30	25
LTRO 2 - OMT	-60 (-62)	-36	-11
Post OMT	36 (29)	41	7

Table 6: **Bank event study**

This table reports in Panel A the average two-day [-1;1] cumulative abnormal returns (CARs) on equity for publicly traded GIIPS, non-GIIPS eurozone (non-GIIPS), and non-eurozone banks that participated in all EBA stress tests surrounding the various ECB interventions. Panel B presents the average two-day [-1;1] cumulative abnormal changes (CARs) in five-year and three-year CDS spreads for publicly traded GIIPS, non-GIIPS eurozone, and non-eurozone banks surrounding the various ECB interventions. These are the LTRO preliminary announcement (12-01-2011), the LTRO announcement (12-08-2011), LTRO 1 (12-21-2011), LTRO 2 (2-29-2012), Draghi's speech (7-26-2012), the preliminary OMT program announcement (8-02-2012), and the announcement of the OMT program details (9-06-2012). The evidence in Panel A is based on 15 GIIPS banks, 9 non-GIIPS eurozone banks, 12 non-eurozone banks, and a market model and autocorrelation adjusted abnormal equity returns. We use the Euro Stoxx Index as the benchmark stock market index in computing these abnormal returns. The evidence in Panel B is based on 12 GIIPS banks, 9 non-GIIPS eurozone banks, 9 non-eurozone banks, and a market model and autocorrelation adjusted abnormal CDS changes. We use the Market iTraxx Europe Crossover index on the most liquid sub-investment grade European corporate entities as the benchmark CDS market index in computing these abnormal changes. T-statistics are in parentheses. ***, **, *, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	Panel A: Bank equity				Panel B: Bank CDS				
	Average Equity CAR		Average 5-yr CDS CAR		Average 3-yr CDS CAR		Average 3-yr CDS CAR		
	GIIPS	Euro core	non-Euro	GIIPS	Euro core	non-Euro	GIIPS	Euro core	non-Euro
LTRO prelim. 12-01-2011	8.495** (2.099)	10.692* (1.869)	5.283 (1.230)	-39.867* (-1.830)	-25.996*** (-4.209)	-19.030*** (-6.000)	-40.702*** (-2.662)	-20.755*** (-3.383)	-9.318*** (-4.157)
LTRO 12-08-2011	-0.963 (-0.238)	-5.442 (-0.955)	-2.442 (-0.572)	13.586 (0.623)	12.904** (2.028)	6.042* (1.752)	6.888 (0.447)	12.333** (1.982)	3.112 (1.325)
LTRO 1 12-21-2011	2.738 (0.681)	3.366 (0.598)	2.311 (0.548)	-18.817 (-0.877)	-10.914* (-1.726)	-3.599 (-1.043)	-12.425 (-0.816)	-11.224* (-1.776)	-2.623 (-1.120)
LTRO 2 2-29-2012	2.830 (0.695)	2.887 (0.508)	0.586 (0.139)	-3.357 (-0.158)	-4.109 (-0.607)	-1.741 (-0.469)	-1.999 (-0.134)	-3.827 (-0.584)	-1.492 (-0.577)
Draghi's speech 7-26-2012	4.949 (1.412)	3.608 (0.909)	2.929 (1.037)	-18.275 (-1.542)	-4.410 (-0.584)	-2.837 (-0.685)	-9.818 (-0.823)	-2.367 (-0.322)	-2.298 (-0.778)
OMT prelim. 8-02-2012	6.770* (1.962)	7.167* (1.841)	2.652 (0.960)	8.166 (0.710)	5.559 (0.757)	0.950 (0.229)	9.115 (0.771)	5.111 (0.717)	1.217 (0.415)
OMT 9-06-2012	2.554 (0.741)	2.951 (0.752)	1.312 (0.508)	-35.656*** (-3.362)	-7.368 (-1.061)	-4.251 (-1.068)	-38.422*** (-3.483)	-5.973 (-0.895)	-3.110 (-1.118)

Table 7: **Regression analysis of CDS CARs surrounding various ECB interventions**

This table presents estimates from a linear regression analysis of the determinants of two-day [-1;1] five-year CDS CARs surrounding the different ECB interventions. Independent variables are each bank's GIIPS and non-GIIPS eurozone sovereign bond holdings scaled by total assets. Tier1 is Tier 1 capital divided by risk-weighted assets; RWA/TA is risk-weighted assets divided by total assets. Bank characteristics and sovereign bond holdings are from the period prior to the intervention. T-statistics based on White heteroskedasticity-robust standard errors are in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. R^2 is the adjusted R^2 .

	5-yr CDS CARs						
	LTRO prelim	LTRO	LTRO 1	LTRO 2	Draghi's speech	OMT prelim	OMT
GIIPS/Assets	-433.85*** (-4.62)	100.85 (1.23)	-148.36 (-1.57)	-105.30* (-1.73)	-365.65*** (-3.57)	117.41 (1.45)	-674.06** (-2.30)
Euro non-GIIPS/Assets	125.07 (1.51)	-75.15 (-1.09)	33.73 (0.40)	-64.89 (-0.70)	-127.64 (-1.17)	49.90 (0.81)	-160.89 (-0.72)
Log-Assets	-8.56** (-2.52)	1.18 (0.51)	2.35 (0.78)	-3.78 (-1.31)	-7.04 (-2.65)	2.93 (1.44)	-3.26 (-0.79)
Tier 1	471.52 (1.61)	-962.19*** (-4.48)	578.55 (1.49)	34.71 (0.11)	-109.12 (-0.21)	289.36 (0.86)	24.42 (0.03)
RWA/Assets	-31.21 (-0.90)	75.43*** (2.96)	-65.27* (-1.85)	-9.49 (-0.33)	17.81 (0.39)	-34.62 (-0.99)	17.39 (0.27)
Constant	23.05 (0.84)	17.38 (0.96)	-24.98 (-1.04)	27.08 (1.09)	44.92 (1.98)	-16.71 (-1.00)	12.75 (0.31)
N	29	29	29	29	27	27	27
R^2 (%)	52.71	50.94	28.91	-7.71	33.54	-9.43	32.33

Table 8: **MMF flows and LTRO flows**

This table presents estimates from cross-sectional regressions examining the demand for public funding through the three-year LTROs. Probit: The dependent variable is a dummy variable equal to one if a bank received LTRO funding (LTRO 1 and 2 combined). OLS: The dependent variable is the logarithm of LTRO funding received, if LTRO amount is positive. GIPS(2011): GIPS gross direct exposure (in hundredth of percentage of total assets) as of end September 2011, CDS(2011): CDS price as of end November 2011. Standard errors in parentheses (White standard errors for OLS regressions). ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	MMF flows during the crisis and the demand for LTRO funding							
	Probit				OLS			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MMF unsecured flow (crisis)	-1.623** (0.615)	-1.447* (0.720)			-5.279*** (1.292)	-4.437** (1.756)		
Debt flow (2011)		-1.408 (3.423)				-5.233 (8.756)		
CDS(2011)			0.660** (0.296)				0.265* (0.128)	
GIPS(2011)				0.402* (0.219)				1.056*** (0.262)
Constant	-0.957* (0.466)	-0.818 (0.536)	-2.094** (0.906)	-0.419 (0.313)	1.778** (0.753)	2.243** (1.024)	3.430*** (1.081)	3.321*** (0.957)
Number of banks	28	24	28	31	28	24	28	31

Table 9: Impact of ECB interventions on U.S. MMF funding flows

This table reports the change in U.S. money market fund investments (in \$ billion) at European banks following LTRO 1 (12-21-2011), LTRO 2 (2-29-2012), and OMT (7-26-2012). Panel A reports the change in unsecured funding. Panel B reports the change in secured funding. Panel C reports the seasonality-adjusted change in secured funding (average over a three-month window $[t-1, t+1]$). Percentage change in parentheses. Note that “OMT” corresponds to the date of Mario Draghi’s speech. Banco Santander is the only GIIPS bank that recovers access to U.S. MMFs (all other GIIPS banks lose access in 2011). Sample: European banks with access to U.S. MMFs.

Panel A: Change in MMF investments in \$bn (%) - unsecured			
	Banco Santander	Euro non-GIIPS	non-Euro
LTRO 1 - LTRO 2	-0.49 (-99%)	14 (19%)	-27 (-16%)
LTRO 2 - OMT	0.10 (-)	-19 (-21%)	-28 (-19%)
Post OMT	0.93 (-)	61 (89%)	11 (8%)

Panel B: Change in MMF investments in \$bn (%) - secured		
	Euro non-GIIPS	non-Euro
LTRO 1 - LTRO 2	56 (44%)	23 (13%)
LTRO 2 - OMT	-46 (-25%)	-27 (-14%)
Post OMT	-47 (-27%)	-87 (-45%)

Panel C: Change in MMF investments in \$bn (%) - secured, seasonality adjusted		
	Euro non-GIIPS	non-Euro
LTRO 1 - LTRO 2	9 (6%)	1 (0%)
LTRO 2 - OMT	3 (2%)	-7 (-4%)
Post OMT	-10 (-6%)	-72 (-40%)

Table 10: **U.S. MMF funding flows at European banks according to risk**

This table presents estimates from a linear regression analysis of the determinants of U.S. MMF flows at a bank surrounding the different ECB interventions. The regression is a pooled OLS regression where the dependent variable is the percentage change in principal amount at date t . The regression is augmented by deterministic interaction terms to account for changing parameters before the sovereign debt crisis (pre-crisis), during the crisis (crisis), after LTRO 1 (post LTRO), and after the OMT program announcement (post OMT). Pre-crisis period: Nov 2010 – May 2011; Crisis period: Jun 2011 – Dec 2011; Post LTRO period: Jan 2012 – Sept 2012; Post OMT period: Oct 2012 – Aug 2014. AR: autoregressive parameter; GIIPSexp: GIIPS gross direct exposure (percentage of total assets) updated before each period starts; CDS: CDS price updated before each period starts. ***, **, and * indicate significance (based on panel robust standard errors) at the 1%, 5%, and 10% levels, respectively.

	Unsecured			Secured		
	(1)	(2)	(3)	(4)	(5)	(6)
CDS, pre-crisis	-0.065***		-0.071***	-0.019		0.002
CDS, crisis	-0.168***		-0.101**	-0.070		0.009
CDS, post LTRO	-0.024		-0.020	0.009*		0.007
CDS, post OMT	0.022**		0.014	0.019***		0.020***
GIIPSexp, pre-crisis		-0.346	0.522		-9.915***	-9.883
GIIPSexp, crisis		-4.903***	-3.267**		-17.432*	-17.694**
GIIPSexp, post LTRO		-2.047	-1.508		3.116***	2.461**
GIIPSexp, post OMT		1.631***	1.044		2.601*	0.842
Pre-crisis	0.041**	-0.032	0.040	0.020	0.094*	0.092**
Crisis	0.101***	-0.050**	0.055	0.070	0.150**	0.141
Post LTRO	0.054	0.010	0.052	-0.019*	-0.012	-0.025**
Post OMT	-0.025***	0.003	-0.016	-0.035***	-0.012	-0.042**
AR	0.534***	0.543***	0.522***	0.451***	0.345***	0.339***
R ² (%)	43.418	42.971	44.256	19.649	28.762	28.985
Adj. R ² (%)	42.877	42.426	43.453	17.555	26.905	26.172
Sample	846 observations 29 banks			316 observations 9 banks		

Table 11: **Losing access to U.S. MMF unsecured funding after ECB interventions**

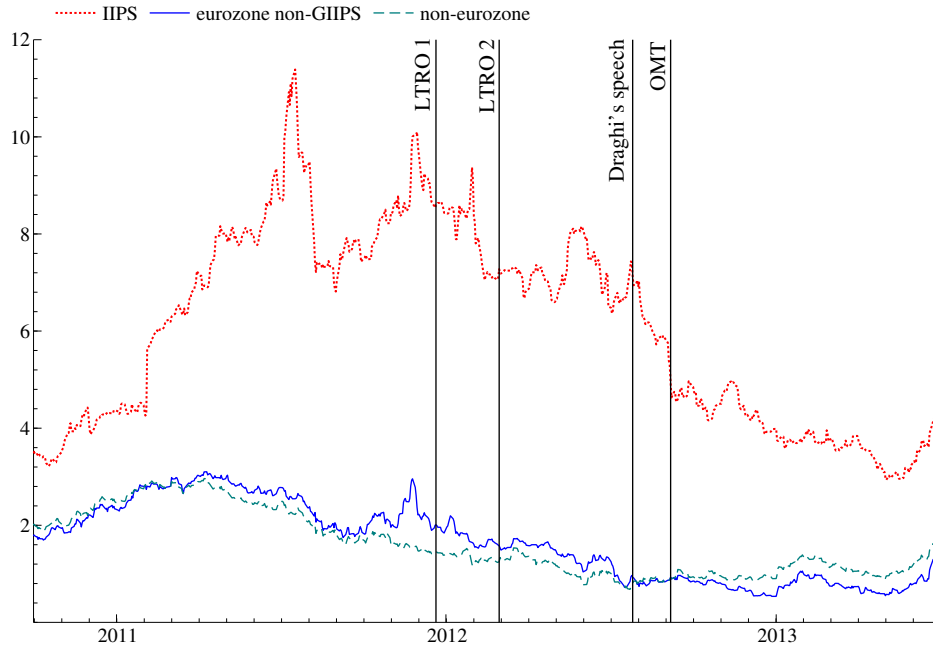
The regression is a pooled probit regression where the dependent variable is the probability of losing access to U.S. MMF unsecured funding when the bank had access at time t-1 ($P(\text{Losing access to all funds})$), or the probability of losing access to one fund when the bank had access to the fund at time t-1 ($P(\text{Losing access to one fund})$). GIIPSexp: GIIPS gross direct exposure (percentage of total assets) updated before each period starts. The reported coefficients for GIIPSexp represent the change in probability corresponding to a 1% increase in GIIPS exposure for the median bank. AR: autoregressive parameter. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Pseudo R² is the Pseudo R² of McFadden.

Probit analysis for the probability of losing access to MMF unsecured funding					
	P(losing access to)			P(losing access to)	
	all funds	one fund		all funds	one fund
GIIPS, pre-crisis	6.67***	23.30***	GIIPSexp, pre-crisis	-0.10	1.88***
GIIPS, crisis	15.00***	35.16***	GIIPSexp, crisis	1.03**	4.93***
GIIPS, post LTRO	14.29***	45.00	GIIPSexp, post LTRO	1.28**	6.20***
GIIPS, post OMT		4.93***	GIIPSexp, post OMT	-0.15	0.50
Euro non-GIIPS, pre-crisis	2.38***	9.66***	Pre-crisis	1.70***	8.01***
Euro non-GIIPS, crisis	8.19***	20.84***	Crisis	3.14***	12.17***
Euro non-GIIPS, post LTRO	6.17***	13.66***	Post LTRO	0.90***	11.37***
Euro non-GIIPS, post OMT	1.79***	11.21***	Post OMT	0.27***	9.28***
Non-Euro, pre-crisis	1.10***	11.46***			
Non-Euro, crisis	1.89***	12.48***			
Non-Euro, post LTRO	0.74***	13.74***			
Non-Euro, post OMT	0.87***	9.30***			
Unconditional probability	2.84	12.09	Unconditional probability	1.71	11.31
Pseudo R ² (%)	2.14	1.50	Pseudo R ² (%)	15.64	2.02
Observations	1,761	63,092	Observations	1,053	45,403
Banks	63	63	Banks	34	30

Figure 1: Sovereign risk

This figure shows the average five-year sovereign bond yields (Panel A) and average five-year sovereign CDS prices (Panel B) of IIPS countries (Ireland, Italy, Portugal, and Spain), non-GIIPS eurozone countries, and non-eurozone countries. Vertical bars indicate ECB interventions: LTRO 1 (12-21-2011), LTRO 2 (2-29-2012), Draghi's speech (7-26-2012), OMT program (9-06-2012).

(a) Average sovereign yields (%)



(b) Average sovereign CDS prices (bps)

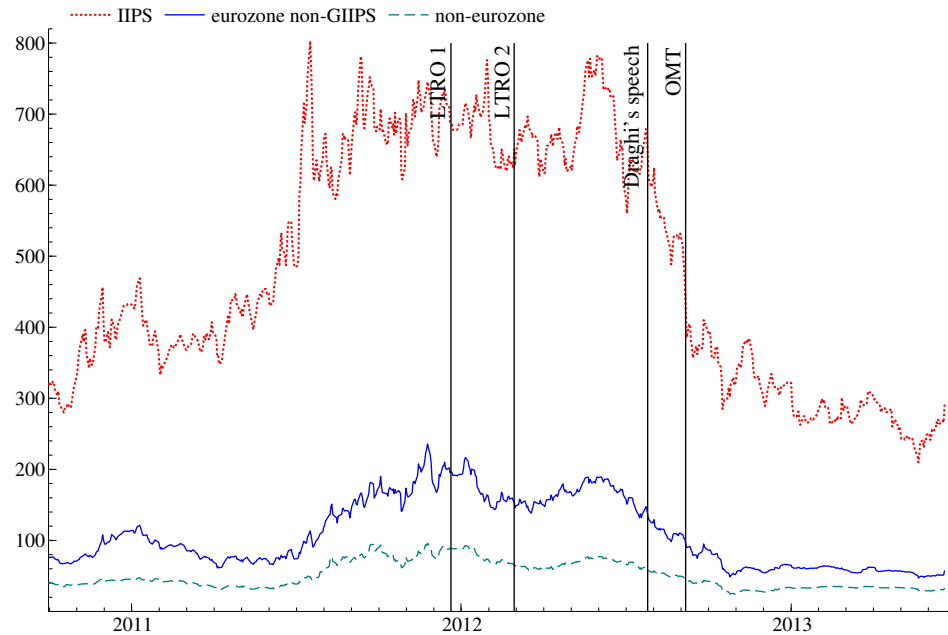
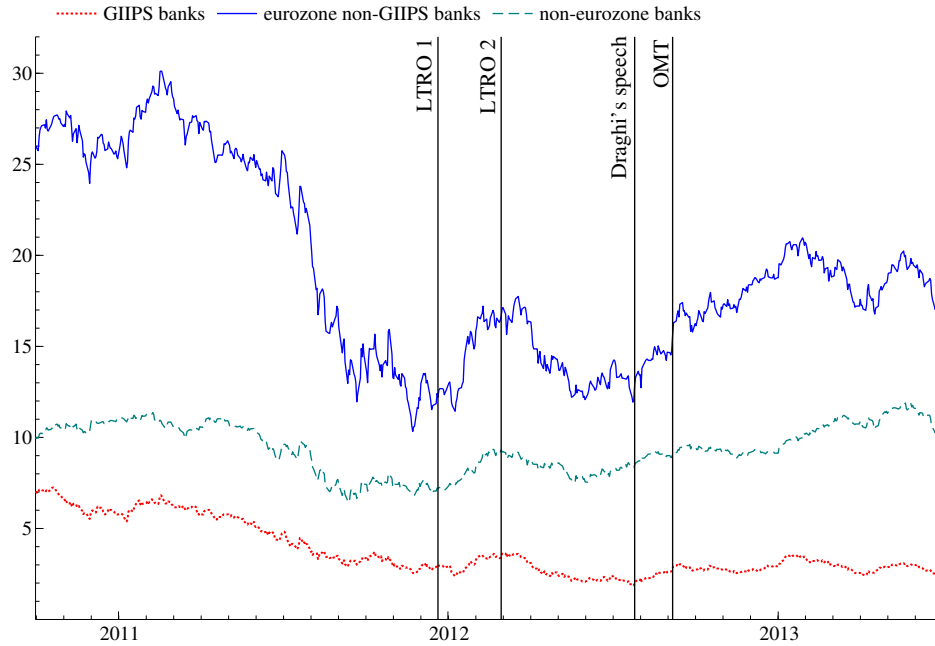


Figure 2: Solvency risk

This figure shows the average equity prices (Panel A) and average five-year CDS prices (Panel B) of GIIPS banks (excluding Greek banks), non-GIIPS eurozone banks (excluding Dexia), and non-eurozone banks. Vertical bars indicate ECB interventions: LTRO 1 (12-21-2011), LTRO 2 (2-29-2012), Draghi's speech (7-26-2012), OMT program (9-06-2012).

(a) Average bank equity prices (€)



(b) Average bank CDS prices (bps)

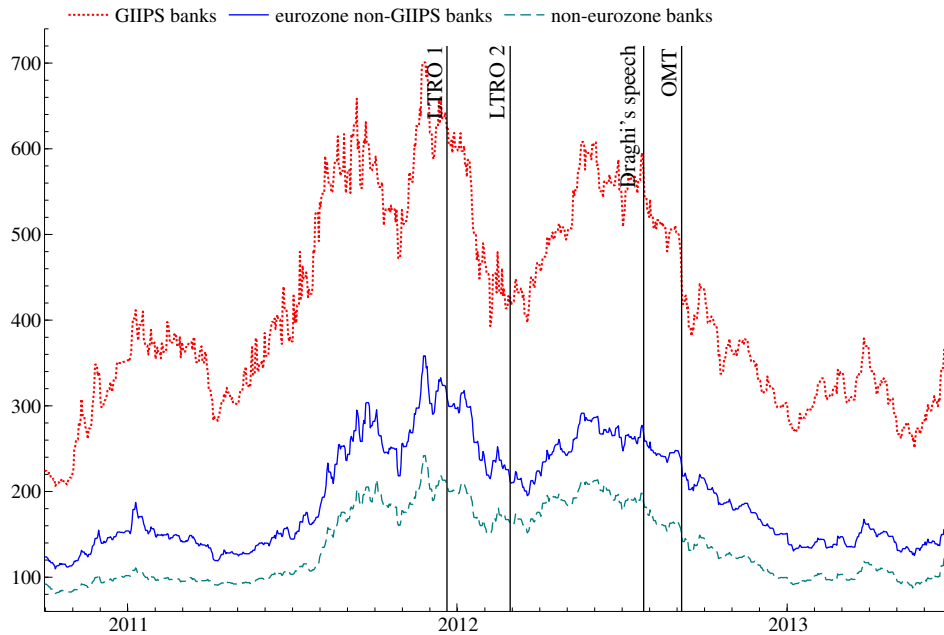
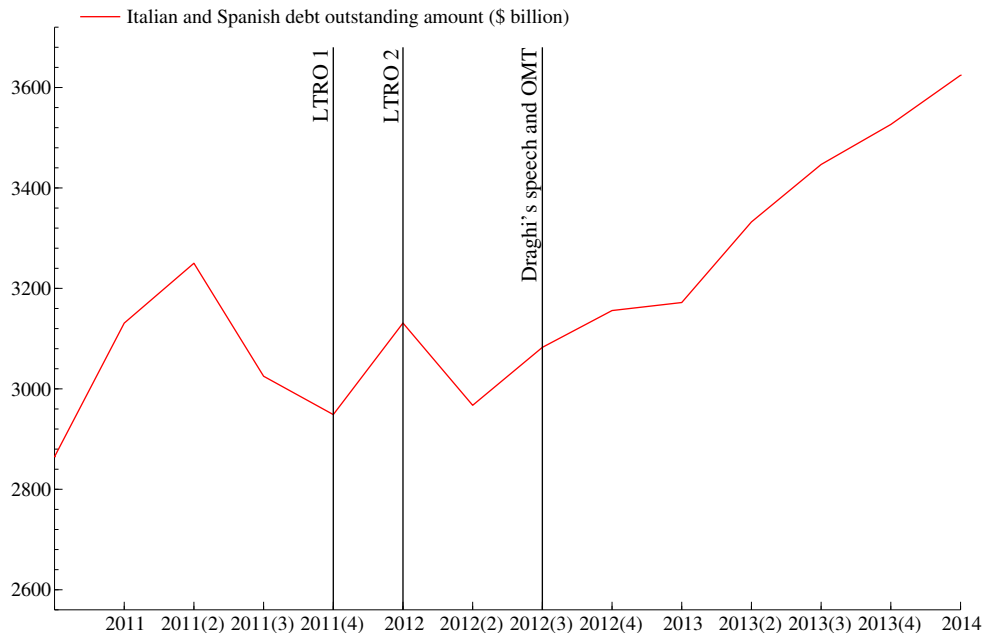


Figure 3: Italian and Spanish sovereign debt

This figure shows the outstanding amount (\$ billion) of Italian and Spanish government debt securities (Panel A), and the national banking sectors' exposure (€ billion) to Italian and Spanish official sectors (Panel B). Sources: BIS Debt securities statistics (Panel A), BIS Consolidated Banking Statistics and ECB (Panel B). Vertical bars indicate ECB interventions: LTRO 1 (Q4 2011), LTRO 2 (Q1 2012), Draghi's speech and OMT program (Q3 2012).

(a) Government debt securities outstanding amount (\$ billion)



(b) National banking sectors' exposure to Italian and Spanish official sectors (€ billion)

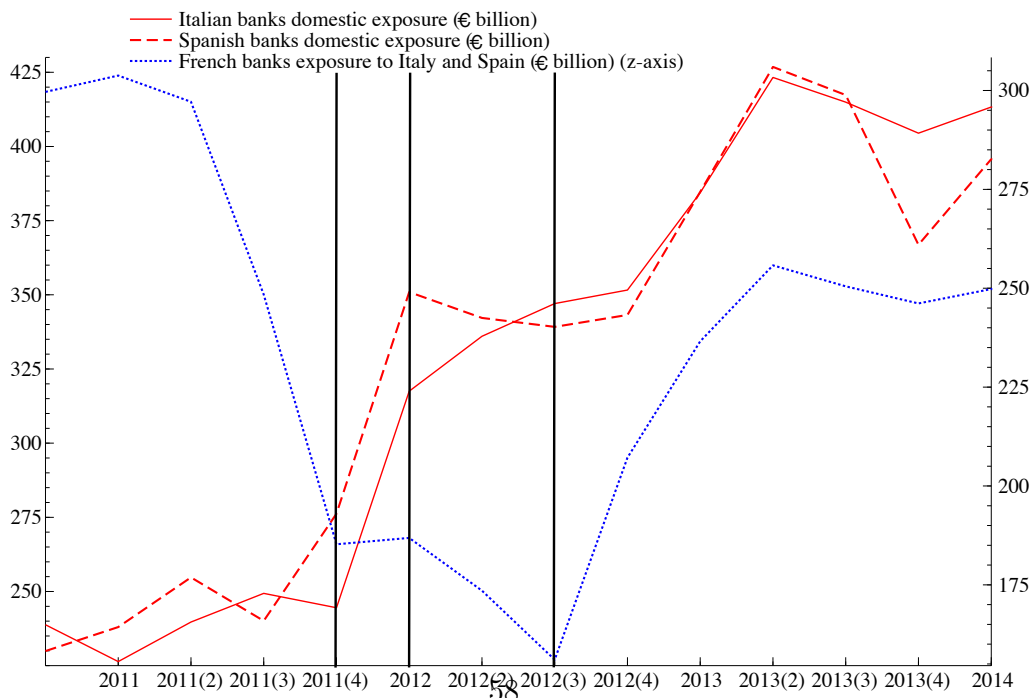
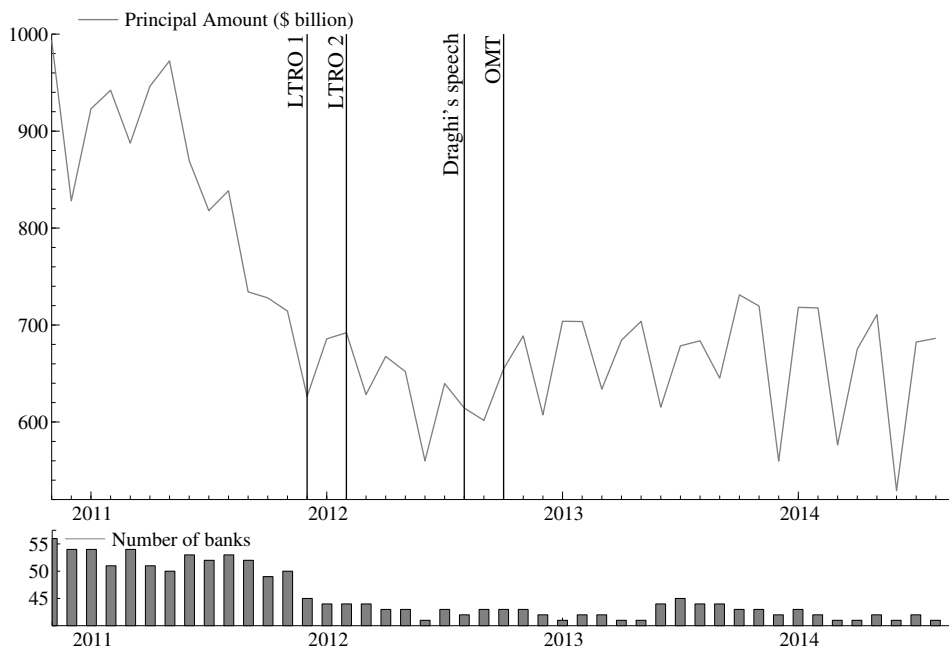


Figure 4: Money market fund investments at European banks

This figure shows the total principal amount (\$ billion) of all securities invested by U.S. MMFs at European banks (Panel A), and the total principal amount (\$ billion) of unsecured funding (CDs and financial CPs) versus secured funding (repos) invested by U.S. MMFs at European banks (Panel B). Vertical bars indicate ECB interventions: LTRO 1 (Dec 2011), LTRO 2 (Feb 2012), Draghi's speech (Jul 2012), OMT program (Sept 2012).

(a) MMF investments (\$ billion) - All securities



(b) MMF investments (\$ billion) - Secured (repos) versus unsecured funding

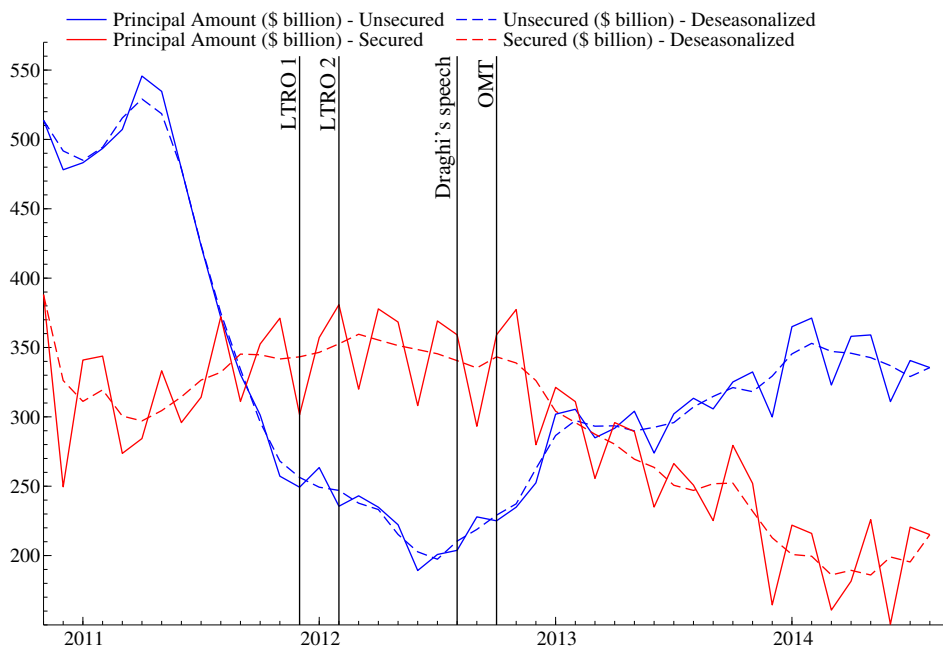


Figure 5: MMF unsecured investments at GIIPS, non-GIIPS eurozone, and non-eurozone banks

This figure shows the principal amounts of unsecured funding (\$ billion) invested at GIIPS, non-GIIPS eurozone, and non-eurozone banks. Vertical bars indicate ECB interventions: LTRO 1 (Dec 2011), LTRO 2 (Feb 2012), Draghi's speech (Jul 2012), OMT program (Sept 2012).

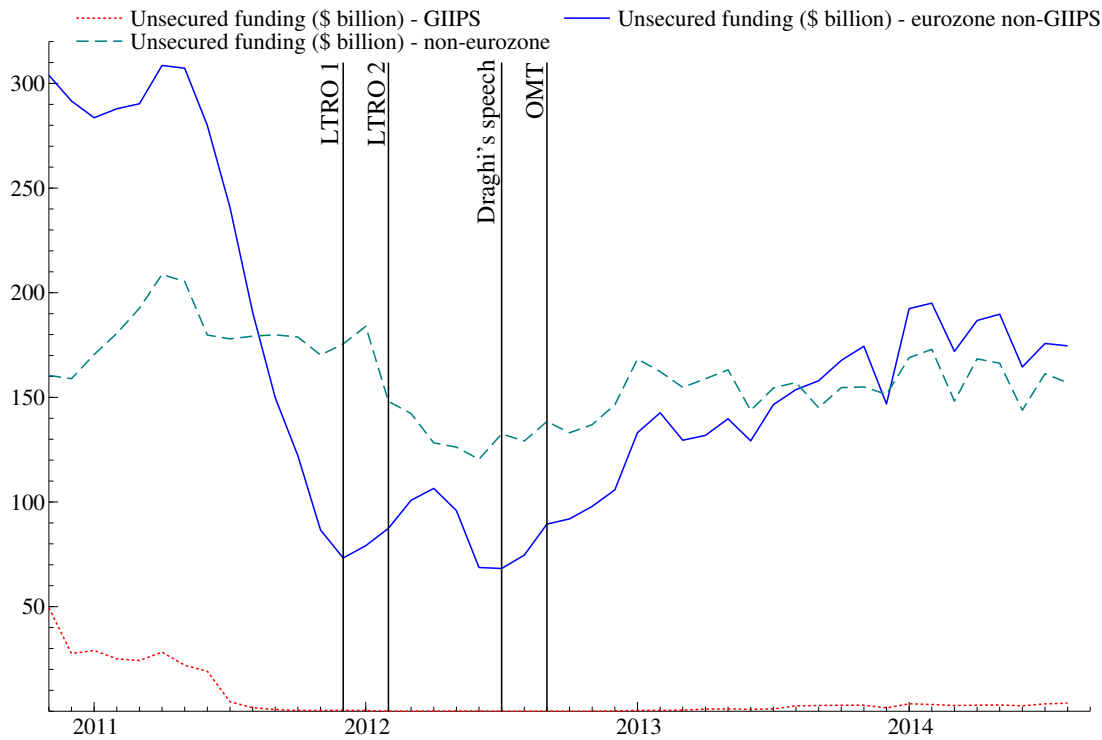
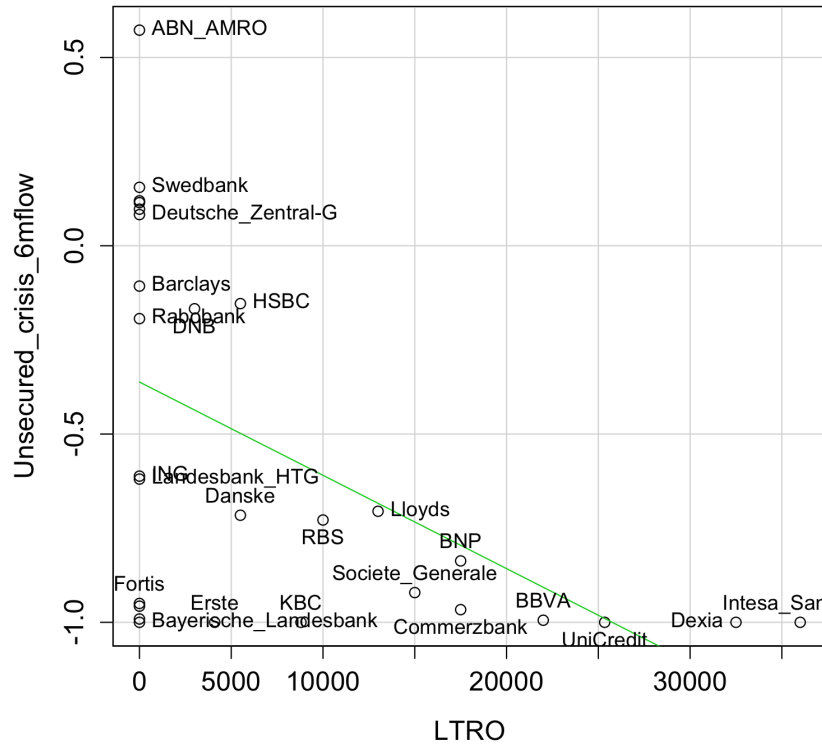


Figure 6: Private vs. public funding

This figure shows the correlation between banks unsecured flows through U.S. MMFs during the sovereign debt crisis and the amount of LTRO funding received (Panel A), and the evolution of U.S. MMF funding versus ECB funding via LTROs (Panel B).

(a) Unsecured U.S. MMF flows against LTRO funding (€ million)



(b) U.S. MMF vs. ECB funding

