The Effect of Central Bank Liquidity Injections on Bank Credit Supply *

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Abstract

We study the effect of the largest central bank liquidity injection ever conducted, the European Central Bank 3-year LTRO, on bank credit supply. Using the Italian credit registry, we show that banks exposed to the foreign wholesale market experience a run and reduce credit supply before the intervention and expand it after the central bank liquidity provision. We then exploit a regulatory change that expands the definition of central bank eligible collateral to identify the portion of liquidity uptakes driven by the funding shock. We show that (i) banks hit by the run are entirely responsible for the transmission to credit supply and (ii) other intermediaries use central bank refinancing to increase their holdings of liquid assets. Our findings show that the ECB liquidity injection had a 2% positive effect on bank credit supply.

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1 Introduction

Since the 2008 financial crisis, many central banks have adopted unprecedented measures to restore and mantain the regular functioning of financial markets. The designs of these so-called "unconventional" monetary policies vary and include new communication strategies, large scale asset purchases, and capital and liquidity injections.[1] While a large body of research analyzes the negative effect of asset market disruptions on bank credit supply, little work has been done on how central banks can sustain lending in bad times.[2] Our goal is to narrow this gap and contribute to policy making by evaluating the effectiveness of unconventional monetary policy and documenting the channels through which it operates.

In this paper, we ask whether central banks can increase bank credit supply by lending to banks. The theory behind the transmission of extraordinary liquidity provisions is based on the observation that banks hold less liquid assets than liquid liabilities and are therefore vulnerable to sudden funding contractions, or runs.[3] Following a run, intermediaries might be unable, especially during bad times, to promptly replace their funding sources and therefore might be forced to engage in costly fire sales, reducing credit supply. Central banks can counter this negative effect by providing liquidity, at more attractive terms compared to the private market, to avoid an inefficient credit contraction ("credit crunch").

In our empirical setting, we examine the effect of the largest liquidity injection ever conducted, the December 2011 European Central Bank (ECB) long-term liquidity

[1] In the U.S., the Term Asset-Backed Securities Loan Facility (TALF) and the Term Auction Facility (TAF) helped banks refinance their short-term debt and the Capital Purchase Program (CPP) and Capital Assistance Program (CAP) increased the availability of capital. Outside the U.S., the Bank of England "Funding for Lending Scheme" and the European Central Bank 3-year Long Term Refinancing Operation and Targeted Long Term Refinancing Operation provided long-term funding to banks. Several central banks (e.g., Fed, ECB, BoJ) also used large scale asset purchases.

[2] The effect of bank funding shocks on credit supply is studied by Khwaja and Mian (2008), Schnabl (2012), and Paravisini (2008). In recent work, Agarwal et al. (2015) and Di Maggio et al. (2015) analyze the pass-through of expansionary monetary policy to households.

[3] The fragility induced by banks' reliance on short-term funding is analyzed in Diamond and Dybvig (1983). The role of central banks as the lender of last resort goes back to Bagehot (1873).

provision, on Italian bank credit supply. The intervention, called the 3-year Long Term Refinancing Operation (LTRO), consisted of the unlimited offering of three-year maturity collateralized cash loans. On two "allotment" dates, December 21, 2011 and February 29, 2012, Eurozone banks could obtain a three-year loan provided that they pledged sufficient collateral. Unprecedented in scale, the ECB liquidity facility provided $1.37 trillion to 800 Eurozone banks with the official goal of "supporting bank lending."[4]

We study the transmission to the Italian bank credit supply for three reasons. First, Italian banks are hit by sudden withdrawals in their foreign wholesale funding sources in the second half of 2011 allowing us to study a textbook case of how a negative shock (run) and a positive shock (central bank liquidity provision) affect credit supply.[5] Second, as Italian and Spanish banks are the largest users of funds, our results shed light on the effectiveness of this unprecedented operation.[6] Third, we take advantage of a unique dataset obtained by matching the Italian credit registry with detailed information on bank characteristics obtained from supervisory and statistical reports submitted to the Bank of Italy. In particular, we observe all outstanding loans to firms with a balance above $32,000 (€30,000).

The analysis of this intervention poses two empirical challenges. First, as borrowers are not randomly assigned to banks, we need to control for borrower observable and unobservable heterogeneity. In other words, if we observe an increase in credit granted by bank j to borrower i following the intervention, it might be that the borrower is *demanding* more credit rather than the bank supplying more. To address this problem, we take advantage of the richness of our dataset by selecting firms that borrow from two or more banks and plugging firm fixed effects into our regressions (Khwaja and

[4]The official LTRO goal was to provide "credit support measures to support bank lending and liquidity in the euro area money market." Source: ECB website [link]. Banks used approximately half of the liquidity injection to rollover previous exposure to the central bank.

[5]In the six months preceding the LTRO, there is a significant contraction of foreign deposits (mainly certificates of deposit and commercial paper held in the U.S.) and Eurozone centrally cleared repurchase agreements (see Bank of Italy (2011a) and Bank of Italy (2011b)).

[6]Italian banks obtain $290 billion (€225 billion) in the two allotments, approximately 26% of total LTRO loans.

Mian (2008)). Second, banks can *choose* how much to borrow from the central bank. Hence, using the liquidity uptakes as a source of variation, we would probably capture other bank characteristics and our results would suffer from an omitted variable bias. To this end, we use bank reliance on the foreign wholesale market in June 2011, prior to the run, as a measure of differential bank exposure to the funding shock and, consequently, to the central bank intervention. The intuition is straightforward. Banks with larger foreign wholesale market exposure are more affected by the run and are therefore more likely to benefit from the central bank intervention.

The following example illustrates our empirical strategy. We consider firm F1 that borrows from bank B1 and bank B2. The two banks have a high and low exposure to the foreign wholesale market in June 2011, respectively. We compare the stock of credit granted by bank B1 to firm F1 and the stock of credit granted by bank B2 to firm F1 during (i) the *normal* period (June 2010 - May 2011) when funding markets are well functioning, (ii) the *run* period (June 2011 - December 2011) when we observe sizable withdrawals in the foreign wholesale market, and the (iii) *intervention* period (January 2012 - June 2012) after the central bank steps in providing liquidity to the banking sector.

Our analysis yields several findings. First, we show that banks with a large exposure to the foreign wholesale market reduce their credit supply during the run and expand it during the intervention period, compared to banks with a smaller exposure. Of course, bank funding structure is not randomly assigned: for example, in our sample, exposed intermediaries have a smaller household deposit base and are larger and more levered. We control for these observable differences and show that our results are robust to the inclusion of several balance sheet controls.

Second, we find that, banks do not reduce their credit supply during the run period to some firms more than others. However, following the liquidity provision, banks increase their credit supply to low leverage firms and, holding bank foreign wholesale market exposure constant, small and low leverage banks drive the increase in credit supply. Taken together, these findings are consistent with a positive transmission of central bank liquidity.

Third, we confirm that some firms are hit during the run period and benefit from the intervention. Note that, in isolation, our findings so far do not imply that firms

are hit by the credit contraction nor take advantage of the credit expansion. In fact, in a frictionless world, firms are able to switch lenders during bad times so to effectively "undo" the credit crunch. In such a world, central bank interventions do not affect credit volumes as firms are not constrained as a result of the credit contraction. Collapsing our dataset at the firm level, we find that borrowers (i) are unable to completely substitute the reduced credit from exposed banks with new credit from non-exposed banks and (ii) increase total credit used after the intervention.

Having documented the evolution of credit supply for exposed and non-exposed banks, we also examine the actual uptakes of the liquidity facility. We face another empirical challenge. The central bank provides three-year collateralized liquidity by applying a haircut lower than the private market one. This haircut subsidy, together with the long loan maturity, successfully attracts all banks to tap the facility, *regardless* of their exposure to the foreign wholesale run. In other words, it is not the case that banks that suffer the run choose to tap the central bank liquidity more. Hence, we need to disentangle the liquidity uptakes driven by the run from those uptakes driven by other motives.

To this end, we exploit a regulatory intervention by the Italian government. The day after the first LTRO allotment, the government approved a Decree Law allowing banks to obtain, for a fee, a government guarantee on part of their balance sheet. As government guaranteed assets are eligible collateral at the ECB, the scheme effectively gives banks a technology to manufacture collateral. The scheme is very popular as banks created and pledged 88$ billion (€69 billion) worth of new collateral at the second allotment, corresponding to a third of total uptakes.

We find that the uptakes backed by the government regulatory intervention are caused by the run in the foreign wholesale market. More specifically, banks hit by the funding shock erode their available collateral to find alternative sources of funding and therefore have scarce central bank eligible collateral at the time of the LTRO allotment. These intermediaries then take advantage of the government scheme to manufacture collateral to access ECB liquidity. The intuition is straighforward and similar, in spirit, to Rothschild and Stiglitz (1976). The scheme creates a separating equilibrium where banks that highly value liquidity self-select into the costly government guarantee program. We find that the uptakes backed by this program are *entirely* responsible

for the transmission of LTRO to the credit supply.

Finally, we examine how the relatively less exposed banks use the central bank liquidity. We show that these intermediaries buy liquid assets, in the form of government bonds. Their behavior is consistent with (i) a precautionary motive (as they effectively replenish their pool of liquid assets while lengthening the maturity of funding) and (ii) a carry trade motive as domestic government bonds have a high yield.[7]

Our findings stress the importance of central bank collateral eligibility for the transmission of liquidity injections. We show that banks more affected by the foreign wholesale market run have scarce collateral at the time of the LTRO announcement and therefore have mechanically less access to central bank funds. The temporary eligibility of illiquid assets gives exposed institutions access to central bank liquidity.

Related Literature This paper relates to two strands of literature. First, we constribute to the literature on the effect of negative funding shocks on bank credit supply. Early theoretical work (Bernanke and Blinder (1988), Bernanke and Gertler (1989), Holmstrom and Tirole (1997), and Stein (1998)) stresses the importance of credit market frictions for a funding shock to cause a credit supply reduction. While the first contributions to the empirical literature have focused on time series (Bernanke and Blinder (1992), Bernanke (1983)) and cross-sectional analysis (Gertler and Gilchrist (1994), Kashyap et al. (1994), Kashyap and Stein (2000), and Ashcraft (2006)), in more recent work, researchers use within borrower estimation, sometimes together with quasi-exogenous liquidity shocks, to disentangle the credit supply effect from credit demand (Khwaja and Mian (2008), Paravisini (2008), Chernenko and Sunderam (2014), and Schnabl (2012)). In line with the most recent strand of the literature many of our specifications include firm fixed effects to control for borrower observed and unobserved heterogeneity. In our empirical setting, the shock is a run in the foreign wholesale market. As in Iyer and Peydro (2011) and Iyer et al. (2014), we

[7] Crosignani et al. (2015) analyze government bond holdings by Portuguese banks and find that LTRO causes an increased demand for domestic public debt as banks buy government bonds between the two allotments to pledge them at the second allotment.

find a reduction in credit supply by banks (ex ante) more exposed to the run.

Following the recent U.S. financial and the Eurozone sovereign debt crisis, many researchers have analyzed the impact of these asset market disruptions on credit supply. In the U.S. context, the effect of the crisis on credit supply and real outcomes is analyzed by, among others, Chodorow-Reich (2014b), Ivashina and Scharfstein (2010), and Puri et al. (2011). In the Eurozone context, in their theoretical work, Bocola (forthcoming) and Perez (2015) analyze, using general equilibrium models, the pass-through of sovereign credit risk on intermediated credit. The related empirical literature (Popov and Van Horen (forthcoming), De Marco (2015), Cingano et al. (2013), Bofondi et al. (2013), Acharya et al. (2015a), Bottero et al. (2015), Del Giovane et al. (2013)) almost unanimously confirms the negative spillover.

Second, we inform the literature on the transmission of monetary policy to credit supply (see Jimenez et al. (2012), Jimenez et al. (2014) for credit to firms and Agarwal et al. (2015) for consumer credit). In particular, we analyze unconventional monetary policy (Chodorow-Reich (2014a), Di Maggio et al. (2015)) in the form of central bank liquidity injections. This type of intervention relates to the seminal lender of last resort literature (Bagehot (1873), Thornton (1802)) as it is based on the idea that central banks can prevent a credit contraction by supplying liquidity to banks.[8]

In the Eurozone, the effect of ECB interventions during the recent sovereign debt crisis is analyzed in Casiraghi et al. (2013), van der Kwaak (2015), Vissing-Jorgensen et al. (2014), Crosignani et al. (2015), Andrade et al. (2015), and Garcia-Posada and Marchetti (2015). The last two papers also study the effect of the 3-year LTRO on credit (in France and Spain, respectively). Compared to these contributions, we

[8]While we observe a run before the ECB, we do not take a stance on whether this is a fundamental or panic-based run, a la Diamond and Dybvig (1983). The existence of non-fundamental runs has been disputed, by pointing out that a solvent bank cannot be illiquid (see Gorton (1985), Jacklin and Bhattacharya (1998), Gorton (1988), Allen and Gale (1998), and Chari and Jagannathan (1988)). Rochet and Vives (2004) bridge a gap between the two views by introducing both liquidity and solvency into an incomplete information model. Drechsler et al. (forthcoming) show that there are also ex post risk-taking incentives. They document that weakly capitalized banks tapped the ECB more by pledging riskier collateral. We contribute to the literature by showing that the central bank can increase bank lending supply by supporting illiquid banks.

innovate in two ways. First, we identify the banks' marginal propensity to borrow (MPB) at the central bank by (i) analyzing the differential impact of the run on banks' funding and (ii) validating our MPB measure using the expansion of the Italian banks' eligible collateral in December 2011. Second, by analyzing the pre-LTRO period, we relate the ECB liquidity injection to the pre-LTRO stress in the foreign wholesale market.

The remainder of the paper is structured as follows. In Section 2, we describe the empirical setting, the dataset, and provide summary statistics. We analyze the effect of the ECB liquidity injections on bank credit supply in Section 3. In Section 4, we discuss the transmission channel exploiting a regulatory intervention by the Italian government in December 2011. In Section 5 we analyze which firms benefit the most from the intervention and report the aggregate effects. In Section 6 we discuss the effect of the liquidity injections on the holdings of liquid assets. Concluding remarks are given in Section 7.

2 Background and Data

Our laboratory is Italy from 2010 to 2012. There are four reasons why we choose Italy to study the effect of central bank liquidity injections on bank credit supply. First, its economy and banking sector have been severely hit by the European sovereign debt crisis, with sovereign and financial credit risk reaching record highs in November 2011.[9] Second, as Italian and Spanish banks are the largest LTRO users, our results shed light on the effectiveness of this unprecedented intervention.[10] Third, the supply of bank credit is particularly important in Italy as firms, heavily dependent on intermediated credit, are less likely to issue debt securities in response to a contraction to bank

[9]The Italian 5-year sovereign (USD denominated) CDS spread and 10-year sovereign bond yields reach record highs on November 15, 2011 and November 25, 2011, respectively. See Figure B.1.

[10]LTRO loans extended to Italian banks constitute 26% of total LTRO loans, just below Spanish banks. In Table E.1, we show LTRO uptakes by country. To get a sense of the magnitude, consider that the Italian share of capital at the ECB was 12.31% as of 1 January 2013. Other big contributions come from Deutsche Bundesbank (18%), Banque de France (14.2%), and Banco de Espana (8.8%).

loan supply compared to, for example, U.S. firms (see Langfield and Pagano (2015)). Fourth, we observe a run in the (foreign) wholesale market in the five months before the LTRO, making the analysis of this intervention a textbook case of central bank liquidity provision following a negative shock.

2.1 Macroeconomic Picture

Up until the end of 2008, the credit risk of core Eurozone countries was basically identical to the credit risk of southern, or "peripheral," countries. In the next three years, rising concerns about public debt sustainability caused a divergence in the credit risk of core countries with respect to Greece, Italy, Ireland, Portugal, and Spain. The top panel of Figure B.1 shows that in Italy both the sovereign cost of borrowing and the sovereign CDS spread increase from 2009 to the end of 2011.

From these time series, one can identify two periods. During the first period, from 2009 to mid-2011, the Italian government bond prices fall by about 25% while sovereign CDS spreads double to reach approximately 200 bps as investors are progressively concerned that the crisis affecting Greece and Portugal might spread to Italy. Political uncertainty, large government debt, and the long-standing slack in GDP growth make Italy very vulnerable to shocks. Investors' concerns materialize in June 2011 when Standard & Poors downgraded Greek debt to CCC and announcements of an involvement of the private sector in Greek debt restructuring led to contagion to Italy. From mid-2011 to December 2011, invesor suddenly started demanding very large risk premia, so sovereign CDS spreads and bond yields started increasing very sharply to reach a record high in November 2011.[11]

[11] Greece was downgraded five times by the three main credit rating agencies in June and July of 2011, as the newly appointed government headed by Prime Minister Evangelos Venizelos implemented, amid protests, the fourth austerity package. As documented in Bofondi et al. (2013), sovereign yields then abruptly rose in Italy too, as investors feared that Italy might also not be able to repay its public debt. With sovereign yields rising, the support for the Italian government fell (the lower chamber rejected the Budget Law in October) forcing Prime Minister Silvio Berlusconi to resign in favor of the technocratic government led by Mario Monti.

2.2 Bank Funding During the Crisis

The structure of the funding of the Italian banks has changed significantly since 2008. As overall funding shrank, the composition underwent large variation. From 2008 to mid 2011, the fraction of retail funding slightly increased, whereas wholesale funding - bonds except those held by households, deposits from non-residents, and liabilities towards central counterparties - dropped by 3 percentage points to 33%. Central bank refinancing partially substituted for this drop, reaching 2% of total funding.

With sovereign yields rapidly rising, wholesale funding declined 5 percentage points, to 28%, in just six months, from June to December 2011. This drain in funds was offset by central bank refinancing which, at the end of 2011, represented 9% of total funds.[12] The drastic decline in wholesale funds was driven mainly by a sharp reduction in deposits of non-residents and net liabilities towards central counterparties (see Chernenko and Sunderam (2014)). In Figure B.2, we illustrate the time series evolution of household deposits, interbank market funding, and ECB borrowing.

In October 2008, the ECB switched to a fixed-rate full-allotment mode for its refinancing operations. This means that Eurozone banks can obtain unlimited short-term liquidity from the central bank at a fixed rate, provided that they pledge sufficient eligible collateral. For example, Bank A can pledge government bonds worth $100 and get a two-week cash loan worth $96. The ECB applies a haircut, 4% in this example, that depends on the (i) asset class, (ii) residual maturity, (iii) rating, and (iv) coupon structure of the security. There is no limit on how much a bank can obtain from ECB on a specific loan, provided that it pledges sufficient collateral.[13]

On December 8, 2011, the ECB increased its support to the Eurozone banking sector even further, announcing the provision of 3-year maturity loans, allotted on December 21, 2011 (LTRO1) and February 29, 2012 (LTRO2), with the stated goal to support bank lending and liquidity in the euro area.[14] When the liquidity injection went

[12] See Giannone et al. (2012) and Bank of Italy (2011a).

[13] Eligible collateral includes government and regional bonds, covered bonds, corporate bonds, ABSs, and other uncovered credit debt instruments. The haircut schedule is publicly available on the ECB website. In Appendix B, we discuss the ECB collateral framework in greater detail.

[14] Loans were settled one day after the allotment, on December 22, 2011 and March 1, 2012,

into effect, the collateral framework for Italian banks remained basically unchanged. Thus the fundamental difference between the LTRO and other refinancing operations for Italian banks lies basically in maturity.[15] The 3-year maturity of the LTRO loans allows the ECB to dispel any concern that it might revert to some less expansionary features in its window, such as variable rate and/or fixed allotment. This long-term horizon allows banks to relax their maturity mismatch between assets and liabilities and to undertake a more long-sighted liquidity management. Banks use the LTRO loans to both rollover previous central bank borrowing and to get new borrowing.[16]

2.3 Data

In this section, we describe the dataset construction and empirical work. For greater detail, the reader is referred to A. The unit of observation is at the (i, j, s, t) level, where $i \in \mathcal{I}$ is a firm, $j \in \mathcal{J}$ is a bank, $s \in \mathcal{S}$ is a security, and $t \in \mathcal{T}$ is a date. Data on banks refer to the banking group level; where original data on a consolidated

respectively with maturity January 29, 2015 and February 26, 2015. The measure was unexpected. We show the price reaction of equity financials in Figure **??**.

[15] In particular, the additional credit claim (ACC) scheme has not yet been introduced, and no major changes have been made on the haircuts of the securities typically used as collateral by Italian banks, including governement bonds. The interest rate on the two long-term loans is an average of the interest rate on the Marginal Refinancing Operation (MRO) rate, to be neutral compared to shorter term loans. As a considerable portion of banks' collateral was already pledged at the ECB at the time of the first LTRO allotment, the ECB relaxes the collateral requirements in two ways at the time of the allotments. First, it reduced the rating threshold for certain asset-backed securities (ABS). At LTRO1 and LTRO2, the ECB starts accepting ABS having a second best rating of at least "single A" in the Eurosystem's harmonized credit scale at issuance and underlying assets comprising residential mortgages and loans to small and medium enterprises. In addition, underlying assets backing the ABS must all belong to the same asset class and cannot include non-performing, structured, syndicated, or leveraged loans. Second, it allowed national central banks to temporary accept additional bank loans (additional credit claims, or ACCs) in addition to those eligible before the intervention. Banks had the option to repay earlier, after one year. The interest rate, paid at maturity, was very low (approximately 1%) and equal to the average rate of MROs over the life of the operation.

[16] For example, consider bank A that is borrowing \$100 short-term from ECB before LTRO1. Suppose it gets \$50 at LTRO1 and decides to use \$25 to rollover, at the longer maturity, previous short-term ECB borrowing and \$25 to increase its total debt with the central bank. The new exposure to the ECB is \$125, which consists of \$50 LTRO1 long-term liabilities and \$75 pre-LTRO short-term liabilities.

basis are not available, individual data for all banks belonging to a given group are collapsed.

We combine data from various sources. First, at the (i, j, t) borrower-bank-period level, we obtain data on all outstanding loans with amount outstanding above \$32,000 (€30,000) from the Italian Credit Registry. We have information on term loans, revolving credit lines, and loans backed by account receivables. For each bank-borrower pair, we observe the type of credit, as well as the amounts granted and drawn. The quality of this dataset is extremely high as banks are required by law to disclose this information to the Bank of Italy. This dataset is available at a monthly frequency.

Second, at the (j, t) bank-period level, we observe standard balance sheet characteristics and LTRO uptakes from the Supervisory and Statistical Reports submitted by intermediaries to the Bank of Italy. A large fraction of balance sheet characteristics is only available biannualy from consolidated reports. Crucially, we also have monthly information on total borrowing, with different maturities, at ECB, so we are able to disentangle the rollover and new borrowing components of both LTRO allotments.[17]

Third, at the (s, j, t) security-bank-period level, from the Supervisory and Statistical Reports we also have the number of available holdings of each marketable security held by Italian banks. A typical observation is "holdings by bank j of security s in month t." For each security, we also know whether the security is pledged (at ECB or in the private market) or if it is available. We merge each security with Datastream and Bloomberg to obtain additional time-invariant information (e.g., coupon structure, maturity, issuer, and issue date). Finally, we also match each security to a list of eligible securities and their haircuts at LTRO1 and LTRO2 from the ECB.

Fourth, at the (i, t) firm-period level, we also have information on firms' characteristics from end-of-year balance-sheet data and profitability ratios from the proprietary Cebi-Cerved database. We lose approximately 45% of observations by merging firm-

[17] If, for example, we observe that bank A borrowed \$50 at LTRO1 (three-year maturity) and increased its total ECB borrowing by \$25, we deduce that \$25 was used to rollover previous ECB borrowing to the longer LTRO maturity.

Bank-Level		**Jun10**	**Dec10**	**Jun11**	**Dec11**	**Jun12**	**Dec12**
Size	€bn	36.8	36.2	36.1	35.9	37.0	37.2
Leverage	Units	11.8	12.2	12.1	12.5	13.9	14.3
Tier 1 Ratio	Units	19.2	15.4	14.4	13.9	13.7	13.4
RWA	%Assets	69.0%	68.8%	68.1%	67.2%	61.5%	59.9%
Credit to Households	%Assets	18.1%	18.8%	18.7%	18.5%	17.3%	16.7%
Credit to Firms	%Assets	41.7%	42.5%	43.0%	42.8%	39.9%	39.1%
Securities	%Assets	17.4%	16.9%	16.3%	17.3%	24.5%	24.1%
Government Bonds	%Assets	9.0%	9.1%	9.0%	10.6%	17.4%	18.2%
Cash Reserves	%Assets	0.4%	0.5%	0.5%	0.5%	0.4%	0.5%
ROA	Profits/Assets	0.1%	0.2%	0.1%	0.1%	0.1%	0.1%
Central Bank Borr	%Assets	0.8%	2.0%	2.3%	5.7%	11.2%	11.0%
Household Dep	%Assets	29.5%	29.6%	29.4%	30.0%	32.5%	35.9%
Interbank Borr	%Assets	4.0%	4.0%	4.2%	5.2%	4.4%	3.9%

Bank-Firm Level	**Loan Type**	**Sep10-Jun11**	**Jun11-Mar12**	**Mar12-Dec12**
Δln(Total Credit Drawn)	All Types	0.6%	-6.8%	-4.6%
Δln(Total Credit Granted)	All Types	-3.6%	-7.8%	-8.0%
Δln(Total Credit Drawn)	Revolving Credit Lines Only	2.4%	5.6%	4.6%
Δln(Total Credit Granted)	Revolving Credit Lines Only	-1.5%	-0.4%	-2.1%

Table 1: Summary Statistics, Bank Characteristics, and Credit Growth. This table shows summary statistics. The top panel shows cross-sectional means of selected balance sheet characteristics during the sample period. The bottom panel shows credit growth during the (i) September 2010 - June 2011 period, (ii) June 2011 - March 2012 period, and (iii) the March 2012 - December 2012 period. The table shows changes in (i) total credit on term loans and drawn from revolving credit lines and loans backed by account receivables, (ii) total credit granted (committed) on term loans, revolving credit lines, and loans backed by account receivables, (iii) total credit drawn from revolving credit lines, and (iv) total credit granted (committed) on revolving credit lines. Sample firms have multiple relationships. In Table E.2, we provide additional summary statistics.

level characteristics with our bank-firm observations. However, we can still count on a large number of observations.

Our final dataset is obtained by merging all our date. We exclude some specific banks from the sample. First, we do not consider foreign banks (branches and subsidiaries) operating in Italy, as we only observe the liquidity injections that they obtain from Bank of Italy and not their overall group exposure to the Eurosystem, which is in fact likely to be much larger. Second, we exclude banks involved in extraordinary administration procedures around the time of the introduction of the LTRO, as their management decisions and credit policies are likely to have very little discretion margins. In addition, our sample does not contain cooperative or mutual banks nor their central institutes, as in most cases the former tapped ECB liquidity

and then redistributed funds among the latter, but we do not observe the allocation of liquidity among affiliated banks. Finally we exclude banks that specialize in specific activities, such as wealth or non-performing loans management. We then restrict our analysis to banks that were counterparties of Bank of Italy in at least one of the two LTRO allotments. Thus, our final sample consists of 72 banks.

Table 1 shows, in the top panel, bank-level summary statistics. We observe (i) an increase in size and leverage after December 2011, (ii) a contraction in credit to households and firms after December 2010, (iii) increased holdings of securities and government bonds between December 2011 and February 2012, and (iv) two jumps in central bank borrowing in correspondence with the two LTRO allotments (December 2011 and February 2012). The bottom panel shows changes in credit during three intervals. Total credit is defined as the sum of term loans, credit drawn from revolving credit lines, and loans backed by account receivables. The three types of loans are term loans, revolving credit lines, and loans backed by account receivables. Changes in both these variables are negative and large after June 2011, when Italy was hit by the Eurozone crisis. Interestingly, drawn credit from credit lines increases in bad times as firms try to smooth a credit contraction. Finally, we do not observe a large decrease in credit granted on credit lines.

3 Effect on Bank Credit Supply

We now present the identification strategy and estimate the causal effect of the central bank liquidity injection on bank credit supply.

3.1 Identification Strategy

Before discussing the identification strategy, we illustrate the ideal experiment. In such setting, (i) the borrower-bank match is random and (ii) central bank liquidity injections are also randomly assigned to banks. The econometrician can therefore estimate the *causal* impact of liquidity injections on bank credit supply by simply using the heterogeneity of ECB liquidity provisions as a source of variaton. The effect on bank credit is fully attributable to a change in supply as borrowers' characteristics are uncorrelated with liquidity injections. In other words, it is not the case that borrowers

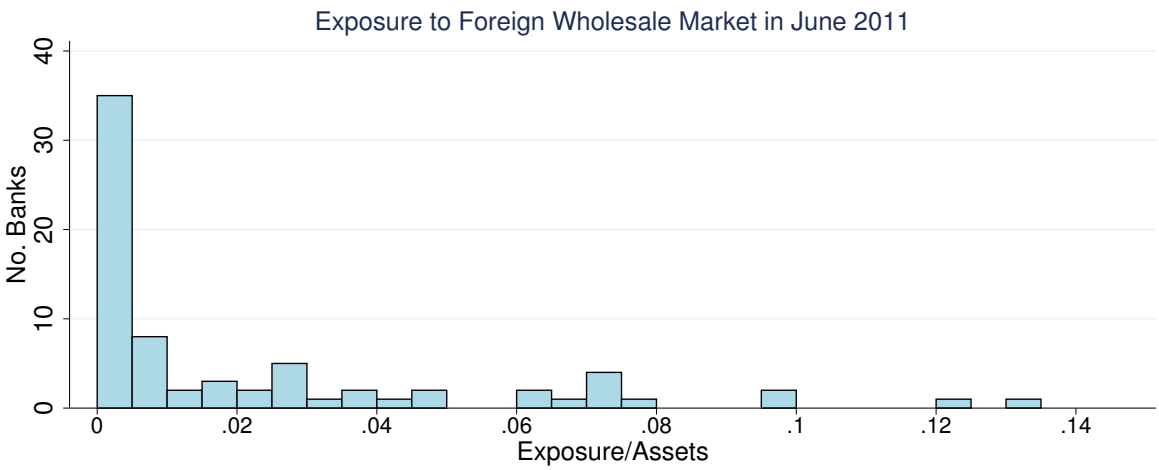

Figure 1: June 2011 Foreign Wholesale Market Exposure. This histogram shows bank-level exposure to the foreign wholesale market run in June 2011. The exposure (winsorized at the 1st and 99th percentile for exposition) is defined as the sum of bank exposures to (i) foreign deposits (e.g., commercial paper and certificates of deposit held by U.S. money market funds) and (ii) centrally (Eurozone) cleared repurchase agreements, divided by total assets.

matched with banks that receive large liquidity injections *demand* more/less credit compared to borrowers matched with banks that receive smaller liquidity injections. Unfortunately, as these two conditions are not satisfied in our setting, we face two empirical challenges.

First, the stock of credit that borrower i obtains from bank j at time t is an equilibrium quantity, resulting from both lender supply and borrower demand. Hence, we need to isolate the change in bank credit originating from a change in bank credit *supply*. To this end, we restrict our sample to the large number of firms that are borrowing, in any given period, from two or more banks and compare changes in borrowing from different banks *within* firms (Khwaja and Mian (2008)).[18] Using this sample, we can fully control for firm observed and unobserved characteristics (firm fixed effects). In other words, we can compare how the same firm's loan growth from one bank changes relative to another more affected bank.

[18]Our sample includes approximately 1.4 million observations at any given date. In most of our analysis we focus on firms with multiple relationships. Such subsample includes approximately 0.7 million observations (approximately 275,000 unique firms) at any given point in time. Approximately 170,000 firms have two relationships at any given date. More than two relationships are also relatively common. Approximately, at any given date, of the 275,000 unique firms, 60,000 have three relationships, 24,000 have four relationships, and 21,000 have five or more relationships.

Second, the uptakes of the ECB liquidity are not randomly assigned to banks. Banks can *choose* the amount of cash loans they want from the central bank. Hence, using the heterogeneity of uptakes as a source of variation, we would probably capture other bank characteristics and our results would suffer from an omitted variable bias. We use banks pre-run exposure to foreign wholesale funding in June 2011 as a measure of differential bank exposure to (i) the June 2011-November 2011 run and, consequently, (ii) the central bank intervention. The intuition is straightforward. Banks with larger exposure to foreign wholesale funding are more affected by the run and are therefore more likely to benefit from the ECB intervention.[19]

We define the pre-run exposure as the share of foreign wholesale funding over total assets in June 2011. Foreign wholesale funding consists of foreign deposits (e.g., commercial paper and certificates of deposit held by U.S. money market funds) and Eurozone centrally cleared repurchase agreements. Figure 1 shows the distribution of banks pre-run exposure to the foreign wholesale market in June 2011. More than half of the banks in our sample have a zero or very small exposure, below 1%. However, banks with exposure above 5% are quantitatively the most important as they hold 75% of total loan to firms in our sample.

Of course, banks' funding mix in June 2011 is correlated with other banks' observable and unobservable characteristics. Table 2 shows bank summary statistics for the two subsamples of "exposed" and "non-exposed" banks, according to their exposure to the foreign wholesale market in June 2011. Exposed banks (above median exposure) tend to be larger, more levered, and more reliant on wholesale funding, compared to non-exposed banks (below median exposure). The difference in observables is intuitive. Large banks obtain a sizable amount of funding through interbank and repo markets. They also have a non-negligible share of total funding coming from foreigners. On the other hand, small banks are usually present in local markets where they have a large

[19] Iyer et al. (2014) use the ex ante exposure to the interbank market to study the effect of the unexpected freeze of the European interbank market on Portuguese bank credit supply in 2008. We use the same source of variation to explain *both* the credit contraction and the credit expansion following the ECB liquidity injection.

		Exposed Banks	Non-exposed Banks	Normalized Difference
Size	€bn	70.51	1.82	2.28
Leverage	Units	13.32	11.07	2.22
Tier 1 Ratio	Units	10.86	17.89	-1.80
RWA	%Assets	67.3%	69.2%	-0.54
Credit to Households	%Assets	17.2%	20.4%	-1.36
Credit to Firms	%Assets	41.7%	44.9%	-0.78
Securities	%Assets	16.6%	16.0%	0.23
Govt Bonds	%Assets	8.0%	10.1%	-1.02
Cash Reserves	%Assets	0.4%	0.6%	-2.17
ROA	Profits/Assets	0.26%	0.02%	3.12
Central Bank Borr	%Assets	3.16%	1.38%	2.27
Household Dep	% Assets	24.7%	37.0%	-4.00
Interbank Borr	% Assets	5.5%	2.7%	1.87

Table 2: Exposed and non-Exposed Banks: Summary Statistics. This table shows June 2011 bank summary statistics for the subsamples of exposed and non-exposed banks. Exposed (non-exposed) banks have exposure to the foreign wholesale market above (below) median in June 2011. The table shows balance sheet characteristics (subsample means). The last column shows Imbens and Wooldridge (2009) normalized difference (defined as the average treatment status, scaled by the square root of the sum of the variances). In Table E.3, we replicate this table with subsamples based on quartiles.

household deposit base.[20]

We compare three periods: (i) the *normal* period from September 2010 to May 2011 when funding markets are well functioning and sovereign credit risk is stable; (ii) the *run* period from June 2011 to February 2012 when banks exposed to the foreign wholesale market experience a run; and (iii) the *intervention* period from March 2012 to December 2012. In the next subsection, we illustrate the three-period difference-in-difference specification we adopt to compare the stock of credit granted by firm i to bank j in each of these three periods.

[20] In Appendix C, we show June 2011 bank summary statistics by exposure quartiles (Table E.3), as well as the time series evolution of balance sheet summary statistics for exposed and non-exposed banks (Table E.4).

3.2 Intensive Margin

We first examine the effect of (i) the run and (ii) the intervention on bank credit supply to existing customers (intensive margin). In our baseline specification, we estimate the following model:

	$\Delta CREDIT$ (Granted)					
$Exposure_{Jun11} \times \mathbb{I}_{Run}$	-0.092**	-0.127***	-0.129***	-0.128***	-0.132***	-0.114***
	(0.041)	(0.045)	(0.037)	(0.037)	(0.040)	(0.031)
$Exposure_{Jun11} \times \mathbb{I}_{Interv}$	0.212***	0.247***	0.251***	0.245***	0.172***	0.115**
	(0.054)	(0.061)	(0.044)	(0.043)	(0.043)	(0.053)
$Share$				-0.002***	-0.026***	-0.026***
				(0.000)	(0.001)	(0.001)
$Overdraft$				0.068***	0.251***	0.249***
				(0.003)	(0.027)	(0.026)
$Drawn/Granted$				0.052	0.252	0.250
				(0.032)	(0.223)	(0.220)
$LEV_{Jun11} \times \mathbb{I}_{Run}$						0.141
						(0.207)
$LEV_{Jun11} \times \mathbb{I}_{Interv}$						0.244
						(0.158)
$ROA_{Jun11} \times \mathbb{I}_{Run}$						-0.038*
						(0.020)
$ROA_{Jun11} \times \mathbb{I}_{Interv}$						0.027
						(0.044)
$T1R_{Jun11} \times \mathbb{I}_{Run}$						0.396**
						(0.155)
$T1R_{Jun11} \times \mathbb{I}_{Interv}$						0.362***
						(0.127)
$NPL_{Jun11} \times \mathbb{I}_{Run}$						-0.321*
						(0.185)
$NPL_{Jun11} \times \mathbb{I}_{Interv}$						0.222**
						(0.101)
$Large \times \mathbb{I}_{Run}$						-0.647
						(0.943)
$Large \times \mathbb{I}_{Interv}$						0.615
						(1.518)
Time FE	✓	✓				
Bank FE	✓	✓	✓	✓		
Firm-Time FE			✓	✓	✓	✓
Bank-Firm FE					✓	✓
Sample	Full	Multiple Lenders	Multiple Lenders	Multiple Lenders	Multiple Lenders	Multiple Lenders
Observations	4,434,431	2,322,142	2,322,142	2,322,142	2,171,749	2,171,749
R-squared	0.004	0.005	0.380	0.394	0.700	0.701

Table 3: Liquidity Injections and Credit Supply, Intensive Margin. This table presents the results from specification (1). The dependent variable is the difference in log (stock of) credit granted. $Exposure_{Jun11}$ is the exposure to the foreign wholesale market, divided by assets, in June 2011. $\mathbb{I}_{Run}$ is a dummy equal to one in the *run* and *intervention* periods. $\mathbb{I}_{Interv}$ is a dummy equal to one in the *intervention* period. The *normal* period runs from December 2010 to June 2011. The *run* period runs from June 2011 to December 2011. The *intervention* period runs from December 2011 to June 2012. *Share* is the share of total firm i credit obtained from bank j, *Drawn/Granted* is the ratio of drawn credit over committed credit between bank j and firm i, $Overdraft$ is the share of overdraft credit between borrower i and bank j, LEV is leverage, ROA is return on assets, $T1R$ is the Tier 1 Ratio, NPL is non-performing loans divided by total asset, and *Large* is a dummy equal to one if the bank has assets above €500 billion. The firms in the sample have at least two bank relationships. Standard errors double clustered at the bank and firm level are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

$$\Delta Log(Credit_{ijt}) = \alpha + \beta_1 Exposure_j \times Run_t + \beta_2 Exposure_j \times Intervention_t + \mu_{it} + \gamma_{ij} + \phi' X_{ijt} + \epsilon_{ijt} \quad (1)$$

where Run_t is a dummy equal to one during the *run* and the *intervention* periods and $Intervention_t$ is a dummy equal to one in the *intervention* period. Observations are at the (i, j, t) borrower-bank-period level. The dependent variable is the change in log (stock of) credit granted by bank j to borrower i at time t. $Exposure_j$ is bank j exposure to the foreign wholesale market in June 2011. We add bank fixed effects to absorb any time-invariant bank characteristic and borrower-time fixed effects to control for both observable and unobservable firm heterogeneity. Finally, we also add time-varying borrower-bank relationship (time-varying) variables to control for the fact that the same borrower might have a different relationship through time with exposed banks compared to non-exposed banks. These variables are (i) the share of total firm i credit obtained from bank j, (ii) the ratio of drawn credit over committed credit, and (iii) the share of overdraft credit by borrower i with respect to bank j. Intuitively, the coefficients β_1 and β_2 measure the effect of the bank exposure to the foreign wholesale market on credit supply during (i) the run and (ii) the intervention period, respectively.[21]

We rely on two identification assumptions: (i) exposed banks would have behaved like non-exposed banks during the *run* period in the absence of the run and (ii) exposed banks would have behaved like non-exposed banks in the absence of the ECB intervention during the *intervention* period. Since bank exposure is not randomly assigned across banks, we ensure that our results are robust to the inclusion of many balance sheet characteristics *interacted* with the two time dummies. These characteristics are leverage, size, tier 1 ratio, non-performing loans, government bond

[21] In Appendix A.1, we prove this claim analytically.

holdings, and a dummy equal to one if a bank is one of the top three banks by assets.[22]

To Rewrite as Table Changed

Table **??** shows the results. We progressively saturate the regression specification with fixed effects (columns (1)-(3)) and augment the model with bank balance sheet time-varying controls (column (4)) and their interaction with the two time dummies (column (5)).[23] The estimation results are robust across different specifications and highlight that banks with high exposure to the foreign wholesale market reduce credit supply to existing customers during the *run* period and increase it during the *intervention* period. Comparing point estimates and standard errors in the first and second column (where we add firm-time fixed effects), we find that the endogenous bank-firm matching does not seem to be a major identification concern. In column (3), we substitute bank fixed effects with bank-firm fixed effects to exploit the variation within the same firm-bank pair over time, thereby controlling for any time invariant relationship characteristics.

We stressed above that our source of variation, the exposure to the run, is correlated with bank characteristics. Hence, we add eight time-varying balance sheet characteristics and their interactions with the two time dummies to make sure that our preferred independent variable is not capturing other bank characteristics, such as size. The two coefficients of interest in columns (4)-(5) survive this test. In Table **??**, we report all the estimates for the most conservative specification and find that large banks and banks with a large new bad loan ratio reduce their credit supply during the run. Interestingly, large banks also reduce their credit supply also during the intervention period while banks with a large new bad loan ratio and sizable holdings of government bonds expand their credit supply during the intervention period.[24]

[22]The top three banks (assets above €200 billion) are different in many dimensions compared to other banks. In particular, they are the only internationally diversified intermediares in Italy.

[23]Balance sheet variables are measured before time t. In particular, since we have balance sheet characteristics at a biannual frequency, we use characteristics in June 2010, June 2011, and December 2011 when the dependent variable is the change in the log stock of credit in May 2011-September 2010, February 2012-June 2011, and December 2012-March 2012, respectively.

[24]The positive and significant coefficient on government bond holdings during the intervention periods might capture banks' market-to-market gains resulting from the sudden increase in peripheral

3.3 Credit Supply Across Firms

We now examine to which firms bank reduce credit during the *run* period and expand credit during the *intervention* period the most. To this end, we use the Cebi-Cerved database to obtain firm-level information on profitability (EBITDA, ROE), size, and credit risk (Z-score, leverage).[25] We re-run our most conservative baseline specification, which includes bank-firm fixed effects and bank balance-sheet interaction terms, interacting our main regressors with firm characteristics, measured in December 2010.

Table **??** shows the results. For example, in column (2) we show the effect of the run and the intervention on credit supply changes depending on firm size, where the variable *Size* is the log of firm total assets in December 2010. Note that the firm-bank and the time-firm double interactions are absorbed by the fixed effects. Oveall, we find that the effect of the run is remarkably stable across different firm characteristics and that banks increase credit supply during the *intervention* period especially to low leverage firms.

3.4 Effect of Exposure and Bank Characteristics

We next examine whether the effect of the exposure to the foreign wholesale market on credit supply varies by bank fundamentals. In Table 5, we interact our main dependent variables with bank balance sheet characteristics, measured in June 2011. For example, we interact the two difference-in-difference regressors with leverage. The results in column (1) show that the banks with high exposure and (i) small, (ii) low

sovereign debt prices following Draghi's "whatever it takes" July 2012 speech (Acharya et al. (2015b)). The negative coefficient of size on both the *run* and the *intervention* periods might reflect the deleveraging of large banks subject to increased Eurozone regulation on systemically important institutions (e.g., EBA stress tests). The signs on non-performing loans (negative during the run and positive during the intervention) suggest that there might be a solvency component in the pre-LTRO credit contraction that is alleviated by the central bank liquidity injection.

[25] We lose 45% of observations by merging the firm-level dataset with our bank-firm observations. However, we can still rely on more than a million observations at the four dates of September 2010, June 2011, March 2012, and December 2012. The reader is referred to A for additional details on data sources and final sample selection.

	$\Delta CREDIT$ (Granted)				
$Exposure_{Jun11} \times \mathbb{I}_{Run}$	-0.114***	-0.117	-0.122***	-0.117***	-0.082*
	(0.031)	(0.268)	(0.041)	(0.038)	(0.045)
$Exposure_{Jun11} \times \mathbb{I}_{Interv}$	0.115**	-0.424***	0.144**	0.121**	0.075
	(0.053)	(0.148)	(0.059)	(0.056)	(0.048)
$Exposure_{Jun11} \times \mathbb{I}_{Run} \times Size_{2010}$		-0.000			
		(0.019)			
$Exposure_{Jun11} \times \mathbb{I}_{Interv} \times Size_{2010}$		0.036***			
		(0.011)			
$Exposure_{Jun11} \times \mathbb{I}_{Run} \times Profitability_{2010}$			0.058		
			(0.202)		
$Exposure_{Jun11} \times \mathbb{I}_{Interv} \times Profitability_{2010}$			-0.339***		
			(0.112)		
$Exposure_{Jun11} \times \mathbb{I}_{Run} \times LEV_{2010}$				-0.018	
				(0.024)	
$Exposure_{Jun11} \times \mathbb{I}_{Interv} \times LEV_{2010}$				0.012	
				(0.036)	
$Exposure_{Jun11} \times \mathbb{I}_{Run} \times Risky_{2010}$					-0.055**
					(0.027)
$Exposure_{Jun11} \times \mathbb{I}_{Interv} \times Risky_{2010}$					0.072***
					(0.026)
Firm-Time FE	✓	✓	✓	✓	✓
Bank-Firm FE	✓	✓	✓	✓	✓
Bank Controls (interacted with dummies)	✓	✓	✓	✓	✓
Relantionship Controls	✓	✓	✓	✓	✓
Observations	2,171,749	1,389,799	1,414,211	1,414,211	1,386,784
R-squared	0.701	0.686	0.688	0.688	0.686

Table 4: Liquidity Injections and Credit Supply, Intensive Margin, Heterogeneity Across Firms. This table presents results from specification (1) augmented to include triple interactions with firm balance sheet characteristics. The dependent variable is the difference in log (stock of) credit granted. $Exposure_{Jun11}$ is the exposure to the foreign wholesale market, divided by assets, in June 2011. $\mathbb{I}_{Run}$ is a dummy equal to one in the *run* and *intervention* periods. $\mathbb{I}_{Interv}$ is a dummy equal to one in the *intervention* period. The *normal* period runs from December 2010 to June 2011. The *run* period runs from June 2011 to December 2011. The *intervention* period runs from December 2011 to June 2012. Relationship controls include (i) the share of total firm i credit coming from bank j, (ii) the ratio of drawn credit over committed credit, and (iii) the share of overdraft credit by borrower i with respect to bank j, LEV is leverage, ROA is return on assets, $T1R$ is the Tier 1 Ratio, NPL is non-performing loans divided by total asset, and $Large$ is a dummy equal to one if the bank has assets above €500 billion. Firm characteristics are measured in December 2010 and defined as follows: $Size$ is log of total assets; $Profitability$ is EBITDA; LEV is firm leverage; $Risky$ is a dummy equal to one if the firm is considered risky based on the Z-score greater or equal than 5 (range 1-9). Standard errors double clustered at the bank and firm level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

leverage, and (iii) belonging to one of the top three banking groups are driving the credit expansion in the March 2012 - December 2012 period.

4 Transmission Channel

In the previous section, we document that banks more exposed to the foreign wholesale market run increase credit supply after the central bank intervention, compared to less exposed banks. In this section, we link the actual bank-level liquidity injections to credit supply and discuss the transmission channel.

We proceed in three steps. First, we show that, during the *run* period, banks substitute the foreign wholesale funding with short-term ECB liquidity. As banks are required to pledge collateral to access this liquidity, the increased reliance on ECB funding erodes banks' available collateral.

Second, we show that LTRO successfully attracts many banks, *regardless* of their exposure to the run. This finding poses an identification challenge as it is not possible to use the pre-run exposure to the foreign wholesale market as an instrument for the LTRO uptakes. In other words, it is not the case that banks that reduce credit during the run period are also those tapping the liquidity the most. One can therefore think at LTRO uptakes as having two components: one driven by the run and one driven by other motives.

Third, we disentangle the two components, using a regulatory change introduced by the Italian government that allowed banks to create new collateral for a fee. We identify uptakes backed by the new government regulation as being driven by the run. Banks with high exposure to the foreign wholesale run not only have little available collateral in June 2011 compared to less exposed banks, but they also have to pledge an increasing amount of collateral to the ECB to obtain short-term funding that substitutes for the drain in the wholesale market. Hence, at the time of the 3-year LTRO announcement, these banks have scarce collateral. We find that these are the banks that typically take advantage of the government regulation. In the remainder of this section, we examine this causal chain and show that liquidity uptakes backed by the government regulation are entirely responsible for the transmission to private credit supply.

	$\Delta CREDIT$ (Granted)					
	(1)	(2)	(3)	(4)	(5)	(6)
$Exposure_{Jun11} \times \mathbb{I}_{Run} \times LEV_{Jun11}$		0.039				
		(0.042)				
$Exposure_{Jun11} \times \mathbb{I}_{Interv} \times LEV_{Jun11}$		0.088***				
		(0.027)				
$Exposure_{Jun11} \times \mathbb{I}_{Run} \times ROA_{Jun11}$			2.853***			
			(1.073)			
$Exposure_{Jun11} \times \mathbb{I}_{Interv} \times ROA_{Jun11}$			-2.056			
			(1.626)			
$Exposure_{Jun11} \times \mathbb{I}_{Run} \times T1R_{Jun11}$				-0.014		
				(0.046)		
$Exposure_{Jun11} \times \mathbb{I}_{Interv} \times T1R_{Jun11}$				0.030		
				(0.064)		
$Exposure_{Jun11} \times \mathbb{I}_{Run} \times NPL_{Jun11}$					-0.078***	
					(0.027)	
$Exposure_{Jun11} \times \mathbb{I}_{Interv} \times NPL_{Jun11}$					0.038	
					(0.040)	
$Exposure_{Jun11} \times \mathbb{I}_{Run} \times Large$						-0.523
						(0.323)
$Exposure_{Jun11} \times \mathbb{I}_{Interv} \times Large$						0.799
						(0.745)
$Exposure_{Jun11} \times \mathbb{I}_{Run}$	-0.114***	-0.741	-0.099***	-0.475***	0.019	0.846**
	(0.031)	(0.667)	(0.035)	(0.135)	(0.437)	(0.335)
$Exposure_{Jun11} \times \mathbb{I}_{Interv}$	0.115**	-1.306***	0.090	0.374**	-0.163	-0.358
	(0.053)	(0.444)	(0.065)	(0.186)	(0.608)	(0.513)
$\mathbb{I}_{Run} \times LEV_{Jun11}$	0.141	-0.064	0.096	0.177	0.134	0.330
	(0.207)	(0.160)	(0.196)	(0.210)	(0.217)	(0.244)
$\mathbb{I}_{Interv} \times LEV_{Jun11}$	0.244	-0.294	0.317*	0.229	0.259	0.161
	(0.158)	(0.188)	(0.186)	(0.146)	(0.164)	(0.152)
$\mathbb{I}_{Run} \times ROA_{Jun11}$	-0.038*	-0.056**	-0.058**	-0.106***	-0.041*	-0.011
	(0.020)	(0.028)	(0.023)	(0.029)	(0.022)	(0.023)
$\mathbb{I}_{Interv} \times ROA_{Jun11}$	0.027	-0.015	0.057	0.075	0.034	0.014
	(0.044)	(0.050)	(0.057)	(0.049)	(0.051)	(0.051)
$\mathbb{I}_{Run} \times T1R_{Jun11}$	0.396**	0.295**	0.397**	0.458**	0.408***	0.509***
	(0.155)	(0.125)	(0.158)	(0.174)	(0.135)	(0.179)
$\mathbb{I}_{Interv} \times T1R_{Jun11}$	0.362***	0.141	0.367***	0.339***	0.339***	0.315**
	(0.127)	(0.118)	(0.120)	(0.110)	(0.116)	(0.125)
$\mathbb{I}_{Run} \times NPL_{Jun11}$	-0.321*	-0.434	-0.396*	-0.305*	-0.340*	0.046
	(0.185)	(0.269)	(0.213)	(0.175)	(0.186)	(0.157)
$\mathbb{I}_{Interv} \times NPL_{Jun11}$	0.222**	0.045	0.336*	0.208**	0.261	0.035
	(0.101)	(0.109)	(0.178)	(0.096)	(0.158)	(0.190)
$\mathbb{I}_{Run} \times Large$	-0.647	1.003	4.261	-5.238***	-0.282	-1.659*
	(0.943)	(2.432)	(3.578)	(1.673)	(1.262)	(0.892)
$\mathbb{I}_{Interv} \times Large$	0.615	3.840*	-6.880	3.941	-0.145	1.149
	(1.518)	(2.104)	(7.345)	(3.495)	(2.444)	(1.800)
Relationship Controls	✓	✓	✓	✓	✓	✓
Firm-Time FE	✓	✓	✓	✓	✓	✓
Bank-Firm FE	✓	✓	✓	✓	✓	✓
Observations	2,171,749	2,171,749	2,171,749	2,171,749	2,171,749	2,171,749
Adj. R-squared	0.701	0.701	0.701	0.701	0.701	0.701

Table 5: Liquidity Injections and Credit Supply, Intensive Margin, Effect by Bank Characteristics. This table presents results from specification (1) augmented to include triple interactions with June 2011 bank characteristics. The dependent variable is the difference in log (stock of) credit granted. $Exposure_{Jun11}$ is the exposure to the foreign wholesale market, divided by assets, in June 2011. $\mathbb{I}_{Run}$ is a dummy equal to one in the *run* and *intervention* periods. $\mathbb{I}_{Interv}$ is a dummy equal to one in the *intervention* period. The *normal* period runs from December 2010 to June 2011. The *run* period runs from June 2011 to December 2011. The *intervention* period runs from December 2011 to June 2012. Relationship controls include (i) the share of total firm i credit coming from bank j, (ii) the ratio of drawn credit over committed credit, and (iii) the share of overdraft credit by borrower i with respect to bank j, LEV is leverage, ROA is return on assets, $T1R$ is the Tier 1 Ratio, NPL is non-performing loans divided by total asset, and $Large$ is a dummy equal to one if the bank has assets above €500 billion. Standard errors double clustered at the bank and firm level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

		Pledged Government Bonds	Available Government Bonds	Central Bank Borrowing	Haircut Adjusted ECB Collateral
Full Sample	Jun11	4.4%	3.9%	2.2%	5.7%
	Nov11	6.7%	3.6%	4.2%	4.7%
Exposure Q1	Jun11	3.4%	6.1%	1.5%	7.7%
	Nov11	4.6%	5.6%	1.8%	6.3%
Exposure Q2	Jun11	3.9%	4.2%	1.0%	6.0%
	Nov11	6.3%	3.6%	2.7%	5.2%
Exposure Q3	Jun11	4.6%	3.3%	2.7%	5.5%
	Nov11	6.9%	3.2%	4.3%	4.4%
Exposure Q4	Jun11	5.3%	2.1%	3.3%	3.7%
	Nov11	9.1%	2.0%	8.0%	2.8%

Table 6: Evolution of Central Bank Collateral. This table shows summary statistics of (i) stock of available (non-pledged) government bonds, (ii) stock of pledged government bonds, and (iii) central bank borrowing, in June 2011 and November 2011. The top panel shows full sample means. The bottom four panels show subsample means for four subsamples based on banks' exposure to foreign wholesale funding in June 2011. The latter is defined as foreign wholesale funding divided by assets. Q1 (Q4) is the subsample with lowest (highest) exposure to foreign wholesale funding.

4.1 Collateral During the Run Period

In the six-month period leading to the LTRO announcement, between June 2011-November 2011, the banks in our sample almost double their ECB borrowing from 2.2% to 4.2% of total assets. This trend is driven by banks exposed to the run that substitute the funds lost during the run with short-term liquidity from ECB. In Table 6, we show that banks in the highest quartile of exposure to the foreign wholesale market increase their exposure to ECB borrowing from 3.3% to 8.0% of total assets compared to a small change from 1.5% to 1.8% of banks in the lowest quartile.

Access to ECB liquidity must be collateralized.[26] Hence, the increase in ECB borrowing taking place during the run period coincides with an increase in the collateral pledged at the central bank. For this purpose, banks increase their holdings of eligible collateral, but this increase is almost entirely used as additional collateral when borrowing from the ECB. In Table 6, we focus on government bonds.[27] These

[26] Koulischer (2015) and Nyborg (2015) discuss the importance of the central bank collateral framework for the transmission of ECB monetary policy.

[27] ECB eligible collateral also includes other asset classes such as ABS, and covered and uncovered

constitute one of the most common classes of collateral, characterized by relatively low haircut levels in central bank refinancing operations and a large degree of liquidity since they are also widely used in other transactions (i.e., repos). Therefore, they represent a good measure of the availability of collateral (see Bank of Italy (2011b)). We show that between June 2011 and November 2011, the holdings of available (non-pledged) government bonds are stable from 3.9% to 3.6% of total assets, while the holdings of pledged government bonds rise from 4.4% to 6.7%.

4.2 Central Bank Liquidity Uptakes

In our sample, 72 banks take advantege of the ECB liquidity and obtain liquidity totalling €170.1 billion. It is an economically large quantity as the median uptake is 9.9% of total assets.[28] Table 7 shows summary statistics of bank (i) total borrowing at ECB and (ii) LTRO uptakes. LTRO uptakes are split between Total Uptake and New Borrowing. The former corresponds to the cash loan amount that the bank received from the LTRO loan. The latter corresponds to how much the total borrowing at ECB changed around the LTRO1 and LTRO2 allotments. The use of LTRO across Italian banks is widespread as 48 out of 49 banks that usually borrow from the ECB also take advantage of the LTRO allotments. The total uptake by our sample banks is €195.4 billion, consisting of a €88.4 billion uptake at LTRO1 and a €117.4 billion uptake at LTRO2. The median bank borrowed 10.1% of its total assets during the two allotments.

Interestingly, in our sample, banks' LTRO uptakes are uncorrelated with their exposure to the foreign wholesale market in 2011. In Figure 2, the banks are divided into quartiles according to their exposure to the foreign wholesale market. We find that the uptake is approximately the same for the four subsamples.

bank bonds.

[28]The average is 10.9% of total assets. Note that the total uptake is used in part to rollover previous short-term borrowing at the ECB, as well as to increase the total debt with the ECB. The median and average "new borrowing" in our sample is 7.9% and 6.1%, respectively. We provide detailed summary statistics in Table E.6.

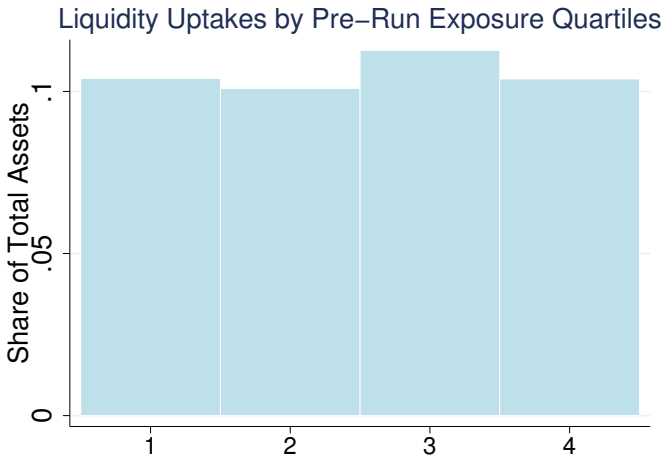

Figure 2: LTRO Uptakes and Bank Exposure to the Foreign Wholesale Market. This histogram shows LTRO uptakes, normalized by assets in December 2011. Banks are divided in four quartiles according to their exposure to the foreign wholesale market in June 2011.

Why do banks borrow at LTRO? As discussed, the distinctive feature of an LTRO compared to existing liquidity measures is the long 3-year maturity. However, in a world with no uncertainty, LTRO is a redundant tool and should not attract banks. With no uncertainty, banks woud be indifferent between borrowing at the central bank at a three-year horizon and borrowing, say, at a two-week maturity and then rolling over bi-weekly for three years. In fact, the two strategies are not equivalent if there is uncertainty about the ECB's role as a liquidity provider in the next three years. This is definitely the case at the end of 2011 as there was uncertainty about the future of the Eurozone and the unlimited feature of ECB liquidity provision.[29] In such an environment, a LTRO intervention attracts a large number of banks.

[29]Right after the collapse of Lehman, the ECB started to adopt the so-called "full allotment" procedure in its liquidity provision operations. Under this process, Eurozone banks can obtain potentially unlimited liquidity, provided that they pledge sufficient eligible collateral. This procedure was still in place at the time of the two LTRO allotments. However, there was uncertainty on whether this feature would have been in place during the three years of the LTRO. Uncertainty about collateral eligibility and haircuts was not eliminated by taking advantage of the LTRO. In fact, if the value of collateral dropped (or the haircuts increased) during the LTRO period, banks were required to either pledge additional collateral or place cash in margin call deposits at the ECB. According to the ECB Risk Control Framework, marketable assets used as collateral are marked to market daily.

	Mean (%Assets)	p(25) (%Assets)	p(50) (%Assets)	p(75) (%Assets)	σ (%)	Sum (€bn)	No. (units)
Balance Nov11	5.9%	3.0%	5.5%	8.2%	42.3%	127.0	49
LTRO							
Total Uptake	10.9%	6.0%	9.9%	15.5%	33.9%	170.1	72
New Borrowing	7.9%	3.5%	6.1%	10.4%	34.4%	54.2	72
LTRO1							
Total Uptake	3.2%	0.0%	2.4%	4.9%	34.3%	87.3	47
New Borrowing	1.4%	0.0%	0.5%	2.9%	34.3%	39.8	47
LTRO2							
Total Uptake	7.7%	3.4%	5.5%	9.7%	34.1%	82.8	72
New Borrowing	6.5%	2.0%	4.1%	9.1%	34.6%	14.4	72

Table 7: Summary Statistics: Borrowing From LTRO. This table shows summary statistics of LTRO uptakes by the banks in our sample. Total uptake is defined as the total LTRO uptake. New borrowing is defined as the change in the total exposure to ECB borrowing around the LTRO allotments. LTRO, LTRO1, and LTRO2 correspond to the the sum of the two allotments, the first allotment, and the second allotment, respectively. The first line shows the total borrowing at ECB in November 2011, before the first LTRO allotment. The last column shows the number of banks taking advantage of the facility. In Table E.6, we show statistics for the subsample of exposed and non-exposed banks.

4.3 The Government Scheme

We now want to link the bank-level uptakes of the LTRO liquidity with the increase in credit supply. As discussed, we face one empirical challenge. Many Italian banks tap ECB liquidity, *regardless* of their June 2011 foreign wholesale exposure. Hence, we need to (i) isolate the portion of the liquidity injections that is driven by the pre-LTRO run in the wholesale market from the liquidity injections driven by other motives and (ii) discuss these eventual other motives.

Thought Experiment Consider the following thought experiment. Suppose that banks can create additional collateral against the payment of the fee. Absent the fee, all banks would choose to secure additional collateral to contain their asset encumbrance. However, once a fee is enforced, only banks that have profitable opportunities yet scarce collateral would want to access this additional collateral. This example is similar in spirit to Rothschild and Stiglitz (1976): banks that self-select in the costly illiquid collateral option have little collateral because of the run. In other words, the usage of the scheme creates a separating equilibrium (see also Hertzberg et al. (2015)).

Institutional Detail We next describe an intervention by the Italian government that resembles the previous example. On December 22, 2011, the day after the first LTRO allotment, the Italian government issued a Decree Law allowing banks to obtain new eligible collateral, after paying a fee to the Treasury. Under this law, banks can obtain a state guarantee on zero coupon, senior, unsecured, euro-denominated bonds that are otherwise (without the state guarantee) non-eligible at the ECB.[30] In the period between the two LTRO allotments, banks could take advantage of this law by issuing and retaining unsecured bank bonds. A retained issuance is effectively a self-issuance as banks do not place the bonds to market or investors, but keep them on the asset side of the balance sheet. Paying a 1% fee to the Treasury, banks then obtain a government guarantee on these newly created bonds (called Government Guaranteed Bank Bonds, or GGBBs) so that they become eligible to be pledged at LTRO2. The popularity of this scheme is shown in the left panel of Figure 3, which shows the total GGBB (self-) issuance reached €79 billion in the two months between the LTRO allotments. The timing of the issuance and the maturity of the bonds coinciding with LTRO maturity strongly suggest that the government scheme is issued to create collateral for the second LTRO allotment. Even if banks can issue GGBBs after the second allotment, they chose not to do so, suggesting that the goal of this collateral creation was to access the second LTRO allotment. Moreover, banks chose to issue GGBBs with maturity matching the maturity of the LTRO loans maturity to minimize their rollover risk at the time of reimbursement. We confirm from our dataset that these securities are pledged at the ECB at the end of February.

The right panel shows the time series of the GGBB holdings. Banks are divided into quartiles, according to their exposure to the foreign wholesale funding in June 2011. The higher the exposure, the more the banks took advantage of the new government law, consistent with our narrative.

[30] In Appendix C.2, we provide a detailed description of the GGBB scheme, as well as anecdotal evidence on its rationale and usage by banks.

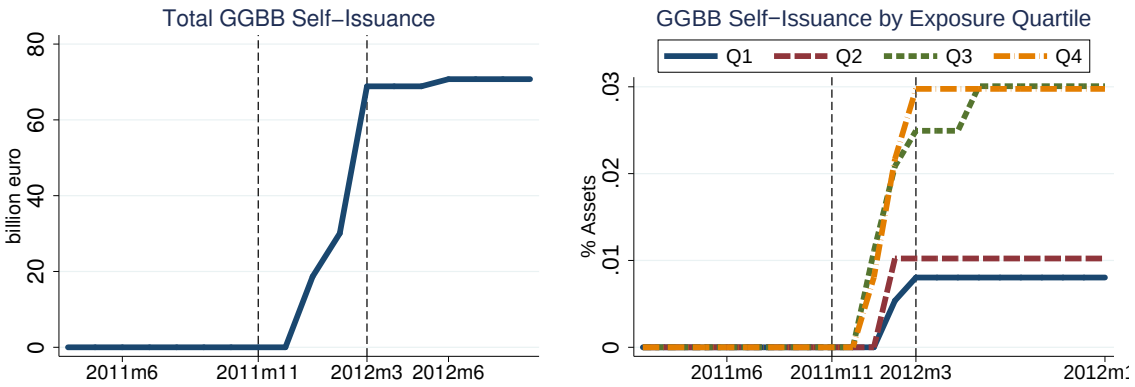

Figure 3: Government Scheme Usage. This figure shows the bank usage of the government law by banks. The left panel illustrates banks' total collateral creation, in billion €. The right panel shows banks collateral creation, normalized by assets in December 2011, for four subsamples of banks according to their exposure to the foreign wholesale market in June 2011. Q1 (Q4) banks are the less (most) exposed to the foreign wholesale market in June 2011.

4.4 Identifying the Transmission Channel

Having confirmed that LTRO uptakes backed by the government scheme capture the share of total LTRO uptakes driven by the run, we next estimate a standard difference-in-difference specification where we compare the *run* and the *intervention* periods:

$$\Delta Log(Credit_{ijt}) = \alpha + \beta_1 Uptake_j \times Intervention_t + \mu_{it} + \gamma_j + \phi' X_{ijt} + \epsilon_{ijt} \quad (2)$$

where the dependent variable is the change in the stock of credit granted by bank j to borrower i at time t. Our dependent variable of interest is $Uptake$, defined as the LTRO uptake divided by assets. Table 8 shows the estimation results. In column (1), $Uptake$ is defined as the total LTRO uptake and the dependent variable is credit granted. We find that the coefficient is not significant. Of course, this result should be interpreted as a simple correlation as the uptake is endogenous. In columns (2) and (3), we repeat the same exercise splitting the uptake backed by the government guarantee ($GovtScheme$) and the uptake backed by standard liquid collateral ($LiquidCollateral$). Consistent with our analysis of the government regulation, we instrument the former with the

	$\Delta CREDIT$ (Granted)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
TotalUptake × *Intervention*	0.104			0.042				
	(0.188)			(0.175)				
GovtScheme × *Intervention*		0.632**	0.614**		0.364**	0.349*	1.417***	1.620**
		(0.257)	(0.254)		(0.180)	(0.190)	(0.304)	(0.756)
LiquidCollateral × *Intervention*			-0.145			-0.156		-0.175
			(0.182)			(0.198)		(0.277)
Bank FE	✓	✓	✓					
Bank-Firm (i, j, t) Controls	✓	✓	✓	✓	✓	✓	✓	✓
Firm-Time FE	✓	✓	✓	✓	✓	✓	✓	✓
Bank-Firm FE				✓	✓	✓		✓
Bal. Sheeet (j, t) Controls (incl. interaction terms)				✓	✓	✓		✓
Model	OLS	OLS	OLS	OLS	OLS	OLS	IV	IV
Observation	1,415,856	1,415,856	1,415,856	1,243,174	1,243,174	1,243,174	1,243,174	1,243,174
Within R-squared	0.3677	0.3676	0.3676	0.3731	0.3732	0.3732	0.4712	0.4701

Table 8: Central Bank Facility Uptakes and Credit Supply. This table presents the results from specification (2). The dependent variable is the difference in log (stock of) credit granted. *TotalUptake* is the total LTRO uptake (sum of the two allotments) divided by assets in December 2011. *LiquidCollateral* is the portion of total uptake backed by liquid collateral, divided by assets in December 2011. *GovtScheme* is the portion of total uptake backed by the government scheme, divided by assets in December 2011. Columns (1)-(3) show the results from a simple OLS regression. Column (4) shows the results of an instrumental variable regression where *GovtScheme* × *Intervention* is instrumented by *Exposure* × *Intervention*. *Intervention* is a dummy equal to one in the *intervention* period and zero in the *run* period. The sample period runs from June 2011 to December 2012. The sample includes only firms with multiple relationships at any time t. Standard errors double clustered at the bank and firm level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

June 2011 exposure to the foreign wholesale market. The idea is straightforward. As the government scheme is costly, only banks that have a high marginal propensity to borrow from the central bank will use it. The results confirm that uptakes backed by the government scheme explain the entire transmission.

5 Firm-Level Credit and Aggregate Impact

In Section 3, we established the following facts: (i) there is a credit supply contraction during the run and a credit supply expansion during the intervention periods, (ii) banks reduce credit supply to all firms, except small and risky firms, during the run period, and (iii) increase credit supply to all firms in the intervention period. We now examine which firms benefit the most from the intervention and which firms are hit the most during the run. We do so by looking at the dynamic of total firm credit, namely the credit drawn from all sources (term loans, revolving credit lines, and loans backed by account receivables). In particular, we check whether during the run, firms are able to substitute away from exposed lenders to non-exposed lenders. Similarly, during the intervention period, an increased credit supply might not be followed by an increase in firm total firm borrowing.

We first analyze the cross-section of firms by collapsing our dataset at the firm-time level. For each firm, we compute the indirect exposure, through its banking relationships, to the foreign wholesale market in June 2011. Formally, the exposure of firm i is given by the weighted average of its banks' exposures, where the weights are given by the total credit drawn from each bank in June 2011. For each firm i, we compute:

$$\widetilde{Exposure}_{i,Jun11} = \frac{\sum_{j \in \mathcal{R}^i} Drawn_{j,Jun11} Exposure_{j,Jun11}}{\sum_{j \in \mathcal{R}^i} Drawn_{j,Jun11}} \tag{3}$$

where $\mathcal{R}^i$ is the subset of banks that have a relationship with firm i in June 2011. We use this measure to analyze (i) the effect of the run and the intervention on bank total credit and (ii) the effect of the intervention on firm profitability, risk, and invesments.

5.1 Effect on Total Firm Credit

First, we examine whether firms are able to avoid the credit contraction during the run by substituting the reduced credit from affected banks with credit from less affected banks. To clarify what we mean by credit substitution, consider the following example. Firm F borrows from bank B1 and bank B2 before the run. The former is exposed to the run. The latter is not exposed. Even if bank B1 reduces its credit supply to firm F, it might still be the case that firm F is able to "undo" the credit contraction by borrowing more from B2 or starting a new relationship with a new bank. By looking at *total* firm credit (extended by all banks), we can check whether this substitution takes place during the run.

Second, we examine whether the increased credit supply during the intervention period corresponds an increased debt at the firm level. It might be the case that firms do not take advantage of the bank credit supply expansion by not expanding their total borrowing. We use the following specifications to address these two questions:

$$\begin{aligned}\Delta Log(Drawn_{it}) = \alpha + \beta_1 \widetilde{Exposure}_{i,Jun11} \times \mathbb{I}_{Run} + \beta_2 \widetilde{Exposure}_{i,Jun11} \times \mathbb{I}_{Interv} \\ + \phi' \Gamma_{it} + \eta_t + \chi_i + \epsilon_{it} \end{aligned} \tag{4}$$

where the dependent variable is the change in the (stock of) total firm i credit at time t, $Exposure_i$ is the indirect exposure of firm i to the foreign wholesale interbank market in June 2011 defined in (3), *Run* and *Intervention* are the usual time dummies, and $\eta_{province,i}$ and $\chi_{industry,i}$ are province and industry fixed effects, respectively.[31] We also saturate the regression with firm-level controls Γ_{it} ($Size$, ROE, $CAPEX$, $Leverage$, $EBITDA$), including their interaction with the two time dummy variables.

Table 9 shows the results.[32] The negative effect of the run on firm credit is stronger

[31] In our sample, province fixed effects are based on 111 Italian provinces and industry fixed effects are based on 86 industries.

[32] Table **??** in Appendix C shows additional results, using other subsamples.

	$\Delta CREDIT$ (Drawn)				
$\mathbb{I}_{Run} \times \widetilde{Exposure}$	-0.701***	-0.563	-0.671***	-0.707***	-0.700***
	(0.159)	(0.492)	(0.172)	(0.158)	(0.159)
$\mathbb{I}_{Interv} \times \widetilde{Exposure}$	0.812***	0.988*	0.781***	0.812***	0.811***
	(0.190)	(0.575)	(0.202)	(0.196)	(0.190)
$\mathbb{I}_{Run} \times \widetilde{Exposure}_{Jun11} \times Size$		-1.854			
		(6.846)			
$\mathbb{I}_{Interv} \times \widetilde{Exposure} \times Size$		-2.381			
		(7.595)			
$\mathbb{I}_{Run} \times \widetilde{Exposure} \times Profitability$			-0.492		
			(0.382)		
$\mathbb{I}_{Interv} \times \widetilde{Exposure} \times Profitability$			0.492		
			(0.331)		
$\mathbb{I}_{Run} \times \widetilde{Exposure} \times LEV$				0.097	
				(0.123)	
$\mathbb{I}_{Interv} \times \widetilde{Exposure} \times LEV$				-0.012	
				(0.251)	
$\mathbb{I}_{Run} \times \widetilde{Exposure} \times Risky$					0.552***
					(0.191)
$\mathbb{I}_{Interv} \times \widetilde{Exposure} \times Risky$					-0.283**
					(0.137)
Time FE	✓	✓	✓	✓	✓
Firm FE	✓	✓	✓	✓	✓
Observations	625,509	625,509	625,509	625,509	625,509
R-squared	0.260	0.260	0.260	0.260	0.260

Table 9: Firm-Level Effects, Credit Substitution. This table presents the results from specification (4), also augmented to include triple interactions with firm balance sheet characteristics. The dependent variable is the difference in log (stock of) total credit. Total credit includes all sources, namely drawn credit from revolving credit lines and loans backed by account receivables and term loans. $\widetilde{Exposure}$ is the firm indirect exposure to the foreign wholesale market in June 2011, divided by assets. $\mathbb{I}_{Run}$ is a dummy equal to one in the *run* and *intervention* periods. $\mathbb{I}_{Interv}$ is a dummy equal to one in the *intervention* period. The *normal* period runs from December 2010 to June 2011. The *run* period runs from June 2011 to December 2011. The *intervention* period runs from December 2011 to June 2012. Firm characteristics are measured in December 2010 and defined as follows: $Size$ is log of total assets; $Profitability$ is EBITDA; LEV is firm leverage; $Risky$ is a dummy equal to one if the firm is considered risky based on the Z-score greater or equal than 5 (range 1-9). The firms in the sample have at least two credit lines with two separate banks at any given time t. Standard errors double clustered at the main bank level (as of June 2011) in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

for smaller and less profitable firms. Large and highly profitable firms do not suffer from the run. Taken together, these results suggest that firms are unable to completely undo the credit contraction and are therefore impacted by the foreign wholesale market run. The ECB intervention has a positive impact on firm credit regardless of the chosen firm level subsample cut. Interestingly, large and low risk firms seem to benefit from the intervention the most as their total credit increases the most during the *intervention* period.

5.2 Aggregate Impact

We next examine the aggregate impact of the intervention. We use a counterfactual exercise to estimate what the drop in credit would have been from March 2012 to December 2012 if the ECB had not offered the two LTRO allotments.[33] We proceed in five steps. First, we estimate the firm-time fixed effects $\hat{\mu}_{it}$ from our baseline regression (1). By capturing all observed and unobserved firm heterogeneity, these fixed effects effectively capture borrowers credit demand. Second, we compute the firm-level *indirect* exposure to the June 2011-November 2011 funding shock using (3). In this way, we obtain both firm demand and pre-run exposure to the wholesale market shock. Third, we plug the stored firm-time fixed effects into the firm-level equation and estimate:

$$\Delta Log(Credit_{it}) = \alpha + \beta_1 Exposure_i \times Run_t + \beta_2 Exposure_i \times Intervention_t + \hat{\mu}_{it} + \epsilon_{it}$$

where (i) the dependent variable is credit granted aggregated at the firm level, (ii) $Exposure_i$ is the firm-level indirect exposure in June 2011 to the foreign wholesale market, and (iii) *Intervention* and *Run* are our standard dummy variables. Fourth, we use the estimated regression coefficients and average exposures to the shock to

[33] See Chodorow-Reich (2014b) for a similar counterfactual exercise.

predict the change in firm loan growth. Finally, we aggregate up at the period-level using a weighted avarege of firm-level loan growths, where the weights are given by firm-level granted credit in December 2012.

We then compare, in a partial equilibrium setting, the world with no ECB intervention to the world with LTROs. We obtain the former by simply setting $\beta_2 = 0$ in the last predictive regression. Of course, the exercise is subject to all caveats associated with a partial equilibrim example. The underlying assumption is that, absent the ECB intervention, the supply of credit granted would have decreased at the same rate during the *run* period. Thus, we find that the LTRO had a positive effect on credit supply, increasing it by 2%. The effect is quantitatively large: without the intervention, according to our partial equilibrium exercise, the credit supply would have contracted by 8.6% in the *intervention* period, instead of the observed 6.6%.

6 Liquid Asset Holdings

Our examination of the LTRO liquidity injection leaves one open question. While all banks take advantage of the ECB extraordinary liquidity facility, the transmission to credit supply occurs mainly through banks exposed to the foreign wholesale market in June 2011. Therefore, how do unexposed banks use ECB liquidity?

Having analyzed the effect on main illiquid asset class (loans to firms), we now examine how banks manage their liquid asset portfolio. In particular, we study government bonds, the largest and most liquid asset class.[34] Figure 4 shows the evolution of government bond holdings for the two subsamples of exposed (top exposure quartile) and non-exposed (bottom exposure quartile) banks. We observe a rapid increase of holdings between the two LTRO allotment dates. The pattern is

[34]There is a large literature on increased government bond holdings by peripheral banks during the crisis. Angelini et al. (2014) suggest that the trend is caused by the general pattern of renationalization and a temporary precautionary liquidity holding following the 3-year LTRO. Other papers attribute the observed pattern to risk-shifting (Acharya and Steffen (2015), Crosignani (2015), and Drechsler et al. (forthcoming)), moral suasion (Ivashina and Becker (2014) and De Marco and Macchiavelli (2015)), or the interplay between regulator and a common central bank (Uhlig (2013)) .

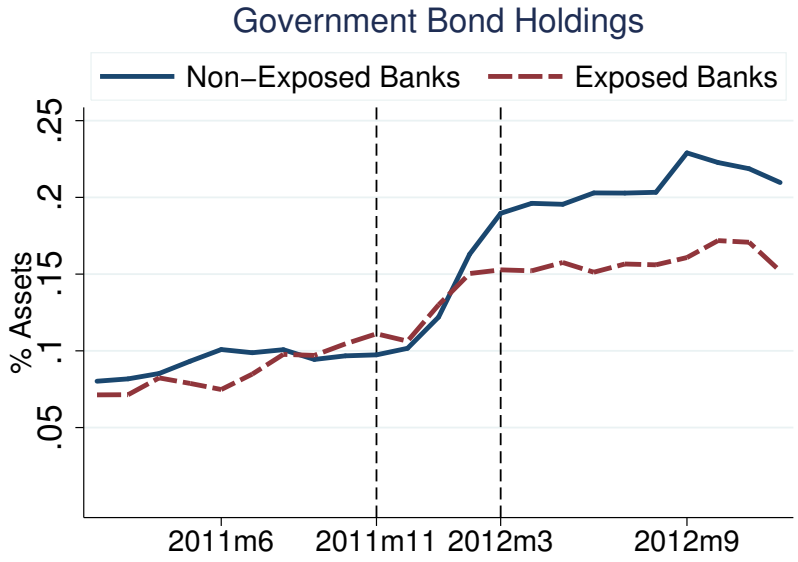

Figure 4: Liquid Asset Holdings. This figure shows government bond holdings, normalized by total assets in December 2011, by banks in our sample. Non-exposed banks are defined as banks in the bottom quartile of exposure to the foreign wholesale market in June 2011. Exposed banks are defined as banks in the top quartile of exposure to the foreign wholesale market in June 2011.

more pronounced for non-exposed banks.

The evidence is consistent with our previous findings as exposed banks use LTRO funds to increase credit supply more compared to non-exposed banks. The large government bond holding increase shown in the figure is consistent with Crosignani et al. (2015), who find a large increase in government bond holdings by Portuguese banks during the LTRO allotments. The authors suggest that peripheral banks, between December 2011 and February 2012, engage in a "collateral trade" by purchasing high yield domestic government bonds that are then pledged at the second LTRO allotment. There might be several motives behind this portfolio choice, ranging from risk-taking to a precautionary hoarding of liquidity.[35]

[35] Angelini et al. (2014) stresses that "banks needed to temporarily invest the funds acquired from the Eurosystem via the three-year LTROs."

7 Conclusion

In this paper, we analyze the transmission of central bank liquidity injections on bank credit supply. In particular, we study the impact of the ECB December 2011 3-year LTRO on Italian bank credit supply. We show that the banks that experience a foreign wholesale market run before the intervention (i) reduce their credit supply during the period of funding stress and (ii) expand their credit supply once the ECB injects liquidity into the system. Taking advantage of the Italian credit registry, we control for borrower (firm) observed and unobserved heterogeneity by comparing how the same firm's loan growth from one bank changes relative to another more affected bank. We find that the 3-year LTRO had a positive effect on credit supply in Italy, increasing it by 2%.

We then link the dynamics of bank credit supply with the ECB liquidity uptakes using a regulatory change that allows us to identify uptakes driven by the run. We show that banks that have a higher exposure to the foreign wholesale market erode their collateral in order to replace their missing funding. These banks therefore have scarce collateral at the time of the LTRO intervention, thus they access the costly government scheme that allows them to create additional collateral. We find that the transmission of LTRO to lending supply initially documented is fully driven by the uptakes backed by this newly created collateral.

The contribution of our paper is twofold. First, we examine how a central bank can counter a credit contraction following a negative shock. Most existing papers study, *in isolation*, the negative effect of funding shocks or the positive effects of accomodative monetary policy. We find that a central bank can counter a credit contraction by providing long-term liquidity to banks in exchange for collateral.

Second, we inform policy regarding the role of collateral in the transmission of central bank liquidity provisions. We show that banks that need the liquidity injection the most are those that are mechanically excluded from accessing the central bank liquidity, since they lack the necessary collateral. In this sense, our results indicate that a temporary relaxation of collateral requirements might be instrumental for well-functioning monetary policy during bad times.

By stressing the role of collateral in the transmission of monetary policy, our

findings open new research questions. One avenue is evaluating if and to what extent collateral availability and eligibility distort bank portfolio choice. If collateral scarcity causes banks to choose projects that they would have not funded otherwise, the central bank collateral fremework might have an effect on asset prices. Anticipating this mechanism, central banks might be able to influence bank portfolio choice and asset prices by changing eligibility requirements and haircuts.

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A.1 Specification

In this subsection, we illustrate analytically our baseline specification. To this end, consider the following simplified version of (1)

$$y_{jt} = \beta_0 + \beta_1 T_j + \beta_2 Run_t + \beta_3 T_j \times Run_t + \beta_4 Intervention_t + \beta_5 T_j \times Intervention_t + \epsilon_{it} \quad \text{(A1)}$$

where j is a bank and t is a date. T_j is a treatment dummy equal to one for the treated group. There are three periods (four dates). The dummy variable Run_t is equal to one in the second and third period. The dummy variable $Intervention_t$ is equal to one in the last period.

Claim. The coefficient β_3 captures the difference in y_{it} for the treated group during the second period relative to control group during the first period. The coefficient β_5 captures the difference in y_{it} for the treated group during the third period relative to control group during the second period. Formally,

$$\begin{aligned}
\beta_3 =& E(y_{jt}|Run_t = 1, Intervention_t = 0, T_j = 1) - E(y_{jt}|Run_t = 0, Intervention_t = 0, T_j = 1) \\
&- \big(E(y_{jt}|Run_t = 1, Intervention_t = 0, T_j = 0) - E(y_{jt}|Run_t = 0, Intervention_t = 0, T_j = 0)\big) \\
\beta_5 =& E(y_{jt}|Run_t = 1, Intervention_t = 1, T_j = 1) - E(y_{jt}|Run_t = 1, Intervention_t = 0, T_j = 1) \\
&- \big(E(y_{jt}|Run_t = 1, Intervention_t = 1, T_j = 0) - E(y_{jt}|Run_t = 1, Intervention_t = 0, T_j = 0)\big)
\end{aligned}$$

Proof. From (A1), we can compute the following conditional expectations

$$\begin{aligned}
&E(y_{jt}|Run_t = 0, Intervention_t = 0, T_j = 0) = \beta_0 \\
&E(y_{jt}|Run_t = 0, Intervention_t = 0, T_j = 1) = \beta_0 + \beta_1 \\
&E(y_{jt}|Run_t = 1, Intervention_t = 0, T_j = 0) = \beta_0 + \beta_2 \\
&E(y_{jt}|Run_t = 0, Intervention_t = 0, T_j = 1) = \beta_0 + \beta_1 + \beta_2 + \beta_3 \\
&E(y_{jt}|Run_t = 1, Intervention_t = 1, T_j = 0) = \beta_0 + \beta_2 + \beta_4 \\
&E(y_{jt}|Run_t = 1, Intervention_t = 1, T_j = 1) = \beta_0 + \beta_1 + \beta_2 + \beta_3 + \beta_4 + \beta_5
\end{aligned}$$

Hence,

$$\begin{aligned}
&E(y_{jt}|Run_t = 1, Intervention_t = 0, T_j = 1) - E(y_{jt}|Run_t = 0, Intervention_t = 0, T_j = 1) \\
&- \big(E(y_{jt}|Run_t = 1, Intervention_t = 0, T_j = 0) - E(y_{jt}|Run_t = 0, Intervention_t = 0, T_j = 0)\big) \\
&= (\beta_0 + \beta_1 + \beta_2 + \beta_3) - (\beta_0 + \beta_1) - \big((\beta_0 + \beta_2) - \beta_0\big) = \beta_3 \\
&E(y_{jt}|Run_t = 1, Intervention_t = 1, T_j = 1) - E(y_{jt}|Run_t = 1, Intervention_t = 0, T_j = 1) \\
&- \big(E(y_{jt}|Run_t = 1, Intervention_t = 1, T_j = 0) - E(y_{jt}|Run_t = 1, Intervention_t = 0, T_j = 0)\big) \\
&= (\beta_0 + \beta_1 + \beta_2 + \beta_3 + \beta_4 + \beta_5) - (\beta_0 + \beta_1 + \beta_2 + \beta_3) - \big((\beta_0 + \beta_2 + \beta_4) - (\beta_0 + \beta_2)\big) = \beta_5
\end{aligned}$$

□

Appendix A - Additional Figures

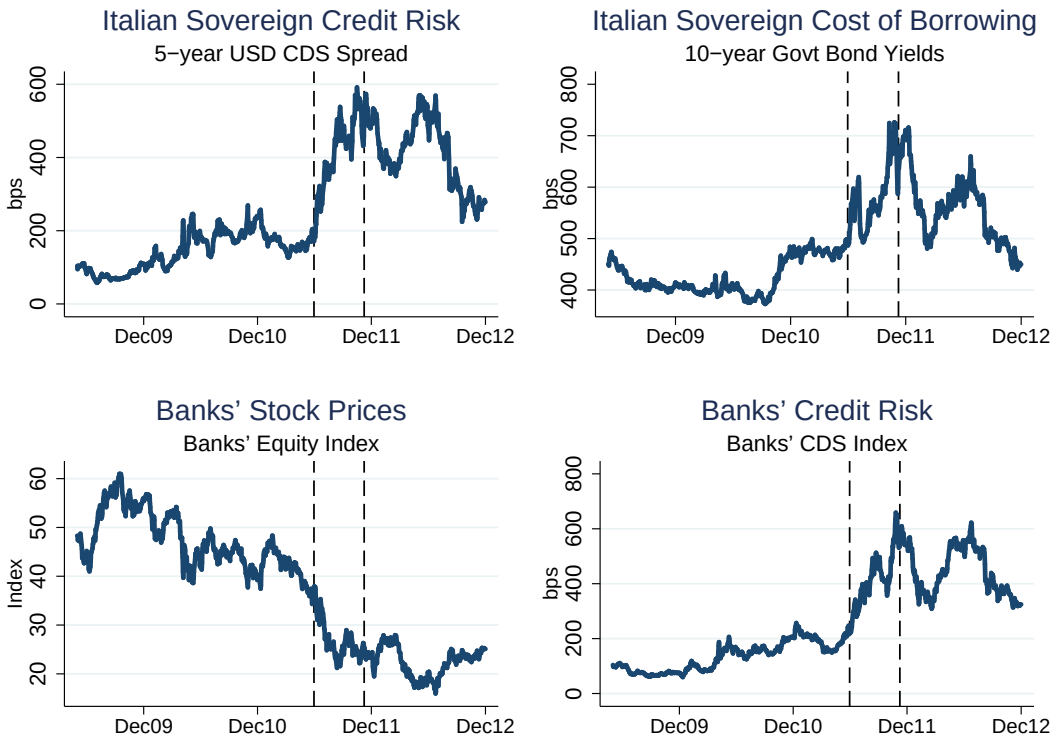

Figure B.1: Financial and Sovereign Credit Risk. The top right left figure shows the Italian Sovereign 5-year USD-denominated CDS spread. The top right figure shows the Italian 10-year government bond yield. The bottom left figure shows banks' equity prices (MSCI Italian Financials Index). The bottom right figure shows the mean banks' CDS spread using data on six major banks with CDS spread available on Bloomberg for the entire sample. The two dashed line correspond to June 2011 (Eurozone crisis contagion for Italy) and November 2011 (just before the 8 December LTRO announcement). Souce: Bloomberg.

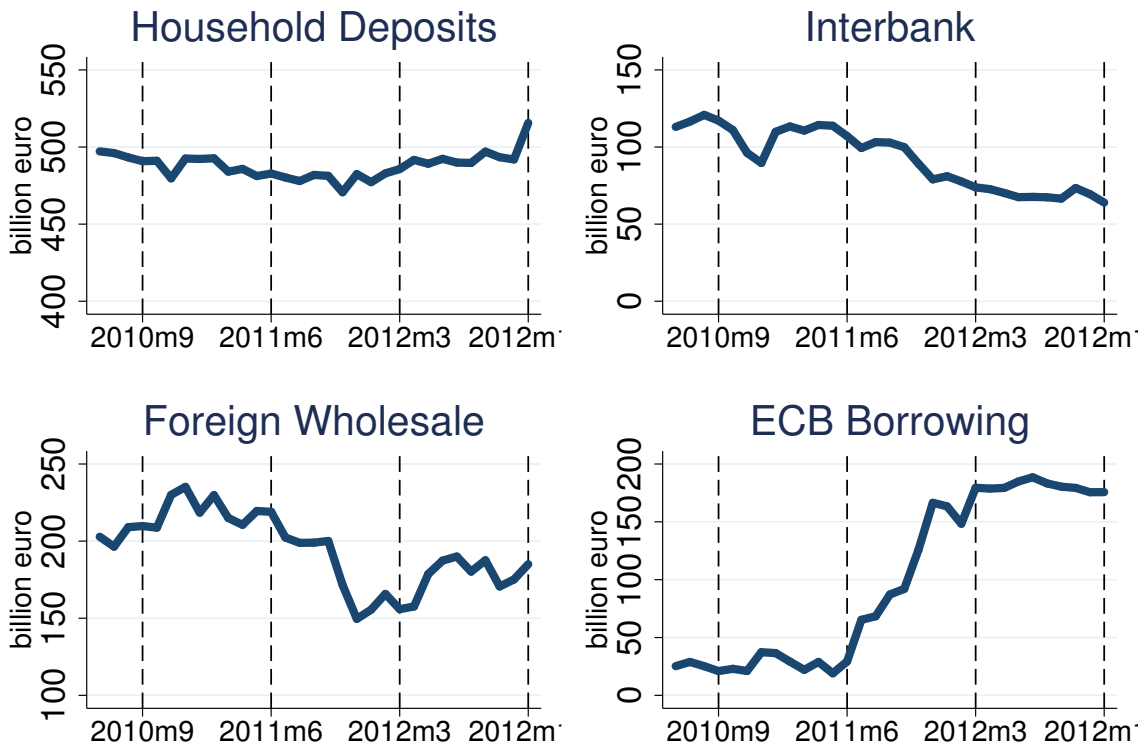

Figure B.2: Bank Funding Sources. This figure shows the composition of bank funding during the sample period. The dashed line correspond to June 2011, March 2012, and December 2012. They identify the three *normal*, *run*, *intervention* periods. The four panel show, respectively, total household deposits, total interbank, foreign wholesale (foreign deposits and centrally cleared repurchase agreements), and borrowing from the European Central Bank. Quantities are in billion €. Source: Supervisory and Statistical Reports at the Bank of Italy.

Appendix B - ECB Collateral

In this Appendix, we discuss the European Central Bank (ECB) collateral framework and describe the evolution of holdings of available (non-pledged) collateral securities during the period June 2011-November 2011.

D.1 Collateral Framework

Every bank has access to ECB liquidity and, in particular, to the 3-Year LTRO. To be able to borrow at ECB, banks are required to post eligible collateral. The list of eligible collateral securities is posted and constantly updated on ECB website. There, intermediaries can check which securities are pledgeable and what is the haircut that the central bank applies to each asset. The haircut depends mainly on the asset class, rating, coupon structure, and residual maturity. Table D.1 and Table D.2 provide examples of valuation haircuts, taken on a specific day, from ECB website.

Levels of valuation haircuts applied to eligible marketable assets

Credit quality	*Residual maturity (years)*	*Liquidity categories* Category I fixed coupon	Category I zero coupon	Category II fixed coupon	Category II zero coupon	Category III fixed coupon	Category III zero coupon	Category IV fixed coupon	Category IV zero coupon	Category V
Steps 1 and 2 (AAA to A-)	0-1	0.5	0.5	1.0	1.0	1.5	1.5	6.5	6.5	16
	1-3	1.5	1.5	2.5	2.5	3.0	3.0	8.5	9.0	
	3-5	2.5	3.0	3.5	4.0	5.0	5.5	11.0	11.5	
	5-7	3.0	3.5	4.5	5.0	6.5	7.5	12.5	13.5	
	7-10	4.0	4.5	5.5	6.5	8.5	9.5	14.0	15.5	
	>10	5.5	8.5	7.5	12.0	11.0	16.5	17.0	22.5	
Credit quality	*Residual maturity (years)*	*Liquidity categories* Category I fixed coupon	Category I zero coupon	Category II fixed coupon	Category II zero coupon	Category III fixed coupon	Category III zero coupon	Category IV fixed coupon	Category IV zero coupon	Category V
Step 3 (BBB+ to BBB-)	0-1	5.5	5.5	6.0	6.0	8.0	8.0	15.0	15.0	Not eligible
	1-3	6.5	6.5	10.5	11.5	18.0	19.5	27.5	29.5	
	3-5	7.5	8.0	15.5	17.0	25.5	28.0	36.5	39.5	
	5-7	8.0	8.5	18.0	20.5	28.0	31.5	38.5	43.0	
	7-10	9.0	9.5	19.5	22.5	29.0	33.5	39.0	44.5	
	>10	10.5	13.5	20.0	29.0	29.5	38.0	39.5	46.0	

Table D.1: ECB Collateral Schedule at LTRO (marketable assets). This table shows the haircuts applied by the European Central Bank for each eligible collateral type pledged during open market operations after 28 July 2010, including longer term LTROs. The liquidity categories are (i) government bonds and debt instrument issued by central banks; (ii) local and regional government debt instruments, Jumpo covered bonds, agency debt instruments, and supranational debt instruments; (iii) traditional and structured covered bank bonds and corporate debt instruments; (iv) uncovered credit institutions debt instruments; (v) ABSs. Standard floaters belong to maturity category 0-1 years and another (unreported) table is applied to inverse floaters. This table is publicly available and directly taken from ECB website `www.ecb.europa.eu` and has been published on 28 July 2010.

Levels of valuation haircuts applied to eligible non-marketable assets				
		Asset categories		
Credit quality	*Residual maturity (years)*	Credit claims: Fixed interest payment and a valuation based on a theoretical price assigned by the NCB	Credit claims: Fixed interest payment and a valuation according to the outstanding amount assigned by the NCB	Non-marketable RMB debt
Steps 1 and 2 (AAA to A-)	0-1	8.0	10.0	24
	1-3	11.5	17.5	
	3-5	15.0	24.0	
	5-7	17.0	29.0	
	7-10	18.5	34.5	
	>10	20.5	44.5	
Credit quality	*Residual maturity (years)*	Credit claims: Fixed interest payment and a valuation based on a theoretical price assigned by the NCB	Credit claims: Fixed interest payment and a valuation according to the outstanding amount assigned by the NCB	Non-marketable RMB debt
Step 3 (BBB+ to BBB-)	0-1	15.5	17.5	Not eligible
	1-3	28.0	34.0	
	3-5	37.0	46.0	
	5-7	39.0	51.0	
	7-10	39.5	55.5	
	>10	40.5	64.5	

Table D.2: ECB Collateral Schedule at LTRO (non-marketable assets). This table shows the haircuts applied by the European Central Bank for each eligible collateral type pledged during open market operations after 28 July 2010, including longer term LTROs. The liquidity categories are (i) government bonds and debt instrument issued by central banks; (ii) local and regional government debt instruments, Jumbo covered bonds, agency debt instruments, and supranational debt instruments; (iii) traditional and structured covered bank bonds and corporate debt instruments; (iv) uncovered credit institutions debt instruments; (v) ABSs. Standard floaters belong to maturity category 0-1 years and another (unreported) table is applied to inverse floaters. This table is publicly available and directly taken from ECB website www.ecb.europa.eu and has been published on 28 July 2010.

Haircuts are applied at the market value of the security. If the market value drops before the ECB loan matures, banks might receive a margin call from ECB asking to post additional collateral. Haircuts are not changed often and, crucially, are unchanged around the allotment of the 3-Year LTRO.

D.2 Available Collateral

In the main body, we discuss the increasing reliance of banks on ECB borrowing during the *run* period and how this, in turn, affects collateral availability. See, for example, Table 6. We now provide additional evidence indicating that the usage of the government guarantee scheme is explained by (i) the funding shock and (ii) the collateral availability.

First, it is important to note that the funding shock originates from (i) the freeze in the foreign fund raising via asset backed commercial paper and certificates of deposits issued mainly in the US and (ii) the centrally cleared Eurozone repurchase agreement market. The timing of these two components of the foreign shock is different though. The first one happens between June 2011 and July 2011. The second happens between October and November 2011. We now show, parametrically, that the usage of the government guarantee scheme is explained by (i) withdrawals caused by the freeze in international deposits during the summer 2011 and (ii) the availability of collateral. We restrict our sample to the 48 banks in our sample that borrow from ECB in November 2011, before the LTRO allotment. We choose this restricted sample as only banks actively borrowing from ECB experience the collateral erosion at the hearth of our narrative.

In Table D.3, we regress the usage of the government scheme ($SchemeUsage$) on several bank characteristics measured in June 2011. The dependent variable is defined as total creation of collateral (through GGBB) divided by assets in December 2011. In the first column, we see that the funding shock, defined as foreign deposits withdrawals divided by assets, explains the usage of the scheme. Banks that experience a large shock are also the ones using the scheme the most. Similarly, in column (2) and (4) we regress the scheme usage on available collateral, measured in June 2011 and November 2011. The results are again in line with our narrative. The less available collateral a bank has on balance sheet, the more it will use the government guarantee scheme to create *new* collateral. In column (3) we ask which factor between the funding schock and the collateral availability explains the GGBB usage the most. We include both explanatory variables, together with their interactions. Results show that both aspects (low collateral in June 2011 and large funding shock) are important in explaining the usage of the government guarantee program.

D.3 LTRO and Liquid Asset Holdings

In this subsection, we test parametrically whether banks with low exposure to the foreign wholesale market increase government bond holdings more compared to banks with higher exposure, around the allotment of the 3-Year LTRO. In other words, we use our security-level dataset to formally test the intuition behind Figure 4 in Section 6. In particular, we test the following model:

$$\Delta H_{j,s,t} = \alpha + \gamma_j + \eta_s + \beta Exposure_j \times Intervention_t + \phi' X_j + \epsilon_{j,s,t} \tag{D1}$$

where the dependent variable is the (log) change in holdings of government bond s by bank j at time t. $Exposure$ is the bank-level exposure to the foreign wholesale market in June 2011,

	Scheme Usage			
Funding Shock × Avail Collat$_{Jun11}$			-60.49**	
			(29.68)	
Funding Shock	1.226*		2.602***	
	(0.718)		(0.954)	
Avail Collat$_{Jun11}$		-0.314**	-0.307**	
		(0.135)	(0.127)	
ROA$_{Jun11}$	-2.208	-0.366	-0.559	0.247
	(2.013)	(2.110)	(1.981)	(2.319)
Big3	0.0319	-0.0021	0.0241	0.0005
	(0.0279)	(0.0225)	(0.0257)	(0.0227)
Size$_{Jun11}$	0.0012	0.0016	0.0028	0.0012
	(0.0036)	(0.0034)	(0.0034)	(0.0035)
Leverage$_{Jun11}$	-0.0006	-0.0003	0.0000	-0.0003
	(0.0015)	(0.0014)	(0.0014)	(0.0014)
Tier 1 Ratio$_{Jun11}$	-0.0019	-0.0004	0.0000	-0.0009
	(0.0013)	(0.0013)	(0.0014)	(0.0013)
Bad Loan$_{Jun11}$	-0.0202	0.157	-0.111	0.178
	(0.454)	(0.437)	(0.421)	(0.444)
Avail Collat$_{Nov11}$				-0.272**
				(0.133)
Observations	48	48	48	48
R-squared	0.188	0.232	0.358	0.211

Table D.3: Government Scheme Usage and Collateral Availability. This table shows estimation results. The dependent variable *SchemeUsage* is given by the total Government Guaranteed Bank Bonds self-issued by banks during the period December 2011 - February 2012, divided by assets in December 2011. *Funding Shock* is the summer 2011 foreign deposit funding shock (mainly ABCP and CD issued outside the Eurozone), divided by assets in December 2011. *Avail Collat* is given by non-pledged government bonds divided by assets. *Size* is ln(assets). *Bad Loan* is the ratio of new bad loans divided by the outstanding amount of loans in the previous period. Other variables are all defined as usual. Sample banks include only banks that have strictly positive borrowing with ECB at November 2011.

divided by assets. *Intervention* is a dummy equal to one during the intra-allotment period (December 2011 - February 2012). We add bank level controls (ROA, size, big3, leverage, tier 1 ratio, non-performing loans), together with bank fixed effects and security fixed effects. Note that this specification is a standard difference in difference where we compare the change in government bond holdings during the intra-allotment period (Mar 2012 - November 2011) by exposed banks with changes during the pre-LTRO period (November 2011-July 2011) by non-exposed banks.

Using this specification we replicate, in the Italian context, the findings of Crosignani et al. (2015) during the LTRO allotment in Portugal. In that paper, authors show that banks purchased government bonds between the two allotments to pledge them at the second and last allotment. We show estimation results in Table D.4. In columns (1)-(2), we use the full sample of government bond holdings. In columns (3)-(4) we include only securities that are issued before July 2011 and mature after March 2012. Finally, we use bank and security

	ΔHoldings			
Exposure × *Intervention*	-4.150**	-3.645**	-4.464**	-3.919**
	(1.936)	(1.771)	(1.849)	(1.721)
ROA × *Intervention*	-0.107	-0.256	0.00770	-0.127
	(1.006)	(1.209)	(0.920)	(1.127)
Leverage × *Intervention*	-0.00579	0.00721	-0.00775	0.00476
	(0.00965)	(0.0155)	(0.00894)	(0.0136)
Size × *Intervention*	0.113**	0.145*	0.112**	0.143*
	(0.0542)	(0.0740)	(0.0507)	(0.0733)
*Big*3 × *Intervention*	-0.415	-0.502	-0.336	-0.412
	(0.333)	(0.416)	(0.307)	(0.408)
BadLoan × *Intervention*	6.664*	4.917	6.864**	4.835
	(3.870)	(5.115)	(3.384)	(4.743)
*Tier*1*Ratio* × *Intervention*	0.00197	0.0131	0.00377	0.0145
	(0.00701)	(0.0112)	(0.00678)	(0.0112)
Sample	Full	Full	Restricted	Restricted
Bank FE	✓	✓	✓	✓
Security FE	✓		✓	
Security-Time FE		✓		✓
Observations	4,634	4,634	4,348	4,348
Adjusted R-squared	0.0261	0.0617	0.0242	0.0654

Table D.4: LTRO and Liquid Asset Holdings. This table presents results from specification (D1). The dependent variable is (log) change in holdings of government bond s by bank j at time t. There are two periods and three dates. The three dates are July 2011, November 2011, March 2012. *Intervention* is a dummy equal to one in the second period. *Exposure* is the exposure to the foreign wholesale market in June 2011, divided by assets. The other independent variables are measured in December 2011. *BadLoan* is the new bad loan ratio (ratio of new bad loans to the outstanding amount of loans in the previous period). *Big*3 is a dummy equal to one if a bank belongs to the top 3 banking groups by assets.

fixed effects in columns (1) and (3) and bank and security-time fixed effects in columns (2) and (4). The security-time fixed effects enable us to control for government bond repurchase and debt agency issuance, when using the full sample.

We find that the observed increase in government bond holdings is driven by banks with low exposure to the pre-LTRO run in the foreign wholesale market. The positive effect is also significant for large banks and banks with more non-performing loans.

Appendix C - Additional Tables

Country	First Allotment	Second Allotment	Total
Austria	7.8	3.7	**11.5**
Belgium	43.7	45.3	**89.0**
UK	6.8	21.1	**27.9**
Cyprus	1.3	3.3	**4.6**
Denmark	2.0	5.3	**7.3**
France	6.5	5.6	**12.1**
Germany	13.1	12.3	**25.4**
Ireland	17.6	21.9	**39.5**
Italy	128.1	172.1	**300.2**
Netherlands	2.0	8.9	**10.8**
Norway	2.6	1.5	**4.1**
Portugal	24.8	24.5	**49.3**
Slovenia	1.1	2.0	**3.1**
Spain	165.5	153.2	**318.7**
Total	**423.0**	**480.6**	**903.5**

Table E.1: Eurozone 3-Year LTRO Uptakes, Public Data Sources. This table shows uptakes (billion €), at the first and second LTRO allotment, by banking group country of incorporation. The data source is Bloomberg which gathers public statements (e.g., by CEOs) regarding banks' uptake of the ECB liquidity facility. The data is therefore not accurate (the real total liquidity injection exceeds €1 trillion). Note that the table shows some non Eurozone countries like UK and Denmark. Banks from these countries were able to tap LTRO funds through foreign subsidiaries in Eurozone countries. For example, Barclays, according to Bloomberg, was able to tap LTRO through its subsidiaries in Spain and Portugal. The true bank-level uptakes are not public.

Bank-Firm Level	Loan Type	Sep10-Jun11	Jun11-Mar12	Mar12-Dec12
p(25)				
Δln(Total Credit Drawn)	All Types	-21.6%	-26.2%	-23.9%
Δln(Total Credit Granted)	All Types	-11.2%	-13.7%	-14.1%
Δln(Total Credit Drawn)	Revolving Credit Lines Only	-29.3%	-27.3%	-25.8%
Δln(Total Credit Granted)	Revolving Credit Lines Only	0.0%	0.0%	0.0%
p(50)				
Δln(Total Credit Drawn)	All Types	-4.3%	-6.7%	-5.8%
Δln(Total Credit Granted)	All Types	0.0%	-2.0%	-2.1%
Δln(Total Credit Drawn)	Revolving Credit Lines Only	1.6%	2.1%	2.3%
Δln(Total Credit Granted)	Revolving Credit Lines Only	0.0%	0.0%	0.0%
p(75)				
Δln(Total Credit Drawn)	All Types	16.5%	9.3%	10.3%
Δln(Total Credit Granted)	All Types	0.0%	0.0%	0.0%
Δln(Total Credit Drawn)	Revolving Credit Lines Only	36.1%	37.9%	36.3%
Δln(Total Credit Granted)	Revolving Credit Lines Only	0.0%	0.0%	0.0%

Table E.2: Additional Summary Statistics, Bank-Firm Credit Growth, Quartiles. This table shows the first, second, and third quartile of credit growth during the (i) September 2010 - June 2011 period, (ii) June 2011 - March 2012 period, and (iii) the March 2012 - December 2012 period. The table shows changes in (i) total credit on term loans and drawn from revolving credit lines and loans backed by account receivables, (ii) total credit granted (committed) on term loans, revolving credit lines, and loans backed by account receivables, (iii) total credit drawn from revolving credit lines, and (iv) total credit granted (committed) on revolving credit lines. This table provides additional summary statistics, compared to Table 1 in the main body. Sample firms have multiple relationships.

		Jun11 Exposure Quartiles			
Balance Sheet Characteristics		Q1	Q2	Q3	Q4
Size	€bn	1.16	2.42	19.67	118.68
Leverage	units	9.77	12.24	13.33	13.32
Tier 1 Ratio	units	24.7	11.8	10.7	11.0
RWA	% Assets	64.1%	73.9%	71.8%	63.2%
Credit to Households	% Assets	21.3%	19.6%	17.1%	17.4%
Credit to Firms	% Assets	40.1%	49.2%	42.1%	41.2%
Securities	% Assets	16.2%	15.8%	17.2%	16.0%
Govt Bonds	% Assets	10.97%	9.29%	8.71%	7.35%
Cash Reserves	% Assets	0.6%	0.5%	0.4%	0.4%
ROA	Profits/Ass	0.0%	0.1%	0.3%	0.3%
Central Bank Borr	% Assets	1.8%	1.0%	2.9%	3.4%
Household Dep	% Assets	39.2%	35.0%	25.8%	23.7%
Interbank Borr	% Assets	1.0%	3.7%	5.3%	5.6%

Table E.3: Additional Summary Statistics, June 2011 Bank Characteristics by Exposure Quartile. This table shows June 2011 summary statistics for four subsamples of banks, based on their foreign wholesale market exposure in June 2011. Banks in the first quartile (Q1) are the least exposed. Banks in the fourth quartile (Q4) are the most exposed. This table extends Table 2 to subsample quartiles.

Panel A Exposed Banks		Jun10	Dec10	Jun11	Dec11	Jun12	Dec12
Size	€bn	71.94	70.65	70.51	71.03	73.03	74.31
Leverage	units	13.41	13.52	13.32	13.29	14.23	14.20
Tier 1 Ratio	units	10.50	10.62	10.86	11.44	11.56	11.58
RWA	%Assets	68.9%	68.2%	67.3%	65.8%	60.5%	58.3%
Credit to Households	%Assets	16.5%	17.0%	17.2%	17.0%	16.0%	15.7%
Credit to Firms	%Assets	41.4%	41.5%	41.7%	40.3%	37.8%	36.7%
Securities	%Assets	17.0%	16.9%	16.6%	18.3%	23.9%	23.8%
Government Bonds	%Assets	7.7%	8.0%	8.0%	10.2%	16.1%	17.6%
Cash Reserves	%Assets	0.4%	0.4%	0.4%	0.4%	0.4%	0.5%
ROA	Profits/Assets	0.24%	0.46%	0.26%	0.15%	0.20%	0.06%
Central Bank Borr	%Assets	1.50%	3.15%	3.16%	8.25%	10.95%	10.54%
Household Dep	%Assets	26.2%	25.3%	24.7%	24.3%	24.1%	24.9%
Interbank Borr	%Assets	6.3%	5.3%	5.5%	4.1%	3.9%	3.1%

Panel B Non-Exposed Banks		Jun10	Dec10	Jun11	Dec11	Jun12	Dec12
Size	€bn	1.71	1.77	1.82	1.83	1.96	2.08
Leverage	units	10.40	11.06	11.07	11.19	12.21	12.74
Tier 1 Ratio	units	27.72	19.81	17.89	16.44	16.02	15.31
RWA	%Assets	69.7%	69.9%	69.2%	69.8%	63.9%	62.7%
Credit to Households	%Assets	19.8%	20.8%	20.4%	20.4%	18.9%	18.1%
Credit to Firms	%Assets	42.0%	43.8%	44.9%	46.3%	43.1%	42.5%
Securities	%Assets	17.8%	16.8%	16.0%	16.2%	24.5%	23.7%
Government Bonds	%Assets	10.3%	10.0%	10.1%	10.7%	17.9%	17.8%
Cash Reserves	%Assets	0.5%	0.6%	0.6%	0.5%	0.5%	0.5%
ROA	Profits/Ass	0.05%	0.05%	0.02%	-0.06%	0.09%	0.04%
Central Bank Borr	%Assets	0.18%	0.92%	1.38%	3.24%	11.24%	11.55%
Household Dep	%Assets	39.9%	38.9%	37.0%	36.4%	34.6%	34.5%
Interbank Borr	%Assets	1.6%	2.6%	2.7%	6.0%	5.1%	4.9%

Table E.4: Additional Summary Statistics, Bank Characteristics, Exposed and Non-exposed Banks. This table shows cross-sectional means of selected balance sheet items during the sample period. The top panel (bottom panel) shows means for the subsample of exposed (non-exposed) banks. Exposed (Non-exposed) banks have a June 2011 exposure to the foreign wholesale market (above) below median. This table extends the top panel of Table 1 to subsample quartiles.

Firm Characteristics	Dec2010	Dec2011	Dec2012
Q1			
ROE	-0.97	-1.77	-3.30
EBITDA	2.20	1.78	0.86
Leverage	37.94	38.46	35.41
CAPEX	0.20	0.19	0.12
Tot. Debt	434	443	424
Fin. Debt	140	150	145
Size	652	665	650
Q2			
ROE	4.29	3.85	3.51
EBITDA	6.22	5.90	5.27
Leverage	67.85	68.56	66.82
CAPEX	1.44	1.35	1.03
Tot. Debt	1,038	1,064	1,027
Fin. Debt	449	469	457
Size	1,533	1,553	1,523
Q3			
ROE	17.73	17.39	16.87
EBITDA	11.42	11.07	10.37
Leverage	87.25	87.89	87.47
CAPEX	5.69	5.28	4.29
Tot. Debt	2,757	2,845	2,768
Fin. Debt	1,432	1,491	1,462
Size	4,058	4,099	4,025
Mean			
ROE	0.27	-1.57	2.10
EBITDA	6.83	5.06	3.04
Leverage	61.05	62.14	61.76
CAPEX	135.17	41.67	30.97
Tot. Debt	6,016	6,325	6,288
Fin. Debt	3,556	3,730	3,751
Size	9,226	9,299	9,312

Table E.5: Summary Statistics, Firms. This table shows firm summary statistics. The four panels show the first quartile, the median, the third quartile, and the mean, respectively. Firm characteristics include ROE, EBITDA, leverage, CAPEX, total debt, financial debt, and size.

Panel A Exposed Banks	**Mean** (%Assets)	**p(25)** (%Assets)	**p(50)** (%Assets)	**p(75)** (%Assets)	σ (%)	**Sum** (€bn)	**No.** (units)
Balance Nov11	5.9%	3.0%	5.5%	8.2%	42.3%	127.0	49
LTRO							
Total Uptake	10.9%	7.3%	9.6%	13.6%	46.6%	162.6	37
New Borrowing	5.8%	3.0%	4.9%	9.3%	47.5%	48.1	37
LTRO1							
Total Uptake	4.8%	2.4%	4.2%	5.7%	47.5%	48.1	37
New Borrowing	2.0%	0.0%	1.2%	4.3%	47.8%	38.6	30
LTRO2							
Total Uptake	6.1%	3.2%	4.8%	7.8%	47.3%	77.0	37
New Borrowing	3.9%	0.5%	2.6%	5.3%	47.8%	9.5	37

Panel B Non Exp. Banks	**Mean** (%Assets)	**p(25)** (%Assets)	**p(50)** (%Assets)	**p(75)** (%Assets)	σ (%)	**Sum** (€bn)	**No.** (units)
Balance Nov11	5.9%	3.0%	5.5%	8.2%	42.3%	127.0	49
LTRO							
Total Uptake	11.0%	4.4%	10.4%	15.7%	47.5%	7.5	37
New Borrowing	10.0%	4.0%	7.3%	13.8%	47.8%	6.2	37
LTRO1							
Total Uptake	1.5%	0.0%	0.0%	2.2%	48.5%	1.7	30
New Borrowing	0.9%	0.0%	0.0%	2.1%	48.5%	1.3	30
LTRO2							
Total Uptake	9.4%	3.6%	7.4%	14.1%	47.8%	5.8	34
New Borrowing	9.1%	3.0%	6.2%	13.8%	47.9%	4.9	34

Table E.6: Liquidity Uptakes. This table shows liquidity uptakes at LTRO. Panel A refers to the full sample. Panel B (panel C) refers to the subsample of exposed (non-exposed) banks. A bank is exposed (non-exposed) if its liquidity mismatch in June 2011 is above (below) median. LTRO1 and LTRO2 are the first and second allotment, respectively.

	Mean (%Assets)	**p(25)** (%Assets)	**p(50)** (%Assets)	**p(75)** (%Assets)	σ (%)	**Sum** (€bn)	**No. Banks** (units)
Collateral Creation	5.0%	3.1%	5.4%	6.4%	55.8%	68.9	27

Table E.7: Collateral Creation. This table shows summary statistics regarding collateral creation using Government Guaranteed Bank Bonds.

Online Appendix to "The Effect of Central Bank Liquidity Injections on Bank Credit Supply"

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A - Data

In this section, we describe, in great detail, data sources and sample selection.

IA.1 Data Sources

The dataset is obtained by merging eight data sources: (i) balance sheet characteristics from Supervisory and Statistical Reports at the Bank of Italy, (ii) three-year LTRO uptakes from Supervisory and Statistical Reports at the Bank of Italy, and (iii) security-level holdings from Supervisory and Statistical Reports at Bank of Italy (BoI), (iv) security-level information from Datastream, (v) Government Guaranteed Bank Bonds issuance from Bloomberg, (vi) security eligibility and haircuts at the central bank from ECB website, (vii) borrower-level data from the Italian Credit Registry, and (viii) firm characteristics from Cerved proprietary dataset. Each observation is a quadruple (i, j, s, t) where $i \in \mathcal{I}$ is a borrower, $j \in \mathcal{J}$ is a bank, $t \in \mathcal{T}$ is a date, and $s \in \mathcal{S}$ is a security. If not explicitly stated otherwise, bank-level quantities are consolidated at the national group level. Quantities are in billion €.

(i) The bank balance sheet dataset is made of (j, t) observations. The sample includes more than 610 banks from December 2009 to December 2012 at a half-yearly frequency. It includes total assets, leverage, securities holdings, government bond holdings, cash reserves, tier 1 capital, profits, risk weighted assets, equity, and new bad loan ratio. Leverage is defined as assets divided by equity. New Bad Loan Ratio is defined as loans with a non-performing status in the previous year divided by total loans. We also have detailed information on bank funding, including bond outstanding, deposits, wholesale funding (repos, interbank, foreign deposits), and total borrowing at ECB.

(ii) The ECB 3-year LTRO uptakes dataset is made of (j) observations. The sample includes the 115 banks that are alive in December 2011 and have been, at any point before that date, counterparty of ECB monetary policy operations. For each bank, we have the uptakes of the first and second allotment. Uptakes can be defined in several ways. First, gross and net uptakes refer to the total amount tapped at a particular allotment and the change in total ECB borrowing around the same allotment, respectively. The two quantities might differ as banks can use LTRO to rollover previous borrowing at ECB. Second, uptakes

might differ depending on the consolidation perimeter. In particular, we observe domestic and global uptakes, where the former refers to uptake by an Italian bank and its domestic branches/subsidiaries and the latter refers to the uptake by an Italian bank and its global branches/subsidiaries. We use the domestic perimeter, but our results still hold when using the global perimeter.

(iii) The security dataset is made of (i, j, s, t) observations. We observe every security held by Italian banks at a monthly frequency. We observe whether the security is on- or off- balance sheet. For securities on balance sheet, we can distinguish between pledged and available (not pledged) securities. The former group includes securities pledged with any counterparty in the private market and securities part of the collateral pool at ECB. For securities off balance sheet, we can distinguish between pledged in the private market, pledged at ECB, and available securities. For each security, we also observe whether the issuer is linked with the entity holding the asset.

(iv) The Datastream dataset is made of (s) observations. For each security in the security dataset, we obtain time invariant characteristics from Reuters Datastream. These include amount issued, bond type, coupon rate, coupon type, maturity date, debt seniority, trading exchanges, type of guarantee, issuer, instrument type, borrower country of incorporation, and issuer industry group.

(v) The dataset on usage of the government guaranteed bank bond scheme is made of (j, s, t) observations. We observe bank holdings of self-issued government guaranteed bank bonds at the security level. This information is publicly available on Bloomberg.

(vi) The ECB security eligibility and haircut dataset is made of (s, t) observations. Each observation is a security eligible to be pledged as collateral at ECB. For each security, we know the haircut applied by the central bank. We have the dataset at two dates only: December 31, 2011 and March 1, 2012.

(vii) The Italian Credit Registry (CR) is made of (i, j, t) observations. Each observation is a stock of debt exposure of borrower i vis-a-vis bank j at time t. Intermediaries are required by Law to disclose information on every single client (firm and households) that has a debt exposure above €30,000. The CR is managed by the Bank of Italy which communicates the total debt of each client to intermediaries at a monthly frequency.* The CR aggregates data at the bank-client level. Data is shared monthly by intermediaries to CR. We use data from

*Intermediaries use the CR to better evaluate the creditworthiness of their clients. Bank of Italy uses the CR for its instutional roles, e.g. supervision and policy-making. The CR can be accessed by (i) intermediaries. (ii) judiciary, (iii) individual client concerned, and (iv) Bank of Italy and other regulatory bodies. A detailed, non-translated, dataset description can be found here.

the CR at four dates: September 2010, June 2011, March 2012, and December 2012.

(viii) CEBI-Cerved dataset is at the (i, t) level. The source is Cerved SpA, a company that collects official balance sheet data deposited by firms to the Chambers of Commerce, as required by the Italian Law. Cerved is a member of the European Committee of Central Balance-Sheet Data Offices. The dataset is used in other papers, such as Ippolito et al. (forthcoming).

IA.2 Final Sample

Our final dataset is obtained by merging our eight datasources above. We exclude (i) foreign banks (we do not observe the liquidity injections uptakes), (ii) banks involved during our sample period in extraordinary administration proceedings (their management decision are influenced by judiciary), (iii) cooperative banks (characterized by a different statutory objective and always excluded or treated as a special class of intermediaries by research papers on the Italian banking system), and (iv) non-banks (they mainly lend to financial sector clients).

B Institutional Details

This section documents, in great detail, the institutional setting. In Appendix C.1, we present the Targeted Long Term Refinancing Operations (TLTROs) announced in July 2014. In Appendix C.2, we present (i) the legislative framework behind government guaranteed bonds and (ii) present anecdotal evidence confirming that the scheme was designed to allow banks to expand their eligible collateral in order to access LTRO2.

C.1 Targeted Long Term Refinancing Operation

On June 5, 2014, ECB announces a new type of liquidity injections, the Targeted Long Term Refinancing Operations (TLTROs). The stated goal is to "enhance the functioning of the monetary policy transmission mechanism by supporting lending to the real economy".[†] Compared to the two 3-Year LTRO allotments, the TLTRO consists of a *series* of allotments spanning a two year period. Eurozone intermediaries have an initial limit (initial allowance) of 7% of the total amount of their loans to the euro area non-financial private sector, excluding loans to households for house purchase. The limit on the amount is then gradually relaxed: (i) in the two September 2014 and December 2014 allotments banks can borrow

[†]The official announcement can be found on ECB website.

an amount that cumulatively does not exceed this initial allowance; (ii) during the period from March 2015 to June 2016, intermediaries can borrow additional amounts in a series of quarterly allotments. These additional amounts can cumulatively reach up to three times each counterpartys net lending to the euro area non-financial private sector. All TLTROs will mature in September 2018. The interest rate on the TLTROs will be fixed over the life of each operation at the rate on the Eurosystems main refinancing operations (MROs) prevailing at the time of take-up, plus a fixed spread of 10 basis points. Interest will be paid in arrears when the borrowing is repaid. Starting 24 months after each TLTRO, counterparties will have the option to repay any part of the amounts they were allotted in that TLTRO at a six-monthly frequency.

C.2 Government Guaranteed Bank Bonds (GGBBs)

After the 2008 financial crisis, the European Commission temporarily relaxes the standard restrictions on financial sector government support. As the sovereign crisis deteriorates even further in the summer of 2011, the European Commission extends the temporary framework to allow peripheral Eurozone governments to back their weak domestic banking sectors (see European Commission (2011)). On 6 December, the Italian government implements the European Commission guideline (see Italian Government (2011)) allocating a government budget of million €200 to bank liabilities guarantees for the 2012-2016 period. Under these scheme Italian banks can apply, not later than June 30, 2012, to receive a government guarantee on specific debt instruments (principal and interests).

The guarantee has a maturity between three months and five years (or seven years in the case of covered bonds). The Bank of Italy is in charge of evaluating the capitalization of the applicant bank in order to ensure that the entity is not insolvent. The guarantee is irrevocable, cannot be conditioned on other obligations, and it might be granted only to banks with Italian legal residence. Banks can obtain government guarantees up to what is "necessary to reactivate their medium- and long-term financing capacity". However, individual bank's guarantees cannot exceed the regulatory capital. The Bank of Italy monitors that these limits are respected. After having determined that the issuer eligible to receive the guarantee, the Bank of Italy communicates the positive response to the Italian Treasury. Within five days, the Treasury then confidentially communicates the approval of the guarantee to the bank.

Eligible financial debt instruments must be senior, euro denominated, plain vanilla, and issued after 22 December 2011. The also need to have fixed coupon and a unique principal payment at maturity. For each bank, the share of financial instruments with maturity greater than three years cannot exceed one third of the total nominal value of guaranteed instruments. The bank needs to pay a fee that is the sum of a fixed commission and a variable part based on the riskiness of the issuer. The cost of the guarantee is approximately one percent of the guaranteed amount.

C.2.1 GGBBs and LTRO2: Anecdotal Evidence

In this subsection, we document anecdotal evidence confirming that (i) self-issued government guaranteed bonds were entirely used to tap the second LTRO allotment and (ii) the cost of the guarantee was non negligible implying that only banks with scarce available collateral had the incentive to pay the government guarantee.

Use of Government Guaranteed Bank Bonds UBI Banca, in the 2012 Annual Financial Financial statement documents that "The increase in the assets [eligible at ECB] is the result of a series of actions undertaken in the first quarter of the year (+€13 billion) [...] The principal strategic initiatives implemented during 2012 were the issuance by UBI Banca, of bonds with a government guarantee for a total nominal amount of €6 billion (€5.8 billion net of haircuts) [...]". In its 2012 annual statement, Banco Popolare di Milano states that "the following are the own bonds issued and repurchased as part of the refinancing operations with the European Central Bank [...] and provided as collateral for the advances received from central banks (OMO Open Market Operations): (i)"BPM 23.03.2012-2017 5.90%" bonds guaranteed by the Government, for a nominal value of €0.5 billion; (ii) "BPM 23.03.2012-2015 4.90%" bonds guaranteed by the Government, for a nominal value of €1.0 billion. In its 2012 annual financial statement, Banca Carige states that " assets held to guarantee own liabilities include [...] own debt securities, irrevocably and unconditionally guaranteed by the Italian Government pursuant to Art. 8 of Law Decree 201/2011, amounting to €2,000 million, pledged as a guarantee to the European Central Bank for Long Term Refinancing Operations (LTRO)."

Rationale for the Italian Government GGBBs Law Fitch Ratings (2012) notes that "The Italian government was quick to establish a government-guaranteed bond scheme to enable the banks to create collateral by issuing selfretained bonds. Fitch understands that the LTRO funds to date have been used primarily to replace short-term interbank and institutional funding or wholesale maturities, with very little invested in government debt so far. The Bank of Italy expects the banks to use LTRO funding to sustain loan availability to the real economy. Measures taken by the Italian government and the central bank have enabled the banking sector to increase available ECB-eligible collateral substantially. This additional collateral has eased pressure on funding, which had intensified during Q411. According to the Bank of Italy, at end-January 2012 the Italian banking sector had about EUR150bn unencumbered eligible collateral. The recent decision to allow additional assets (rated loans) as collateral could increase available collateral by about EUR70bn-90bn. This puts the total of potential unutilised available collateral prior to February's LTRO at around EUR250bn." Similarly, Unicredit Credit Research (2014) illustrate that the government law was "carried out in order to stabilize the Italian credit system and to provide Italian banks with state guarantees on their bonds, which could then be posted as ECB collateral for much needed liquidity: 3Y LTROs".

Cost of the Government Guarantee Intesa Sanpaolo, in its 2012Q1 financial statement, reports that "compared to the fourth quarter of 2011, net fee and commission income for the first quarter of 2012 fell slightly by 1.6%, entirely due to the impact of the cost for the government guarantee on the banks bonds [...]." Similarly. in its 2012 annual financial statement, Banco Popolare states that "net fee and commission income was negative, corresponding to €-37.4 million, insofar as it includes the cost of bonds guaranteed by the government". Monte dei Paschi Siena, in its 2012 annual report, states that "net fees and commissions were impacted by the cost of the Government guarantee required to gain access to ECB LTROs, as against a slight growth in retail and corporate components [...] The downtrend as compared to 2011 was mainly accounted for by institutional funding charges (particularly commissions on the Government guarantee required to gain access to ECB LTROs)."