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

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Abstract

We study the effectiveness of central bank liquidity injections in restoring bank credit supply following a wholesale funding dry-up. We combine the Italian credit registry with bank security-level holdings and analyze the transmission of the European Central Bank 3-year Long Term Refinancing Operation. Exploiting a regulatory change that expands the pool of eligible collateral, we show that banks more affected by the dry-up use the central bank liquidity to restore credit supply, while less affected banks to increase their holdings of high-yield government bonds. Unable to completely switch from affected banks during the dry-up, firms benefit from the intervention.

JEL: E50, E58, G21, H63

Keywords: Unconventional Monetary Policy, Bank Credit Supply, Wholesale Funding Markets

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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. 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.[1] Our goal is to narrow this gap 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 restore bank credit supply by lending to banks hit by a shock.[2] 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 dry-ups. Following a dry-up, 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.

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 provision, on Italian bank

[1]The effect of bank funding shocks on credit supply is studied by Khwaja and Mian (2008), Schnabl (2012), Ivashina and Scharfstein (2010), Iyer et al. (2014), and Paravisini (2008). In recent work, Goldstein et al. (2016), Di Maggio et al. (2016), and Darmouni and Rodnyansky (2016) analyze the effect of quantitative easing on credit.

[2]In the U.S., the Term Asset-Backed Securities Loan Facility and the Term Auction Facility helped banks refinance their short-term debt by lending to them. Outside the U.S., The Bank of England Funding for Lending Scheme and the European Central Bank Long Term Refinancing Operations (LTROs/TLTROs) provided long-term funding to banks. The Central Bank of Russia and the People's Bank of China have also recently adopted similar measures.

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 trillion to 800 Eurozone banks with the official goal of "supporting bank lending."[3]

We study the transmission to Italian bank credit supply for two reasons. First, Italian banks are hit by sudden withdrawals in their foreign wholesale funding sources in the six months before the liquidity provision allowing us to study a textbook case of how a negative shock ("dry-up") and a positive shock ("intervention") affect bank credit supply.[4] Second, we take advantage of a unique data set obtained by combining the national credit registry, banks' security-level holdings, and detailed balance sheet characteristics from supervisory and statistical reports submitted to the Bank of Italy. We observe all outstanding loans to firms with a balance above €30,000 and holdings of *all* securities held by banks located in Italy. As Italian and Spanish banks are the largest users of LTRO liquidity, our results also shed light on the effectiveness of this unprecedented operation.

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 data set by selecting firms that borrow from two or more banks and plugging firm fixed effects into our

[3] The official goal was to provide "credit support measures to support bank lending and liquidity in the euro area money market." Source: ECB website.

[4] In the six months preceding the LTRO, from June 2011 to December 2011, we observe a significant contraction of foreign deposits (mainly certificates of deposit and commercial paper held in the U.S.) and Eurozone centrally cleared repurchase agreements (Chernenko and Sunderam (2014), Giannone et al. (2012)).

regressions (Khwaja and 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 June 2011-December 2011 dry-up, as a measure of differential bank exposure to the funding shock and, consequently, to the central bank intervention. The intuition, confirmed by our data, is straightforward. Banks with larger foreign wholesale market exposure are more affected by the dry-up 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 (December 2010 - June 2011) when funding markets are well functioning, (ii) the *dry-up* period (June 2011 - December 2011) when we observe a dry-up in bank foreign wholesale funding, and (iii) the *intervention* period (December 2011 - June 2012) after the central bank steps in providing liquidity to the banking sector.

We find that banks with a large exposure to the foreign wholesale market reduce their credit supply during the dry-up and restore it during the intervention period, compared to banks with a smaller exposure. As the composition of bank funding is not randomly assigned (more exposed banks tend to be larger and more levered in our sample), we saturate our specifications with bank-borrower fixed effects and key time-varying bank balance sheet controls. We then analyze the heterogeneity across firms and banks. In the cross-section of banks, holding the bank exposure to the dry-up constant, we find that high leverage banks drive the increase in credit supply, consistent with the idea that the effect of expansionary monetary policy on bank credit assumes that banks are financially constrained (Kashyap and Stein (1995), Bolton and Freixas (2006)). In the cross-section of firms, we find that banks reduce credit supply especially to risky firms and restore it especially to low profitability and risky firms, consistent with a risk-taking transmission channel (Jimenez et al. (2014), Paligorova and Santos (2013)).

Having documented that the evolution of credit supply depends on bank exposure to the funding dry-up, we then link the actual bank-level central bank liquidity uptakes to credit supply. We observe that the attractive pricing of the LTRO liquidity, together with its long maturity, successfully attract almost all banks to tap the facility, *regardless* of their exposure to the dry-up. In other words, it is not the case that banks that suffer more from the dry-up choose to tap more aggressively the central bank loans. Hence, to confirm our narrative and dissect the transmission channel, we need to reconcile the observations that the funding dry-up is positively correlated with the restoration of credit supply and uncorrelated with bank borrowing at the LTRO.

To this end, we exploit a regulatory intervention by the Italian government that offered banks a government guarantee, against the payment of a fee, on otherwise ineligible securities. As all government guaranteed securities are eligible collateral at the ECB, the program effectively gave banks a technology to manufacture collateral. We show that banks hit by the dry-up, having little collateral left at the time of the LTRO, self-select into the costly government guarantee program to access the ECB liquidity. Consistent with our narrative, we find that bank LTRO borrowing collateralized by government guaranteed securities (approximately half of the total LTRO borrowing) drives the credit supply increase during the intervention period.

On the other hand, banks relatively less exposed to the dry-up use the central bank liquidity to buy high yield securities, mainly in the form of risky (domestic and non-domestic) Eurozone government bonds. These securities are particularly attractive as they offer a high yield and can be pledged at the ECB for new liquidity.[5] We find that banks in our sample, of the €181.5 borrowed at LTRO, invested €22.7 billion in increased private credit supply and €83 billion in government bonds. The effect on credit supply is sizable: in a counterfactual exercise, we find that without the intervention, credit supply would have contracted by −5.6% in the *intervention* period, instead of the observed −3.6%.

Finally, we analyze firm borrowing behavior. Note that, in a frictionless world, firms are not necessarily hit by the credit supply contraction as they are able to switch lenders during bad times so to effectively "undo" the credit crunch. Similarly, in such world, central bank interventions do not necessarily affect credit volumes as firms are not constrained as a result of the credit contraction. We collapse our data set at the firm-level and find that firms are unable to completely substitute missing funds from exposed banks with new credit from non-exposed banks and increase total borrowing after the intervention.[6] Interestingly, risky firms are able to partially smooth the credit crunch by drawing down their credit lines and therefore benefit less from the intervention, consistent with the idea that constrained firms drive runs on bank credit lines following bank negative shocks (Ippolito et al. (forthcoming)).

Contribution to the Literature This paper contributes to two strands of literature. First, we contribute to the literature on the transmission of funding shocks to bank credit supply. Early theoretical work (Bernanke and Blinder (1988), Bernanke and Gertler (1989), Holmstrom and Tirole (1997), 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

[5] Crosignani et al. (2016) analyze bank purchases of securities during the allotment of the LTRO liquidity and find that Portuguese banks bought short-term high-yield government bonds funding their position with the LTRO loans.

[6] Firms might be unable to switch because the capital of unaffected banks is "slow moving" (Duffie and Strulovici (2012)) or because borrowers left looking for a new lender are adversely selected (Darmouni (2016)).

time series (Bernanke and Blinder (1992), Bernanke (1983)) and cross-sectional analysis (Gertler and Gilchrist (1994), Kashyap et al. (1994), Kashyap and Stein (2000), 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), Schnabl (2012)). In line with the most recent literature, our specifications include firm fixed effects to control for borrower observed and unobserved heterogeneity. In this paper, we first confirm that a negative shock causes banks to reduce credit supply and then contribute to the literature by showing how a positive funding shock, namely the central bank liquidity injection, can *restore* bank credit supply, following a bank credit supply contraction.

Following the recent U.S. financial and the Eurozone sovereign debt crises, many researchers have studied the transmission of these asset market disruptions on credit supply through bank balance sheets during these episodes. 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 (2016) 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 (2015), De Marco (2015), Cingano et al. (forthcoming), Bofondi et al. (2013), Acharya et al. (2016a), Bottero et al. (2016), Del Giovane et al. (2013)) almost unanimously confirms the negative spillover.

Second, we contribute the literature on the transmission of monetary policy to credit supply (see Jimenez et al. (2012) and Jimenez et al. (2014) for credit to firms and Agarwal et al. (2016) and Di Maggio et al. (2015) for credit to households). In particular, we analyze unconventional monetary policy (Chodorow-Reich (2014a), Di Maggio et al. (2016), Goldstein et al. (2016), Darmouni and Rodnyansky (2016)) aimed at restoring bank credit supply by lending to banks following a negative shock. 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 following a dry-up. We contribute by showing, in the cross-section of banks, how central bank liquidity is transmitted to increased private credit supply and increased holdings of risky securities, therefore linking the literature on the bank lending channel with the one on the risk-taking channel of monetary policy.

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. (2015), Crosignani et al. (2016), Daetz et al. (2016), Andrade et al. (2015), and Garcia-Posada and Marchetti (2015). The last three papers also study the effect of the 3-year LTRO on bank credit. Compared to these contributions that simply rely on bank endogenous uptakes of liquidity as a source of variation, we better identify the causal effect of the ECB liquidity injection by using banks' exposure to a pre-intervention funding dry-up and a regulatory change by the Italian government. We also contribute by analyzing the joint transmission to bank private credit supply and bank holdings of securities.

The remainder of the paper is structured as follows. In Section 2, we describe the empirical setting, the data set, and provide summary statistics. We analyze the effects of the dry-up and the central bank intervention on bank credit supply in Section 3. In Section 4, we discuss the transmission channel. In Section 5 we check whether firms benefited from the intervention and calculate aggregate effects. Concluding remarks are given in Section 6.

2 Setting and Data

Our laboratory is Italy from December 2010 to June 2012. There are two reasons why we choose Italy during this period to study the effect of central bank liquidity injections on bank credit supply. First, we observe a dry-up in the (foreign) wholesale market in the six months before the LTRO, making the analysis of this intervention a textbook case of central bank liquidity provision following a negative shock. Second, we exploit a regulatory intervention by the Italian government to dissect the transmission channel. Moreover, as Italian (and Spanish) banks are the largest LTRO users and Italian firms are heavily dependent on bank credit, our results shed light on the effectiveness of this unprecedented intervention. [7]

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 "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 peripheral countries like Greece, Italy, Ireland, Portugal, and Spain.

The crisis in Italy starts is 2009 and can be divided in two periods. During the first period, from 2009 to mid-2011, the Italian government bond prices fell by about 25% while sovereign CDS spreads doubled to reach approximately 200 bps as investors became progressively concerned that the crisis affecting Greece and Portugal was going to spread to Italy. Political uncertainty, large government debt, and the long-standing slack in GDP growth made, and still make, Italy very vulnerable to shocks. Investors' concerns materialized 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.

During the second period, from June 2011 to December 2011, investors suddenly started demanding very large risk premia and sovereign CDS spreads and bond yields started increasing very

[7] LTRO loans extended to Italian banks constitute 26% of total LTRO loans, just below Spanish banks. In the Online Appendix, we show LTRO uptakes by country. To get a sense of the magnitude, consider that the Italian share of capital at the ECB was 12.3% as of 1 January 2013. Other big contributions come from Deutsche Bundesbank (18%), Banque de France (14.2%), and Banco de Espana (8.8%).

sharply to reach a record high in November 2011.[8] As concerns about solvency of the sovereign and its financial sector mounted, Italian banks experienced a dry-up of their wholesale funding, driven by withdrawals of foreign investors. In the next subsection, we illustrate this dry-up, also called "quiet run" by Chernenko and Sunderam (2014).

2.2 Bank Funding During the Crisis

The structure of the funding of Italian banks has changed significantly since the beginning of the crisis in 2008. As overall funding shrank, the composition underwent large variation. During the first phase, from 2008 to June 2011, the fraction of retail funding slightly increased, whereas wholesale funding dropped by 3 percentage points to 33%. Central bank refinancing partially substituted for this drop, reaching 2% of total funding.

During the second phase, from June to December 2011, wholesale funding declined 5 percentage points, to 28% of total funding. This drain in funds was offset by central bank refinancing which, at the end of 2011, represented 9% of total funds. The drastic decline in wholesale funds was driven by a sharp reduction in *foreign* funding, mainly caused by sudden drops in certificate of deposits and commercial paper held by US money market funds and Eurozone centrally cleared repurchase agreements. In Figure 1, we illustrate the drop in wholesale funding, driven by foreign withdrawals, between June 2011 and December 2011. In December 2011, the ECB announces its 3-Year Long

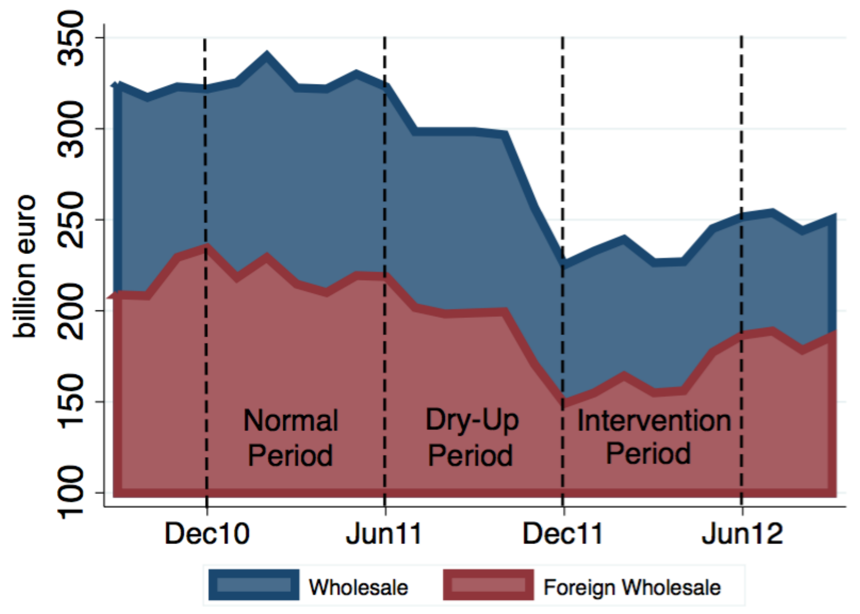

Figure 1: Foreign Wholesale Funding Dry-Up. This plot shows the total wholesale market funding and the foreign wholesale market funding of Italian banks in our sample. Quantities are in billion €.

Term Refinancing Operation.[9]

The ECB started providing extraordinary liquidity to banks in October 2008, as it 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. The ECB applies a haircut that depends on the asset class, residual maturity, rating, and 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.[10]

[8]Greece was downgraded five times by the three main credit rating agencies in June and July of 2011. As documented in Bofondi et al. (2013), sovereign yields then abruptly rose in Italy too, as investors feared that Italy might have also been unable to repay its public debt. With sovereign yields rising, the support for the Italian government fell, forcing Prime Minister Silvio Berlusconi to resign in favor of the technocratic government led by Mario Monti. In Figure B.1 in the Appendix, we show the time series evolution of various macroeconomic variables around this time.

[9]In Figure B.2 in the Appendix, we illustrate the time series evolution of household deposits, interbank funding, and borrowing from the ECB. The foreign wholesale dry-up is also described by Giannone et al. (2012), Chernenko and Sunderam (2014), and Bank of Italy (2011).

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

The LTRO On December 8, 2011, the ECB increased its support to the Eurozone banking sector even further, announcing the provision of two 3-year maturity loans, the 3-year Long Term Refinancing Operation (LTRO), 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". The distinctive feature of the LTRO, compared to pre-existing liquidity facilities, is the long 3-year maturity. Interest rate and haircut did not change compared to previous standing operations.[11] Banks had the option to repay the ECB loans early, after one year.

Note that, in a frictionless world with no uncertainty, LTRO is a redundant tool and should not attract banks as they would be indifferent between borrowing at the central bank at a three-year horizon and borrowing at the central bank, say, at a two-week maturity and then rolling over bi-weekly for three years. However, 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 the ECB liquidity provision.[12]

2.3 Data

In this section, we describe the data set construction and empirical work. For greater detail, the reader is referred to the Online Appendix. The unit of observation is at the (i, j, s, t) level, where

[11] The interest rate on the two LTRO loans is the average rate of the main refinancing operations over the life of the operation, to be neutral compared to pre-existing shorter term loans. In addition, no major changes were made on the haircuts or eligibility collateral securities, with the exception of certain asset-backed securities. In December 2011, the ECB starts in fact accepting ABS having a second best rating of at least "single A". The ECB also allowed national central banks to temporary accept additional bank loans (additional credit claims) in addition to those eligible before the intervention, but this change was implemented only in July 2013 by the Bank of Italy.

[12] More specifically, there was uncertainty on whether the full allotment procedure would have been in place during the three years of the LTRO. Crucially, LTRO was not protecting banks against changes of collateral eligibility or haircuts, as the central bank makes margin calls, if the value of collateral drops (or the haircuts increases) during the loan period. Marketable assets used as collateral are marked to market daily.

$i \in \mathcal{I}$ 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, consolidated at the national level.

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

Second, at the (j, t) bank-period level, we observe standard balance sheet characteristics, detailed funding sources, 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 isolate banks' LTRO uptakes at both LTRO allotments.

Third, at the (s, j, t) security-bank-period level, we observe, from the Supervisory and Statistical Reports, holdings of each marketable security held by Italian banks. A typical observation is "holdings by bank j of security ISIN 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, 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 official firm balance sheet data deposited to the Chambers of Commerce (Cebi-Cerved database). We lose approximately 45% of observations

Bank-Level		Jun10	Dec10	Jun11	Dec11	Jun12	Dec12
Size	€billions	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 Borrowing	%Assets	0.8%	2.0%	2.3%	5.7%	11.2%	11.0%
Household Deposits	%Assets	29.5%	29.6%	29.4%	30.0%	32.5%	35.9%
Interbank Borrowing	%Assets	4.0%	4.0%	4.2%	5.2%	4.4%	3.9%

Bank-Firm Level	Loan Type	Dec10-Jun11	Jun11-Dec11	Dec11-Jun12
Δln(Total Credit Drawn)	All Types	6.2%	-2.1%	-3.1%
Δln(Total Credit Granted)	All Types	4.7%	-2.2%	-3.6%
Δln(Total Credit Drawn)	Revolving Credit Lines Only	8.7%	-1.6%	-1.6%
Δln(Total Credit Granted)	Revolving Credit Lines Only	4.0%	-0.5%	-3.5%

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) December 2010 - June 2011 period, (ii) June 2011 - December 2011 period, and (iii) the December 2011 - June 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 the Online Appendix, we provide additional summary statistics.

by merging firm-level characteristics with our bank-firm observations.

Our final data set is obtained by merging all our data sources. 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 the ECB through the Bank of Italy and not their overall ECB borrowing, 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. Third, our final sample does not include 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 73 banks.

In Table 1, we show, 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 June 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 drawn is defined as the sum of term loans, credit drawn from revolving credit lines, and loans backed by account receivables. Granted credit is defined as the sum of term loans and credit *committed* from revolving credit lines and loans backed by account receivables. Changes in both credit granted and drawn are negative and large after June 2011, when Italian banks are hit by the foreign wholesale market dry-up.

3 Effect on Bank Credit Supply

Our strategy to estimate the causal effect of the central bank liquidity injection on bank credit supply follows two steps. First, in this section, we show that banks more exposed to the foreign wholesale market dry-up reduce credit supply during the dry-up and restore credit supply after the central bank steps in providing liquidity to banks. Second, in Section 4, we take advantage of a regulatory change to the definition of ECB eligible collateral to link the actual bank-level uptakes of central bank liquidity to bank credit supply after the intervention.

3.1 Identification Strategy

Before discussing the identification strategy, we illustrate the experiment that we would ideally design to answer our research question. In this setting, we would make the firm-bank match random and also randomly assign central bank liquidity to banks. Using the heterogeneity of ECB liquidity injections as a source of variation, we would be able to estimate the *causal* impact of the central bank liquidity provision on bank credit supply. The effect on bank credit would be fully attributable to a change in supply as borrowers' characteristics would be uncorrelated with liquidity injections. In other words, it would not be the case that borrowers matched with banks that receive large liquidity injections *demand* more/less credit compared to borrowers matched with banks that receive smaller liquidity injections. Moreover, as the liquidity injection is randomly assigned to banks, it would not be the case that some types of banks (e.g., larger or more levered) systematically obtain more central bank funding. Unfortunately, as these two conditions are not satisfied in our setting, we face two empirical challenges.

First, the stock of credit that firm i obtains from bank j at time t is an equilibrium quantity, resulting from both bank supply and firm demand for credit. 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)).[13] Using this sample, we can fully control for firm observed and unobserved characteristics using firm fixed effects. In other words, we can compare how the same firm's loan growth from one affected

[13] 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.

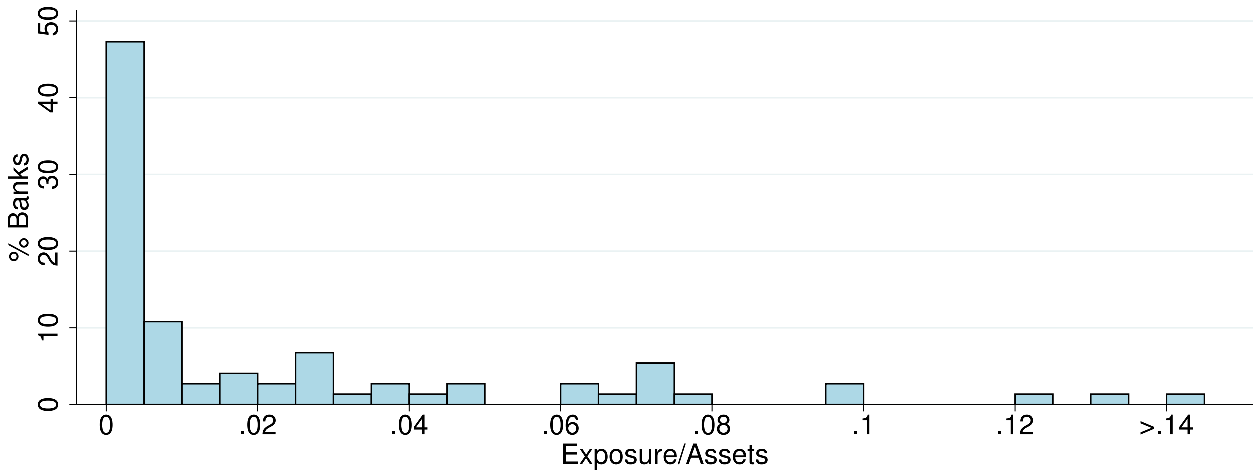

Figure 2: June 2011 Foreign Wholesale Market Exposure. This histogram shows bank-level exposure to the foreign wholesale market dry-up in June 2011. The y-axis is the share of sample banks in percentages. The exposure is defined as the sum of bank exposures to foreign deposits (e.g., commercial paper and certificates of deposit held by U.S. money market funds) and centrally (Eurozone) cleared repurchase agreements, divided by total assets in June 2011.

bank changes relative to the loan growth from another less affected bank.

Second, the uptakes of the ECB liquidity are not randomly assigned to banks. Banks can *choose* the amount of cash loans they want to obtain 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.[14] We use banks' reliance on the foreign wholesale funding in June 2011 as a measure of differential bank exposure to (i) the June 2011-December 2011 dry-up and, consequently, (ii) the central bank intervention. The intuition, confirmed by our data, is straightforward. Banks with larger exposure to foreign wholesale funding are more affected by the dry-up and are therefore more likely to benefit from the ECB intervention.[15] In Section 4, we link the actual bank-level liquidity uptakes to the wholesale market dry-up.

[14] Compared to existing papers on the transmission of LTRO that use banks' uptakes as a source of variation (Andrade et al. (2015), Daetz et al. (2016), Garcia-Posada and Marchetti (2015)), our identification strategy allows us to better identify the causal effect of central bank liquidity on credit and discuss the transmission channels.

[15] 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 type of variation to capture *both* the funding contraction and the central bank funding expansion following the LTRO. In Table C.1 and Table C.2 in the Appendix, we show that the exposure to the foreign wholesale market explains the dry-up (both in total wholesale funding and in foreign wholesale funding), controlling for several bank balance sheet characteristics.

		Exposed Banks	Non-exposed Banks	Normalized Difference
Size	€billions	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 Borrowing	%Assets	3.16%	1.38%	2.27
Household Deposits	% Assets	24.7%	37.0%	-4.00
Interbank Borrowing	% 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. In the Online Appendix, we replicate this table with subsamples based on quartiles.

We define the pre-dry-up exposure as the foreign wholesale funding normalized total assets in June 2011. Foreign wholesale funding consists of foreign deposits (mainly commercial paper and certificates of deposit held by U.S. money market funds) and Eurozone centrally cleared repurchase agreements. In Figure 2, we show the distribution of banks' pre-dry-up exposure to the foreign wholesale market in June 2011. Approximately 58% of the banks in our sample have a very small exposure, below 1%. However, banks with exposure above 5% are quantitatively important as they hold 75% of total bank credit to firms in our sample.[16]

Of course, banks' funding mix in June 2011 is correlated with other banks' observable and unobservable characteristics. In Table 2, we show bank summary statistics for the two subsamples of "exposed" and "non-exposed" banks, defined according to their exposure to the foreign wholesale

[16] The 10th, 30th, 50th, 70th, 90th percentiles of the distribution of the exposure variable across banks are 0.00%, 0.11%, 0.75%, 2.74%, and 7.57%, respectively. In Figure B.3 in the Appendix, we show the correlation between bank exposure to the foreign wholesale market dry-up in June 2011 and bank total credit to firms.

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 wholesale markets and 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 household deposit base.[17] As it will become clear from our main specification, we tackle the potential omitted variable bias originating from these differences in observables by saturating our regressions with banks' balance sheet controls, as well as stringent fixed effects.

Our choice to use banks' exposure to the (foreign) wholesale funding as a source of heterogeneity (as in Iyer et al. (2014)) also closely follows the theory of wholesale market dry-ups. Dry-ups are the result of asymmetric information as borrowers know more of their financial health compared to lenders. In an economy with only uninformed lenders, following a shock, these become concerned about the quality of borrowers and interest rates go up for *all* borrowers. High-quality borrowers then self-select out of the market causing uninformed lenders to stop lending to all banks (Akerlof (1970)). However, in case there are some informed lenders in the economy, these will stop lending to low-quality banks (Gorton and Pennacchi (1990), Calomiris and Kahn (1991), Dang et al. (2012)), while uninformed lenders stop lending to all banks. Our bank balance sheet controls are therefore key to control for the potential selective withdrawals of informed lenders from weaker banks.[18]

Following the timing highlighted in Figure 1, we compare three periods: (i) the *normal* period from December 2010 to June 2011 when funding markets are well functioning; (ii) the *dry-up* period

[17] In Table C.3 in the Appendix, we show the time series evolution of balance sheet summary statistics for exposed and non-exposed banks.

[18] Perignon et al. (2016) show that in the European market during the period from 2008 to 2014 wholesale market dry-ups are consistent with theories featuring informed and uninformed lenders reacting to a deterioration in the quality of borrowers.

from June 2011 to December 2011 when we observe a dry-up in the foreign wholesale market; and (iii) the *intervention* period from December 2011 to June 2012.[19] In the next subsection, we illustrate the three-period difference-in-difference specification we adopt to (i) compare the stock of credit granted by firm i to bank j in the *dry-up* period to the same (i, j) stock of credit in the *normal* period and (ii) compare the stock of credit granted by firm i to bank j in the *intervention* period to the same (i, j) stock of credit in the *dry-up* period.

3.2 Intensive Margin

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

$$\Delta Log(Credit_{ijt}) = \alpha + \beta_1 Exposure_j \times \mathbb{I}_{Dry-up} + \beta_2 Exposure_j \times \mathbb{I}_{Interv} + \mu_{it} + \gamma_{ij} + \phi' X_{ijt} + \epsilon_{ijt} \quad (1)$$

where $\mathbb{I}_{Dry-up}$ is a dummy equal to one during the *dry-up* and the *intervention* periods and $\mathbb{I}_{Interv}$ is a dummy equal to one in the *intervention* period. Observations are at the (i, j, t) borrower-bank-period level. We use the four dates that delimit the *normal*, the *dry-up*, and the *intervention* periods, namely December 2010, June 2011, December 2011, and June 2012. The dependent variable is the change in log (stock of) credit granted by bank j to borrower i at time t.[20] $Exposure_j$ is bank j exposure to the foreign wholesale market in June 2011. We add bank-firm fixed effects to absorb

[19]We decide to end the sample in June 2012 in order to not overlap with the July 2012 Draghi OMT announcement, also known as "whatever it takes" speech, that caused large market-to-market gains on bank holdings of government bonds and other risky securities (see Acharya et al. (2016b)).

[20]Credit granted and total credit are not necessarily equivalent for revolving credit lines as the former is the total amount *committed* on the credit line. As the amount drawn from a credit line is likely driven by firm demand, we choose to use credit granted as our dependent variable.

any bank-firm time-invariant characteristics, including any time-invariant bank characteristic. We also plug firm-time fixed effects to control for both observable and unobservable firm heterogeneity, crucially capturing firm demand for credit at time t.

Finally, we add time-varying borrower-bank relationship variables, in the vector X_{ijt}, 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 (measuring the strength of the relationship), (ii) the ratio of drawn credit over committed credit (measuring how close firm i is from exhausting its borrowing capacity from bank j), and (iii) the share of overdraft credit by borrower i with respect to bank j (measuring the extent of an eventual over-borrowing).

Intuitively, as in a standard difference-in-difference setting, the coefficient β_1 captures the difference in credit growth for more exposed banks during the *dry-up* relative to less exposed banks during the *normal* period. Similarly, the coefficient β_2 captures the difference in credit growth for more exposed banks during the *intervention* period relative to less exposed banks during the *dry-up* period.[21] We rely on two identification assumptions: (i) exposed banks would have behaved like non-exposed banks during the *dry-up* period in the absence of the dry-up 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 key balance sheet characteristics *interacted* with the two time dummies. These characteristics are leverage, tier 1 ratio, non-performing loans normalized by total assets, and a dummy equal to one if a bank belongs to the largest banking groups (assets above €500 billion).

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

	$\Delta CREDIT$ (Granted)					
	(1)	(2)	(3)	(4)	(5)	(6)
$Exposure_{Jun11} \times \mathbb{I}_{Dry-up}$	-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)
$LEV_{Jun11} \times \mathbb{I}_{Dry-up}$						0.141
						(0.207)
$LEV_{Jun11} \times \mathbb{I}_{Interv}$						0.244
						(0.158)
$ROA_{Jun11} \times \mathbb{I}_{Dry-up}$						-0.038*
						(0.020)
$ROA_{Jun11} \times \mathbb{I}_{Interv}$						0.027
						(0.044)
$T1R_{Jun11} \times \mathbb{I}_{Dry-up}$						0.396**
						(0.155)
$T1R_{Jun11} \times \mathbb{I}_{Interv}$						0.362***
						(0.127)
$NPL_{Jun11} \times \mathbb{I}_{Dry-up}$						-0.321*
						(0.185)
$NPL_{Jun11} \times \mathbb{I}_{Interv}$						0.222**
						(0.101)
$Large \times \mathbb{I}_{Dry-up}$						-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. $\mathbb{I}_{Dry-up}$ is a dummy equal to one in the *dry-up* 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 *dry-up* 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. Standard errors double clustered at the bank and firm level are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

In Table 3, we show estimation results, progressively saturating our specification with fixed effects and controls. In columns (1) and (2), we just include time and bank fixed effects, but no firm-time fixed effects, hence not controlling for credit demand. The sample is the only difference between the two columns as column (1) covers the full sample and column (2) only includes firms that have multiple relationships. In column (3), we substitute time fixed effects with firm-time fixed effects in order to control for firm credit demand. These estimation results show a negative significant effect of the dry-up on bank credit supply and a positive significant effect of the intervention on bank credit supply. Note that results are basically unchanged when we include firm-time fixed effects, suggesting that firm borrowing from more exposed banks are not demanding less credit in the dry-up period and more credit during the intervention period. In other words, firm demand and the endogenous bank-firm matching do not seem to be major identification concerns in this setting.

In column (4), we augment the specification with the three relationship control variables to account for any time-varying bank-firm characteristics. The two coefficients of interest are stable and the coefficients on the relationship controls show that banks in this period tend to reduce credit supply to the clients they are most exposed to. In column (5) we substitute bank fixed effects with the more stringent bank-firm fixed effects so to exploit the variation within the same firm-bank pair over time, thereby controlling for any time invariant relationship characteristics. Affected banks' credit supply contraction during the dry-up relative to unaffected banks is then offset by an approximately equivalent increase during the intervention period.[22]

[22]When bank-firm fixed effects are included, the number of observations shrinks from 2.32 million to 2.17 million, approximately. With bank fixed effects, the sample includes firms that have multiple credit relationships at each date t. With bank-firm fixed effects, the sample includes only observations about the same bank-firm relationship through time.

In column (6), we saturate the specification with June 2011 bank-balance sheet characteristics *interacted* with the two time dummies. We find that, during the dry-up, credit granted by banks with high exposure to the dry-up (top decile of the exposure distribution) grew by about one percentage point less than credit granted by banks with low exposure to the dry-up (bottom decile of the exposure distribution). On the other hand, during the intervention period, we observe a credit supply expansion by high exposure banks that undoes the credit contraction during the dry-up period. In Section 5.2, we aggregate up these within firm-bank estimation results to obtain aggregate effects. Moreover, we find that, during the dry-up, banks with low regulatory capital and high non performing loans reduce credit supply compared to other banks. During the intervention, banks with high non performing loans on balance sheet increase their credit supply compared to banks with less non-performing loans, suggesting that the intervention might have helped also low-quality banks that suffered withdrawals from informed lenders during the dry-up.

3.3 Credit Supply Across Banks

We next examine whether the effect of the exposure to the foreign wholesale market on credit supply varies across bank fundamentals. As anticipated, the foreign wholesale market dry-up and the central bank liquidity provision are unlikely to have hit all banks equally. We should therefore expect the effect on credit supply to vary across banks.

To answer this question, we interact again our two key independent variables with bank balance sheet characteristics, measured in June 2011. For example, we interact the two difference-in-difference regressors with leverage to check whether high leverage banks reduced credit supply to their client more compared to low leverage banks during the dry-up and, similarly, to check whether high leverage banks restored credit supply to their client more compared to low leverage banks during the intervention periods.

	$\Delta CREDIT$ (Granted)					
	(1)	(2)	(3)	(4)	(5)	(6)
$Exposure_{Jun11} \times \mathbb{I}_{Dry-up} \times LEV_{Jun11}$		0.039				
		(0.042)				
$Exposure_{Jun11} \times \mathbb{I}_{Interv} \times LEV_{Jun11}$		0.088***				
		(0.027)				
$Exposure_{Jun11} \times \mathbb{I}_{Dry-up} \times ROA_{Jun11}$			2.853***			
			(1.073)			
$Exposure_{Jun11} \times \mathbb{I}_{Interv} \times ROA_{Jun11}$			-2.056			
			(1.626)			
$Exposure_{Jun11} \times \mathbb{I}_{Dry-up} \times T1R_{Jun11}$				-0.014		
				(0.046)		
$Exposure_{Jun11} \times \mathbb{I}_{Interv} \times T1R_{Jun11}$				0.030		
				(0.064)		
$Exposure_{Jun11} \times \mathbb{I}_{Dry-up} \times NPL_{Jun11}$					-0.078***	
					(0.027)	
$Exposure_{Jun11} \times \mathbb{I}_{Interv} \times NPL_{Jun11}$					0.038	
					(0.040)	
$Exposure_{Jun11} \times \mathbb{I}_{Dry-up} \times Large$						-0.523
						(0.323)
$Exposure_{Jun11} \times \mathbb{I}_{Interv} \times Large$						0.799
						(0.745)
$Exposure_{Jun11} \times \mathbb{I}_{Dry-up}$	-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)
$\mathbb{I}_{Dry-up} \times LEV_{Jun11}$	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)
$\mathbb{I}_{Dry-up} \times ROA_{Jun11}$	-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)
$\mathbb{I}_{Dry-up} \times T1R_{Jun11}$	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)
$\mathbb{I}_{Dry-up} \times NPL_{Jun11}$	-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)
$\mathbb{I}_{Dry-up} \times Large$	-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 4: 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. $\mathbb{I}_{Dry-up}$ is a dummy equal to one in the *dry-up* 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 *dry-up* 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.

We show the estimation results in Table 4. In column (1), we report the estimation results of our most conservative baseline specification that we then augment with triple interactions in columns (2)-(6). During the dry-up, less profitable banks and banks with larger holdings of non-performing loans reduced credit supply more compared to relatively healthier banks. During the intervention period, high leverage banks increased credit supply more compared to low leverage banks. The evidence suggests that, holding constant the negative shock of the dry-up, high leverage and low profitability banks reduce credit supply more aggressively compared to relatively more solid banks. Once the central bank steps in providing liquidity to banks, high leverage institutions drive the restoration of credit supply.

These findings are consistent with the literature showing the the transmission of monetary policy is driven by financially constrained institutions Kashyap and Stein (1995) and that bank lending is usually constrained by capital adequacy requirements, rather than through changes in bank liquidity (Bolton and Freixas (2006)).

3.4 Credit Supply Across Firms

We now examine to which firms bank reduce credit during the *dry-up* period and restore credit during the *intervention* period the most. To this end, we use exploit firm-level information on profitability (EBITDA), size, leverage, and credit risk (Z-score). We re-run our most conservative baseline specification (column (6) in Table 3), interacting our two key independent variables with firm characteristics, measured in December 2010.[23]

[23] We lose 45% of observations by merging the firm-level data set with our bank-firm observations. However, we can still count on more than a million observations at any given date. As firm-level characteristics are available at annual frequency, we choose to use characteristics measured December 2010 (last observation before the dry-up). In Table C.4 in the Appendix, we present firm summary statistics.

	$\Delta CREDIT$ (Granted)				
	(1)	(2)	(3)	(4)	(5)
$Exposure_{Jun11} \times \mathbb{I}_{Dry-up}$	-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)
$Exposure_{Jun11} \times \mathbb{I}_{Dry-up} \times FirmSize_{2010}$		-0.000			
		(0.019)			
$Exposure_{Jun11} \times \mathbb{I}_{Interv} \times FirmSize_{2010}$		0.036***			
		(0.011)			
$Exposure_{Jun11} \times \mathbb{I}_{Dry-up} \times FirmProfitability_{2010}$			0.058		
			(0.202)		
$Exposure_{Jun11} \times \mathbb{I}_{Interv} \times FirmProfitability_{2010}$			-0.339***		
			(0.112)		
$Exposure_{Jun11} \times \mathbb{I}_{Dry-up} \times FirmLeverage_{2010}$				-0.018	
				(0.024)	
$Exposure_{Jun11} \times \mathbb{I}_{Interv} \times FirmLeverage_{2010}$				0.012	
				(0.036)	
$Exposure_{Jun11} \times \mathbb{I}_{Dry-up} \times FirmRisky_{2010}$					-0.055**
					(0.027)
$Exposure_{Jun11} \times \mathbb{I}_{Interv} \times FirmRisky_{2010}$					0.072***
					(0.026)
Firm-Time FE	✓	✓	✓	✓	✓
Bank-Firm FE	✓	✓	✓	✓	✓
Bank Controls (interacted with time dummies)	✓	✓	✓	✓	✓
Relationship 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 5: 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. $\mathbb{I}_{Dry-up}$ is a dummy equal to one in the *dry-up* 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 *dry-up* period runs from June 2011 to December 2011. The *intervention* period runs from December 2011 to June 2012. The regression includes time-varying relationship controls (the share of total firm i credit coming from bank j, the ratio of drawn credit over committed credit, and the share of overdraft credit by borrower i with respect to bank j), bank characteristics in June 2011 (leverage, return on assets, tier 1 ratio, non-performing loans divided by total asset, and a dummy equal to one if the bank has assets above €500 billion), interacted with the two time dummies. Firm characteristics are measured in December 2010 and defined as follows: $FirmSize$ is log of total assets; $FirmProfitability$ is EBITDA; $FirmLeverage$ is firm leverage; $FirmRisky$ 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.

We show the estimation results in Table 5. Again, we report our baseline specification in column (1), as a reference. In columns (2)-(5), we include triple interaction terms. For example, in column (2) we show how the effect of the dry-up and the intervention on credit supply changes depending on firm size, where the variable $FirmSize$ is the log of firm total assets in December 2010. Similarly, the last three columns include triple interactions with firm profitability, firm leverage, and firm riskiness. Note that the firm-bank and the time-firm double interactions are absorbed by the fixed effects.

We find that the effect of the dry-up is stable across different firm characteristics, with the exception of risky clients, to which affected banks reduce credit supply more compared to less risky clients. However, during the *intervention* period, banks with high exposure to the dry-up increase their credit supply, compared to banks with low exposure, especially to large, low profitability, and risky firms, compared to the dry-up period.

The evidence is consistent with the recent literature on the risk-taking channel of monetary policy showing that a lower overnight interest rate induces lowly capitalized banks to grant more loan applications to ex-ante risky firms (Jimenez et al. (2014)), loan spreads for riskier firms become lower during period of monetary easing compare to tightening (Paligorova and Santos (2013)), and a decline in foreign monetary policy rates and an expansion in QE lead to higher credit supply for borrowers with higher ex-ante loan rates, with substantial higher ex-post loan defaults (Morais et al. (2015)).

4 Transmission Channel

In the previous section, we document that banks more exposed to the foreign wholesale market reduce credit supply during the dry-up and restore credit supply after the central bank intervention, compared to less exposed banks. In this section, we link the actual bank-level central bank liquidity injections to the restoration of credit supply and discuss the transmission channel.

4.1 Central Bank Liquidity Uptakes

The LTRO intervention successfully attracted many banks. In our sample, 69 banks tap this facility obtaining €181.5 billion, consisting of a €88.4 billion uptake at LTRO1 and a €93.1 billion uptake

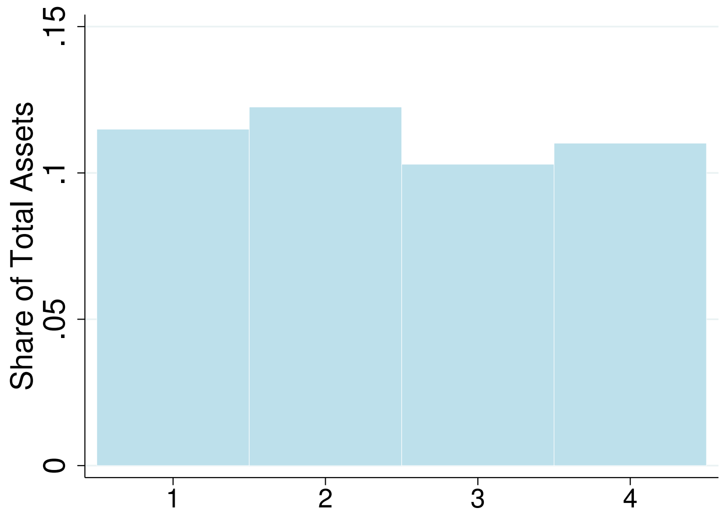

Figure 3: LTRO Uptakes and Bank Exposure to the Dry-up. This histogram shows, for each dry-up exposure quartile, mean LTRO uptakes, normalized by assets in June 2011. Banks are divided in quartiles according to their exposure to the foreign wholesale market in June 2011.

at LTRO2. It is an economically large quantity as the median uptake is 9.7% of total assets.[24] Banks' large uptakes are perhaps not surprising. LTRO was an opportunity not to miss for banks, as the ECB provided long-term liquidity at more favorable terms compared to the private market. The combination of haircut and interest rate was in fact, in peripheral countries like Italy, generally more attractive compared to prices in the private markets.[25]

Interestingly, there is little heterogeneity in banks' uptakes of the ECB liquidity: banks tap approximately liquidity for 10% of total assets, *regardless* of their exposure to the dry-up. In other words, it is not the case that banks that reduce credit during the dry-up period are also those tapping the liquidity facility the most. In Figure 3, we divide banks, on the x-axis, in quartiles

[24] The average is 10.9% of total assets. Banks' enthusiasm in tapping LTRO is also confirmed by the observation that 47 out of the 48 sample banks that are usually counterparty of the ECB open market operations tap LTRO. For summary statistics of LTRO borrowing by all banks operating in Italy, see Bank of Italy (2012). We provide additional summary statistics of bank borrowing at LTRO in Table C.5 in the Appendix.

[25] Consistent with the observation that the ECB liquidity provision to banks was subsidized in the Eurozone periphery, approximately two thirds of the total LTRO liquidity was allotted to Italian and Spanish banks. Banks located in core Eurozone countries could in fact, in general, obtain cheaper funding in the private markets. See Drechsler et al. (2016) for a discussion of the ECB subsidy.

according to their exposure to the foreign wholesale market in June 2011. Each bar illustrates, for each quartile, total LTRO uptakes normalized by total assets, showing that bank exposure to the dry-up and LTRO uptakes are uncorrelated.

This observation poses an identification challenge as it is not possible to use the exposure to the dry-up as an instrument for the LTRO uptakes. Moreover, this finding raises the possibility that the effect on bank credit supply is unrelated to the central bank liquidity provision.

4.2 Identification Strategy

We now reconcile the observation that banks with high exposure to the dry-up restored credit supply after the intervention with the observation that basically every bank took advantage of the cheap (with respect to the private market) ECB liquidity. To this end, we exploit a regulatory intervention by the Italian government, together with data on bank-level collateral pledged at ECB, to trace the effect of ECB liquidity on bank credit supply.

The government intervention was aimed at increasing the stock of central bank eligible collateral on banks' balance sheets. The ECB accepts any security that is guaranteed by national governments as collateral. On December 22, 2011, the day after the first LTRO allotment, the Italian government announced that banks could obtain a guarantee from the national Treasury, paying a fee, on otherwise ineligible securities. Once these securities received the government guarantee, they automatically became eligible collateral at the central bank.[26] In other words, the government guar-

[26] Banks could obtain the state guarantee on zero coupon, senior, unsecured, euro-denominated bonds that are otherwise (without the state guarantee) non-eligible at the ECB. 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 the 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) so that they become eligible to be pledged at LTRO2. In the Online Appendix, we provide a detailed description of the government scheme, as well as anecdotal evidence on its rationale and usage by banks.

antee program gave banks access to a costly technology to create eligible collateral. In the period before the second LTRO allotment, banks used the government program creating haircut-adjusted collateral worth €102.8 billion. Using our security-level data set, we confirm that these government guaranteed securities are used as collateral at the ECB at LTRO2 at the end of February.

The government program, explicitly motivated with the need of helping banks with scarce collateral access the ECB liquidity, was mainly used by banks hit by the dry-up.[27] More formally, we check whether this observation is robust by running, in the sample of banks that borrow at ECB before the LTRO, the following simple cross-sectional regression:

$$\Delta Uptake_j = \alpha + \beta Exposure_{j,Jun11} + \mu X_{j,Jun11} + \epsilon_{jt} \tag{2}$$

where $Uptake$ is bank LTRO uptakes normalized by total assets. The independent variables are the exposure to the dry-up and bank characteristics measured in June 2011 (vector X).

We show estimation results in Table 6. In column (1), the dependent variable is *total* borrowing at LTRO. Consistent with the non-parametric observation shown in Figure 3, we confirm that bank exposure to the dry-up is uncorrelated with the uptake of ECB liquidity, even after controlling for bank balance sheet characteristics. In column (2), the dependent variable is the portion of LTRO uptake backed by the government guarantee program, which amounts to 57% of total central bank borrowing at LTRO. The estimation result shows that bank borrowing at LTRO backed by collateral guaranteed by the Treasury is positively correlated with the exposure to the dry-up.

Our interpretation of the results is intuitive. During the dry-up, between June 2011 and Decem-

[27] For example, government guaranteed collateral backs 68% of central bank liquidity for banks in the top quartile of exposure to the dry-up, while the same collateral backs only 17% of of central bank liquidity for banks in the bottom quartile.

	$TotalUptake$	$Uptake^{GovtCollateral}$
$Exposure_{Jun11}$	-0.164	0.236**
	(0.197)	(0.101)
LEV_{Jun11}	0.901***	-0.000
	(0.284)	(0.146)
ROA_{Jun11}	0.093**	-0.024
	(0.041)	(0.021)
$T1R_{Jun11}$	0.636***	-0.191*
	(0.220)	(0.113)
NPL_{Jun11}	0.071	0.066
	(0.247)	(0.127)
$Large_{Jun11}$	-7.628*	0.042
	(4.312)	(2.215)
Observations	48	48
R-squared	0.395	0.228

Table 6: Bank Use of the Government Guarantee Program. This table presents the results from specification (2). The dependent variable in column (1) is total LTRO uptake. The dependent variable in column (2) is the LTRO uptake backed by government guarantee program. Independent variables are exposure to the foreign wholesale market, leverage, return on assets, tier 1 ratio, non-performing loans normalized by total assets, and a dummy equal to one if a bank belongs to a banking group with assets greater than €500. Sample banks have non-zero borrowing at ECB before LTRO1. All variables are measured in June 2011. *** p<0.01, ** p<0.05, * p<0.1.

ber 2011, we observe that banks more affected by the funding contraction eroded their available collateral, by either pledging it in the private market or at the central bank to obtain short-term funding. At the time of the LTRO announcement in December 2011, these exposed banks had in fact available collateral to borrow a maximum of 2.8% of total assets at LTRO. On the other hand, the relative unaffected banks had a borrowing capacity of 6.3% of total assets.[28] The Italian government intervened effectively giving banks access to a technology to create eligible collateral, paying a fee to the Treasury. On the one hand, banks hit by the dry-up had scarce collateral on balance sheet and were then willing to pay the government guarantee fee to access LTRO funds. On the other hand, banks relatively unaffected by the dry-up could access LTRO using their own

[28] The reader is referred to Table C.6 in the Appendix for more details on the time series evolution of bank-level available collateral during the dry-up.

collateral, avoiding the payment of the fee.[29]

4.3 Transmission of Central Bank Liquidity

Having provided evidence consistent with the LTRO uptakes backed by the government program being driven by the dry-up, we next estimate a standard difference-in-difference specification. We now simply compare the *dry-up* and the *intervention* periods, using bank LTRO uptakes as a source of variation. Again, we will distinguish between (i) bank total LTRO uptakes, (ii) bank LTRO uptakes backed by the government guarantee, and (iii) bank LTRO uptakes backed by standard (i.e., not guaranteed by the government) collateral. More formally, we estimate the following specification:

$$\Delta Log(Credit_{ijt}) = \alpha + \beta_1 Uptake_j \times \mathbb{I}_{Interv} + \mu_{it} + \gamma_{ij} + \phi' \Gamma_{jt} + \epsilon_{ijt} \tag{3}$$

where the dependent variable is the change in log (stock of) credit granted by bank j to borrower i at time t. Again, we compare the change between the dry-up period (June 2011-December 2011) and the intervention period (December 2011-June 2012). Our independent variable of interest is $Uptake$, defined as the bank-level LTRO uptake divided by assets. The time dummy $\mathbb{I}_{Interv}$ is equal to one in the *intervention* period. Similar to the baseline specification, we saturate the regression with firm-time fixed effects, bank-firm fixed effects, and bank-level control variables interacted with the time dummy.

[29] According to our interpretation, absent the fee, all banks would have chosen to secure additional collateral using the government scheme. In the Online Appendix we provide anecdotal evidence, from banks' annual reports, that the fee was high enough to discourage unaffected banks to use the government program. This setting is similar, in spirit, to Rothschild and Stiglitz (1976) as banks that *self-select* in the costly collateral option had little collateral because of the dry-up (see also Hertzberg et al. (2016)).

	$\Delta CREDIT$ (Granted)					
	(1)	(2)	(3)	(4)	(5)	(6)
$TotalUptake \times \mathbb{I}_{Interv}$	-0.066	-0.042				
	(0.131)	(0.144)				
$Uptake^{GovtCollateral} \times \mathbb{I}_{Interv}$			0.228**	0.249**		
			(0.111)	(0.122)		
$Uptake^{StandardCollateral} \times \mathbb{I}_{Interv}$					-0.275**	-0.269*
					(0.131)	(0.142)
$LEV \times \mathbb{I}_{Interv}$	0.538***	0.618***	0.520***	0.596***	0.498***	0.576***
	(0.184)	(0.200)	(0.164)	(0.179)	(0.181)	(0.197)
$ROA \times \mathbb{I}_{Interv}$	0.029	0.031	0.057	0.061	0.054	0.054
	(0.063)	(0.070)	(0.063)	(0.070)	(0.063)	(0.070)
$T1R \times \mathbb{I}_{Interv}$	0.720**	0.805**	0.564**	0.633**	0.557*	0.644*
	(0.338)	(0.362)	(0.274)	(0.296)	(0.305)	(0.329)
$NPL \times \mathbb{I}_{Interv}$	0.474***	0.547***	0.435***	0.497***	0.355**	0.425**
	(0.158)	(0.168)	(0.139)	(0.152)	(0.155)	(0.164)
$Large \times \mathbb{I}_{Interv}$	1.022	0.959	1.449	1.279	0.098	-0.054
	(2.235)	(2.459)	(2.062)	(2.277)	(2.359)	(2.605)
Firm-Time FE	✓	✓	✓	✓	✓	✓
Bank FE	✓		✓		✓	
Bank-Firm FE		✓		✓		✓
Observations	1,512,104	1,381,420	1,512,104	1,381,420	1,512,104	1,381,420
R-squared	0.385	0.655	0.385	0.655	0.385	0.655

Table 7: Central Bank Facility Uptakes and Credit Supply. This table presents the results from specification (3). The dependent variable is the difference in log (stock of) credit granted. $TotalUptake$ is the total LTRO uptake (sum of LTRO1 and LTRO2) divided by assets in June 2011. $Uptake^{StandardCollateral}$ is the portion of total uptake backed by standard collateral, divided by assets in June 2011. $Uptake^{GovtCollateral}$ is the portion of total uptake backed by the government guarantee program, divided by assets in June 2011. $\mathbb{I}_{Interv}$ is a dummy equal to one in the *intervention* period and zero in the *dry-up* period. The sample period runs from June 2011 to June 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.

In Table 7, we show the estimation results. In columns (1)-(2), $Uptake$ is defined as the total LTRO uptake. In the second column, we drop the bank fixed effects to include more restrictive bank-firm fixed effects. The coefficient on the interaction between $TotalUptake$ and the time dummy is close to zero and not significant suggesting that banks that tapped more LTRO liquidity did not increase credit supply during the intervention period more compared to banks that tapped less LTRO liquidity, relative to the dry-up period. Of course, the result should be interpreted as a simple correlation as banks choose how much to borrow at LTRO.

In columns (3)-(4), the independent variable of interest is the interaction between the uptake backed by government guaranteed collateral and the time dummy. Similarly, in columns (5)-(6), the independent variables of interest is the interaction between uptake backed by standard (i.e., not guaranteed by the government) collateral and the time dummy. We find that banks that borrowed more at ECB pledging government guaranteed collateral increased their credit supply more during the intervention period compared to banks that borrowed less using the government guaranteed collateral, relative to the dry-up period. The opposite is true for banks that used standard collateral to borrow at ECB.[30] The results suggest that uptakes backed by the guarantee of the Treasury explain the bank restoration of credit supply as banks hit by the dry-up self-select in the costly government guarantee program.

However, the last results raise the possibility that it is the government guarantee, not the central bank liquidity, that drives the restoration of credit supply. Bank behavior during the dry-up is however a valid counterfactual to dismiss this hypothesis. Given that during the dry-up (i) the ECB was providing unlimited *short-term* liquidity to banks and (ii) banks had sizable holdings of available collateral to borrow freely at ECB, our analysis suggests that the *long-term* maturity provision by the ECB helped banks restoring their credit supply. Of course, the government guarantee program was effective in granting banks that had scarce collateral in December 2011 access to ECB and might have even been a necessary condition for the transmission.[31]

4.4 Government Bond Holdings

Our examination of the transmission of central bank liquidity to bank credit supply leaves one open question. While all banks borrow at LTRO, the restoration of bank private credit supply occurs

[30] Given that the total LTRO uptake is the sum of the uptake backed by government guaranteed collateral and the uptake backed by standard collateral, the coefficient on the interaction variable of interest in columns (5)-(6) is mechanically negative.

[31] By allowing banks with scarce eligible collateral to access the central bank liquidity, the government guarantee likely had a cost in terms of ex-ante moral hazard. The quantification of such cost is beyond the scope of this paper.

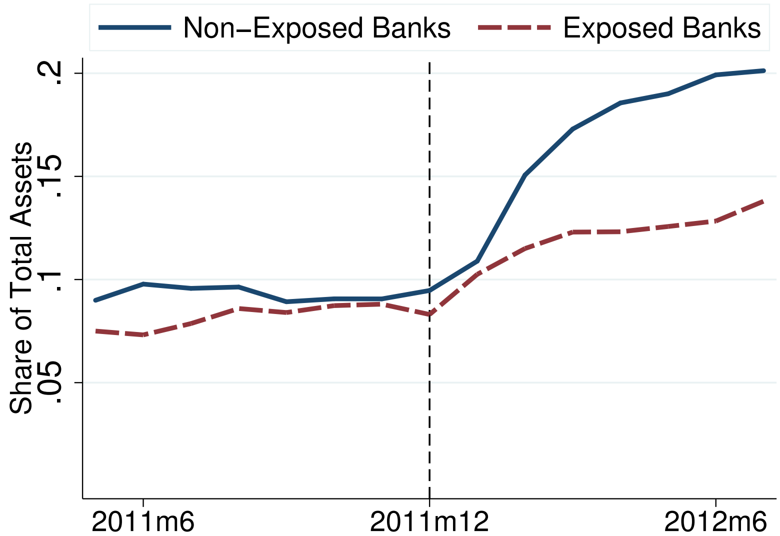

Figure 4: Government Bond Holdings and Exposure to the Dry-up. This figure shows government bond holdings, normalized by total assets in December 2011, by banks in our sample. Non-exposed banks are defined as banks in the bottom quartile of exposure to the foreign wholesale market in June 2011. Exposed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

mainly through banks more exposed to the dry-up. How do less exposed banks use the central bank liquidity?

In Table 1, we show the time series evolution of various bank balance sheet characteristics. The statistic regarding holdings of government bonds around the LTRO intervention stands out: government bond holdings in fact increase from 10.6% to 17.3% of total assets between December 2011 and June 2012 and changes before December 2011 and after June 2012 are close to zero. In Figure 4, we show 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 after the first LTRO allotment, especially pronounced for non-exposed banks.

This non-parametric evidence is consistent with our previous findings, as exposed banks also use LTRO funds to increase private credit supply more compared to less exposed banks. More

	$Govt$	$Govt^{Domestic}$	$Govt^{GIIPS}$	$Govt^{GIPS}$	$Govt^{non-GIIPS}$
$Exposure_{Jun11} \times \mathbb{I}_{Interv}$	-0.521**	-0.485**	-0.485**	-0.522**	-0.436
	(0.244)	(0.243)	(0.243)	(0.243)	(0.270)
$LEV_{Jun11} \times \mathbb{I}_{Interv}$	0.090	0.131	0.134	0.093	0.102
	(0.253)	(0.255)	(0.255)	(0.253)	(0.277)
$ROA_{Jun11} \times \mathbb{I}_{Interv}$	0.050	0.047	0.047	0.050	0.033
	(0.053)	(0.052)	(0.052)	(0.052)	(0.047)
$T1R_{Jun11} \times \mathbb{I}_{Interv}$	0.171**	0.165**	0.166**	0.171**	0.127**
	(0.069)	(0.068)	(0.068)	(0.069)	(0.059)
$NPL_{Jun11} \times \mathbb{I}_{Interv}$	-0.075	-0.064	-0.063	-0.073	-0.055
	(0.129)	(0.128)	(0.128)	(0.129)	(0.130)
$Large_{Jun11} \times \mathbb{I}_{Interv}$	-2.625	-2.151	-2.139	-2.613	-3.451
	(2.533)	(2.382)	(2.383)	(2.535)	(2.751)
Observations	949	949	949	949	949
R-squared	0.849	0.849	0.849	0.849	0.874

Table 8: Transmission to Holdings of Government Bonds. This table presents the results from specification (4). The dependent variable in column (1) is total holdings of government bonds. The dependent variable in column (2)-(5) is holdings of domestic, GIIPS (Greece, Italy, Ireland, Portugal, Spain), GIPS (Greece, Ireland, Portugal, Spain), and non-GIIPS government bonds, respectively. All dependent variables are normalized by total assets in June 2011. Independent variables are exposure to the foreign wholesale market, leverage, return on assets, tier 1 ratio, non-performing loans normalized by total assets, and a dummy equal to one if a bank belongs to a banking group with assets greater than €500. All dependent variables are measured in June 2011. The sample period runs from June 2011 to June 2012. *** p<0.01, ** p<0.05, * p<0.1.

formally, we run the following regression in the period June 2011-June 2012:

$$Govt_{j,t} = \alpha + \gamma_j + \eta_t + \beta Exposure_{j,Jun11} \times \mathbb{I}_{Interv} + \Gamma_{j,t} + \epsilon_{j,t} \tag{4}$$

where the dependent variable is holdings of government bonds by bank j in month t normalized by total assets in June 2011.[32] Independent variables include time fixed effects, bank fixed effects, the exposure to the dry-up interacted for a dummy equal to one in the intervention period, and balance sheet characteristics, in the vector Γ, also interacted with the same time dummy variable.

We show the estimation results in Table 8. In the first column, the dependent variable is

[32] We observe bank total assets at a biannual frequency and cannot therefore normalize holdings of government bonds in month t by total assets at time t.

total holdings of government bonds, normalized by assets. In columns (2)-(5), the dependent variables are holdings of domestic, peripheral (Greece, Ireland, Italy, Portugal, Spain), peripheral non-domestic (Greece, Ireland, Portugal, Spain), and non-peripheral government bonds, normalized by total assets, respectively. We find that banks relatively less exposed to the dry-up increased their holdings of *risky* government bonds more compared to relatively more exposed banks during the intervention period. The coefficients of interest in the last three columns show that exposed banks did not increase their holdings of safe non-peripheral bonds and did not favor domestic securities over other risky non domestic ones.

The evidence is consistent with a reach-for-yield behavior, also documented by Crosignani et al. (2016), who find that Portuguese banks purchased short-term high-yield government bonds funding their position by borrowing at the LTRO. Moreover, the acceptance of these securities as collateral during bad times at the ECB makes them even more attractive as they also effectively constitute holdings of precautionary liquidity.[33]

5 Effect on Firms

In this section, we examine the effect of the funding dry-up and the intervention on firm borrowing behavior and compute the aggregate effect of the intervetion. To this end, we analyze the dynamic of *total* firm credit, namely the credit *drawn* from all sources (term loans, revolving credit lines, and loans backed by account receivables).

[33]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 re-nationalization 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 (2016), and Drechsler et al. (2016)), moral suasion (Ivashina and Becker (2016) and De Marco and Macchiavelli (2015)), or the interplay between regulator and a common central bank (Uhlig (2013)).

We collapse our data set at the firm-time level. For each firm, we compute the indirect exposure, through its banking relationships, to the dry-up. Formally, the indirect exposure of firm i is given by the weighted average of its banks' exposures to the foreign wholesale market, where the weights are given by the total credit drawn from each bank in June 2011. For each firm i, we compute:

$$\widetilde{Exposure}_{i,Jun11} = \frac{\sum_{j \in \mathcal{R}^i} Drawn_{j,Jun11} Exposure_{j,Jun11}}{\sum_{j \in \mathcal{R}^i} Drawn_{j,Jun11}} \tag{5}$$

where $\mathcal{R}^i$ is the subset of banks that have a relationship with firm i in June 2011.

5.1 Firm-Level Credit Drawn

In this subsection, we ask (i) whether firms are able to avoid the credit contraction during the dry-up by substituting the reduction in credit from affected banks with more credit from less affected banks and, similarly, (ii) whether firms expand their total borrowing following the increased credit supply during the interventions period.

To clarify the channel, consider the following example. Firm F borrows from bank B1 and bank B2 before the dry-up. The former is exposed to the dry-up and the latter is not. 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 dry-up. We use the following specification to address these two questions:

$$\begin{aligned} \Delta Log(Drawn_{it}) = \alpha + \beta_1 \widetilde{Exposure}_{i,Jun11} \times \mathbb{I}_{Dry-up} + \beta_2 \widetilde{Exposure}_{i,Jun11} \times \mathbb{I}_{Interv} \\ + \psi' \Lambda_{it} + \phi' \Gamma_{it} + \eta_t + \chi_i + \epsilon_{it} \end{aligned} \tag{6}$$

where the dependent variable is the change in the log (stock of) total firm i credit at time t,

$\widetilde{Exposure}_i$ is the indirect exposure of firm i to the dry-up, $\mathbb{I}_{Dry-up}$ and $\mathbb{I}_{Interv}$ are the usual time dummies, η are time fixed effects, and χ are firm fixed effects. We also saturate the regression with bank-characteristics and firm-characteristics controls. Bank-characteristics controls (vector Λ) include the indirect effect of all bank balance sheet characteristics used in our baseline regression on firms, following the definition illustrated in (5), interacted with the two time dummies. Firm-characteristics controls (vector Γ_{it}) include the interaction between the time dummies and a series of firm characteristics, namely (log of) total assets, profitability measured by EBITDA, leverage, and a dummy equal to one if the firm has a Z-score greater or equal than five. As firm variables are available at an annual frequency, we use observations in December 2010.

We show the estimation results in Table 9. In the first column, we find that firms more exposed, through their banks, to the dry-up reduced their total credit during the dry-up and restored their total credit during the intervention compared to firms (indirectly) less exposed to the dry-up. These results suggest that (i) firms were unable to completely undo the credit contraction and were therefore impacted by the foreign wholesale market dry-up and (ii) the intervention helped firms accessing bank credit again.

In columns (2)-(5), we include triple interaction terms to ask which types of firms were able to at least partially undo the credit crunch and which types of firms were able to benefit the most from the intervention. We find that risky firms are able to smooth the credit crunch as they draw down their credit lines during the dry-up. They also benefit less from the intervention by borrowing less in the intervention period compared to less risky firms.

The inability to substitute source of funding during the credit contraction is consistent with two strands of literature. In the literature on "slow-moving" capital, keeping capital in liquid form in anticipation of possible fire sales is costly in terms of foregone profitable investments (Acharya et al. (2013), Duffie and Strulovici (2012)). In the literature on informational frictions, lenders have

	$\Delta CREDIT$ (Drawn)				
	(1)	(2)	(3)	(4)	(5)
$\mathbb{I}_{Dry-up} \times \widetilde{Exposure}$	-0.701***	-0.435	-0.671***	-0.707***	-1.060***
	(0.159)	(0.953)	(0.172)	(0.158)	(0.164)
$\mathbb{I}_{Interv} \times \widetilde{Exposure}$	0.812***	1.152	0.781***	0.812***	0.994***
	(0.190)	(1.085)	(0.202)	(0.196)	(0.188)
$\mathbb{I}_{Dry-up} \times \widetilde{Exposure}_{Jun11} \times FirmSize$		-0.019			
		(0.068)			
$\mathbb{I}_{Interv} \times \widetilde{Exposure} \times FirmSize$		-0.024			
		(0.076)			
$\mathbb{I}_{Dry-up} \times \widetilde{Exposure} \times FirmProfitability$			-0.492		
			(0.382)		
$\mathbb{I}_{Interv} \times \widetilde{Exposure} \times FirmProfitability$			0.492		
			(0.331)		
$\mathbb{I}_{Dry-up} \times \widetilde{Exposure} \times FirmLEV$				0.097	
				(0.123)	
$\mathbb{I}_{Interv} \times \widetilde{Exposure} \times FirmLEV$				-0.012	
				(0.251)	
$\mathbb{I}_{Dry-up} \times \widetilde{Exposure} \times FirmRisky$					0.552***
					(0.191)
$\mathbb{I}_{Interv} \times \widetilde{Exposure} \times FirmRisky$					-0.283**
					(0.137)
Time FE	✓	✓	✓	✓	✓
Firm FE	✓	✓	✓	✓	✓
Double Interactions Λ_{it}	✓	✓	✓	✓	✓
Double Interactions Γ_{it}	✓	✓	✓	✓	✓
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 (6). The dependent variable is the difference in log (stock of) total credit. Total credit includes 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. $\mathbb{I}_{Dry-up}$ is a dummy equal to one in the *dry-up* 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 *dry-up* 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: $FirmSize$ is log of total assets; $FirmProfitability$ is EBITDA; $FirmLEV$ is firm leverage; $FirmRisky$ 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). Estimated coefficients on double firm-time interactions and double bank-time interactions (with exception of the exposure-time term) are included in the estimation, but omitted in this table. 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 (calculated as of June 2011) in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

private information about their borrowers, and borrowers left looking for a new lender are adversely selected, preventing a full reallocation of credit (Darmouni (2016)). Finally, our finding that risky firms are able to partially soften effect of the dry-up is consistent with Ippolito et al. (forthcoming) that show that financial constrained firms increase the draw down on their credit lines more than the average firm following a negative shock hitting their lender bank, as they might face tougher consequences if they run out of credit, compared to less constrained firms.

5.2 Aggregate Effect

We next examine the aggregate impact of the intervention. We use a counterfactual (Chodorow-Reich (2014b)) exercise to estimate what drop in credit would have happened from December 2011 to June 2012 if the ECB had not offered the LTRO liquidity.

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 time-varying heterogeneity, these fixed effects effectively capture borrowers credit demand. Second, we compute the firm-level *indirect* exposure to the June 2011-December 2011 dry-up using definition (5). In this way, we obtain both firm demand and pre-dry-up exposure to the wholesale market shock. Third, we plug the stored firm-time fixed effects into the firm-level equation and estimate:

$$\Delta Log(Credit_{it}) = \alpha + \beta_1 \widetilde{Exposure}_{i,Jun11} \times \mathbb{I}_{Dry-up} + \beta_2 \widetilde{Exposure}_{i,Jun11} \times \mathbb{I}_{Interv}$$
$$+ \hat{\mu}_{it} + \psi' \Lambda_{it} + \phi' \Gamma_{it} + \eta_t + \chi_i + \epsilon_{it} \quad (7)$$

where the dependent variable is credit granted aggregated at the firm level. The saved fixed effects from the baseline regressions are in the vector $\hat{\mu}$. All other independent variables are the same illustrated in (6). In the fourth step, we use the estimated regression coefficients and average exposures to the shock to predict the change in firm loan growth. Finally, we aggregate up at the period-level using a weighted average of firm-level loan growths, where the weights are given by firm-level granted credit in December 2011.

We then compare, in a partial equilibrium setting, the world with no ECB intervention to the world with LTRO intervention. 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 equilibrium exercise. The underlying assumption is that, absent the ECB intervention, the supply of credit granted would have decreased at the same rate during the *intervention* 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 -5.6% in the *intervention* period, instead of the observed -3.6%. The intervention does not however fully restore bank credit supply given that the dry-up caused a credit contraction of 3.7%.

6 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 dry-up 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. A large fraction of the central bank liquidity injection is however transmitted to increased holdings of high-yield securities, in the form of domestic government bonds. Banks hit by the wholesale funding dry-up are driving the restoration of bank credit supply.

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 accommodative 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 increasing bank credit supply. The likely costs in terms of moral hazard are not here analyzed.

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 framework 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. We believe these are interesting questions for future research.

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Appendix A Specification

In this section, we consider the following simplified version of (1):

$$y_{jt} = \beta_0 + \beta_1 T_j + \beta_2 \mathbb{I}_{Dry-up} + \beta_3 T_j \times \mathbb{I}_{dry-up} + \beta_4 \mathbb{I}_{Interv} + \beta_5 T_j \times \mathbb{I}_{Interv} + \epsilon_{it} \tag{A1}$$

where j is a bank and t is a date. T_j is a treatment dummy and there are three periods. The dummy $\mathbb{I}_{dry-up}$ is equal to one in the second and third period. The dummy $\mathbb{I}_{Interv}$ is equal to one in the last period.

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

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

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

$$E(y_{jt}|Dry-up_t = 0, Intervention_t = 0, T_j = 0) = \beta_0$$

$$E(y_{jt}|Dry-up_t = 0, Intervention_t = 0, T_j = 1) = \beta_0 + \beta_1$$

$$E(y_{jt}|Dry-up_t = 1, Intervention_t = 0, T_j = 0) = \beta_0 + \beta_2$$

$$E(y_{jt}|Dry-up_t = 0, Intervention_t = 0, T_j = 1) = \beta_0 + \beta_1 + \beta_2 + \beta_3$$

$$E(y_{jt}|Dry-up_t = 1, Intervention_t = 1, T_j = 0) = \beta_0 + \beta_2 + \beta_4$$

$$E(y_{jt}|Dry-up_t = 1, Intervention_t = 1, T_j = 1) = \beta_0 + \beta_1 + \beta_2 + \beta_3 + \beta_4 + \beta_5$$

$$\Rightarrow (y_{jt}|Dry-up_t = 1, Intervention_t = 0, T_j = 1) - E(y_{jt}|Dry-up_t = 0, Intervention_t = 0, T_j = 1)$$

$$- \big(E(y_{jt}|Dry-up_t = 1, Intervention_t = 0, T_j = 0) - E(y_{jt}|Dry-up_t = 0, Intervention_t = 0, T_j = 0)\big) = \beta_3$$

$$\Rightarrow E(y_{jt}|Dry-up_t = 1, Intervention_t = 1, T_j = 1) - E(y_{jt}|Dry-up_t = 1, Intervention_t = 0, T_j = 1)$$

$$- \big(E(y_{jt}|Dry-up_t = 1, Intervention_t = 1, T_j = 0) - E(y_{jt}|Dry-up_t = 1, Intervention_t = 0, T_j = 0)\big) = \beta_5$$

□

Appendix B Additional Figures

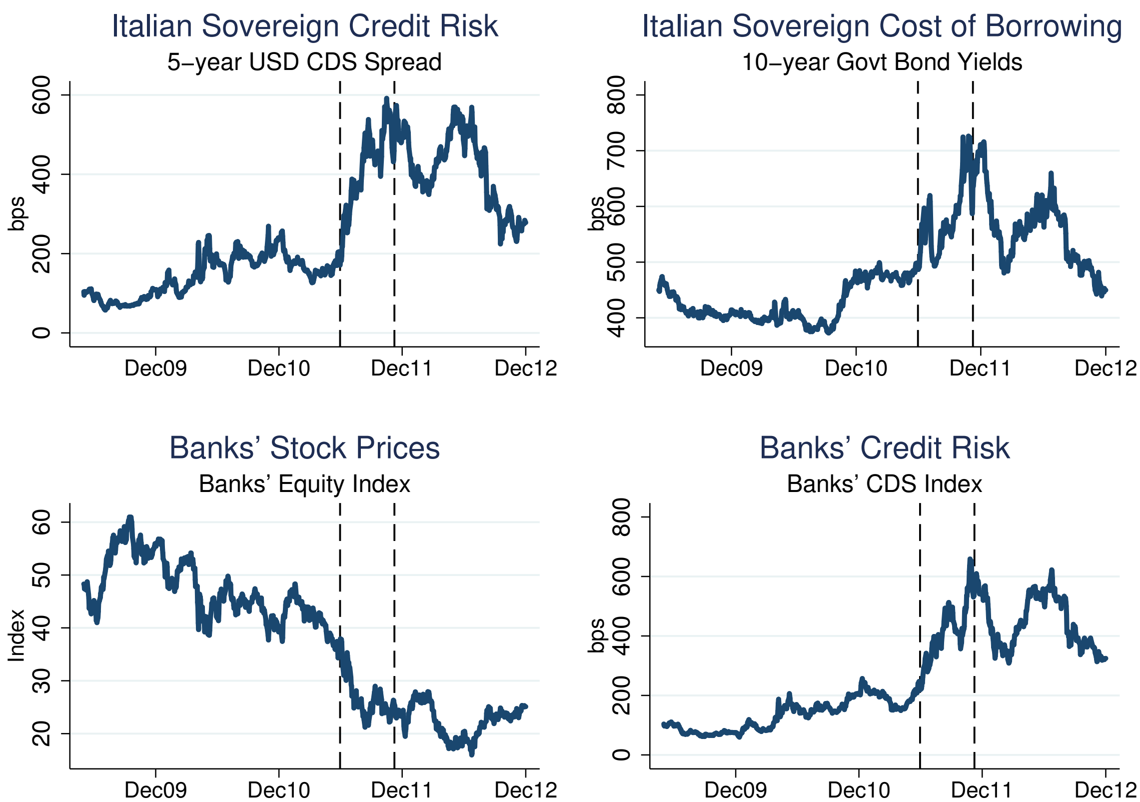

Figure B.1: Italian Bank and Sovereign Credit Risk. The top right left figure shows the Italian Sovereign 5-year USD-denominated CDS spread. The top right figure shows the Italian 10-year government bond yield. The bottom left figure shows Italian banks' equity prices (MSCI Italian Financials Index). The bottom right figure shows mean Italian 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 and November 2011. Souce: Bloomberg.

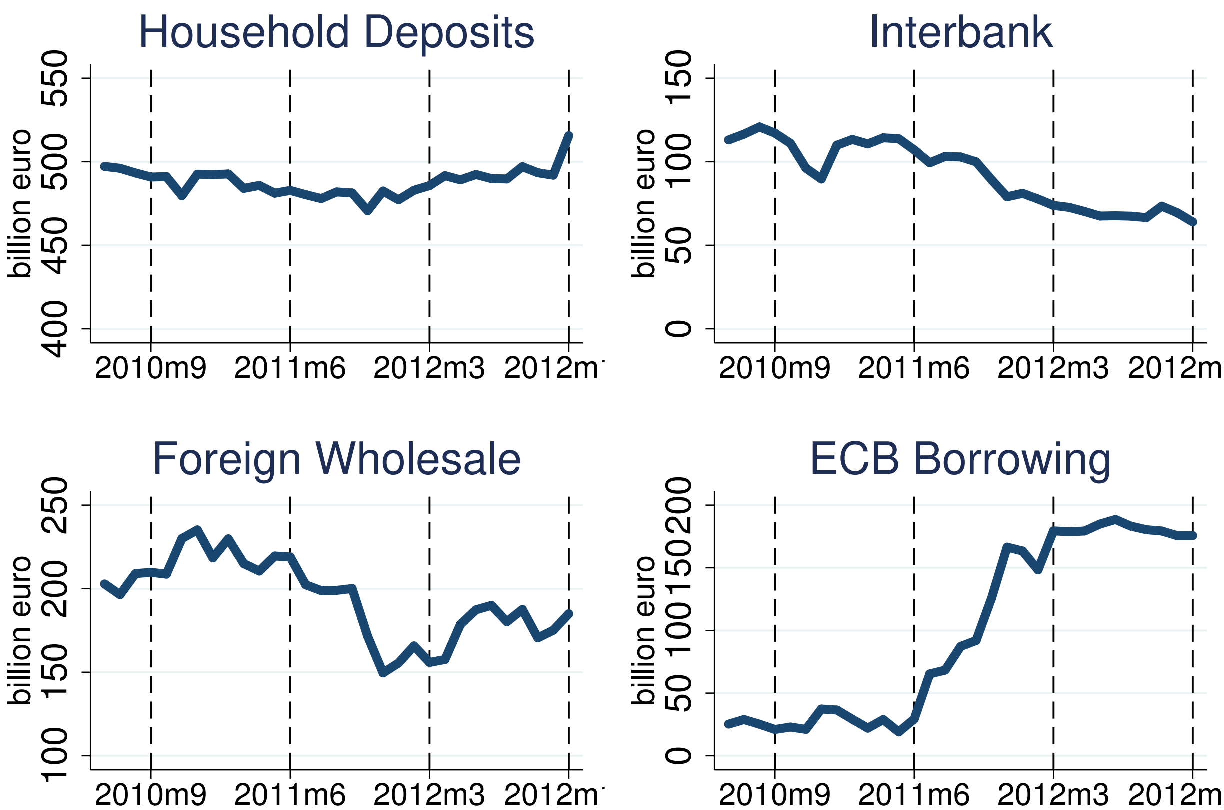

Figure B.2: Bank Funding Sources. This figure shows the composition of bank funding during the sample period. The dashed line correspond to June 2011, March 2012, and December 2012. They identify the three *normal*, *dry-up*, *intervention* periods. The four panel show, respectively, total household 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.

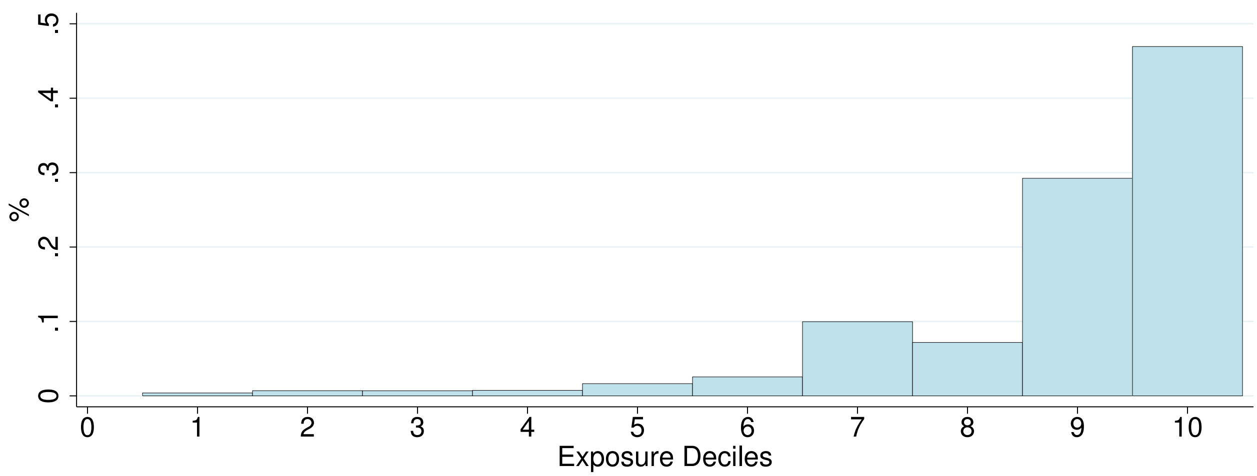

Figure B.3: June 2011 Foreign Wholesale Market Exposure and Loans to Firms. This bar chart shows the correlation between bank-level share of total loans to firms funded and exposure to the foreign wholesale market. The x-axis groups banks in ten deciles according to their exposure to the foreign wholesale market in June 2011. Each bar measures the share of total credit to firms funded by banks in each decile. Exposure deciles are delimited by p(10)=0.000%, p(20)=0.027%, p(30)=0.108%, p(40)=0.207%, p(50)=0.750%, p(60)=1.476%, p(70)=2.737%, p(80)=4.559%, and p(90)=7.567%. The exposure 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.

Appendix C Additional Tables

	Wholesale Funding Dry-Up					
$Exposure_{Jun11}$	-0.439***	-0.425***	-0.403***	-0.400***	-0.411***	-0.405***
	(0.116)	(0.117)	(0.121)	(0.122)	(0.120)	(0.124)
LEV_{Jun11}		-0.097	-0.068	-0.091	-0.092	-0.093
		(0.101)	(0.108)	(0.118)	(0.116)	(0.117)
ROA_{Jun11}			-0.011	-0.014	-0.025	-0.024
			(0.014)	(0.016)	(0.016)	(0.017)
$T1R_{Jun11}$				-0.018	-0.043	-0.042
				(0.018)	(0.020)	(0.020)
NPL_{Jun11}					-0.147*	-0.145*
					(0.078)	(0.080)
$Large_{Jun11}$						-0.576
						(2.850)
Observations	73	73	73	73	73	73
R-squared	0.168	0.178	0.185	0.188	0.229	0.229

Table C.1: Wholesale Market Exposure and Dry-up. This table presents the results from a cross-sectional regression. The dependent variable is the change in total wholesale market funding between June 2011 and December 2011 (normalized by total assets in June 2011). The independent variables are the exposure to the foreign wholesale market (normalized by total assets), leverage, return on assets, tier 1 ratio, non-performing loans (normalized by total assets), and a dummy equal to one if a bank belongs to a banking group with assets greater than €500. All independent variables are measured in June 2011. *** p<0.01, ** p<0.05, * p<0.1.

	Foreign Funding Wholesale Dry-Up					
$Exposure_{Jun11}$	-0.283***	-0.291***	-0.278***	-0.277***	-0.277***	-0.263***
	(0.062)	(0.063)	(0.065)	(0.065)	(0.066)	(0.068)
LEV_{Jun11}		0.055	0.072	0.062	0.062	0.059
		(0.054)	(0.058)	(0.063)	(0.064)	(0.064)
ROA_{Jun11}			-0.006	-0.008	-0.008	-0.007
			(0.008)	(0.008)	(0.009)	(0.009)
$T1R_{Jun11}$				-0.007	-0.009	-0.008
				(0.018)	(0.020)	(0.020)
NPL_{Jun11}					-0.009	-0.003
					(0.043)	(0.044)
$Large_{Jun11}$						-1.303
						(1.556)
Observations	73	73	73	73	73	73
R-squared	0.226	0.237	0.245	0.247	0.247	0.255

Table C.2: Foreign Wholesale Market Exposure and Dry-up. This table presents the results from a cross-sectional regression. The dependent variable is the change in foreign wholesale market funding between June 2011 and December 2011 (normalized by total assets in June 2011). The independent variables are the exposure to the foreign wholesale market (normalized by total assets), leverage, return on assets, tier 1 ratio, non-performing loans (normalized by total assets), and a dummy equal to one if a bank belongs to a banking group with assets greater than €500. All independent variables are measured in June 2011. *** p<0.01, ** p<0.05, * p<0.1.

Panel A Exposed Banks		Jun10	Dec10	Jun11	Dec11	Jun12	Dec12
Size	€billions	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 Borrowing	%Assets	1.50%	3.15%	3.16%	8.25%	10.95%	10.54%
Household Deposits	%Assets	26.2%	25.3%	24.7%	24.3%	24.1%	24.9%
Interbank Borrowing	%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	€billions	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 C.3: 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 C.4: 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.

	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 C.5: 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.

		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 C.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.