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 borrower-level data from the Italian credit registry with bank security-level holdings and analyze the transmission of the European Central Bank's three-year Long Term Refinancing Operation. Exploiting a regulatory change that expands collateral eligibility, we show that banks more affected by the dry-up use central bank liquidity to restore their credit supply, while less affected banks use it to increase their holdings of high-yield securities. Unable to switch from affected banks during the dry-up, firms benefit from the intervention.

JEL: E50, E58, G21, H63

Keywords: Central Bank Liquidity, Bank Credit Supply, Bank Wholesale Funding

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1 Introduction

Since the 2008 financial crisis, many central banks have adopted unprecedented measures to restore and maintain 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 effects 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 fill 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 liquidity provisions is based on the observation that banks hold fewer 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 to banks to avoid an inefficient credit contraction.

While intuitive and dating back to Bagehot (1873), this theory has been proven elusive

[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. (2016b), and Darmouni and Rodnyansky (forthcoming) 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.

to test mainly because of lack of suitable episodes and available data. We contribute to this seminal literature by analyzing the effect of the largest central bank liquidity injection ever conducted, the December 2011 European Central Bank (ECB) long-term liquidity provision, on Italian bank credit supply. The intervention, called the three-year Long Term Refinancing Operation (LTRO), consisted of an 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 they pledged sufficient eligible collateral. Unprecedented in scale, the ECB liquidity facility provided €1 trillion to 800 eurozone banks with the goal of "supporting bank lending."[3]

There are three reasons that make our setting the perfect laboratory to study the transmission of central bank liquidity injections. First, Italian banks are hit by sudden withdrawals in their foreign wholesale funding sources in the six months before the central bank intervention giving us a rare case of a funding dry-up followed by a central bank liquidity injection.[4] Second, thanks to a regulatory change on collateral eligibility unique to the Italian setting, we are able to trace the transmission of central bank liquidity to private credit supply and holdings of securities. Third, we are the first ones to combine security-level data contained in supervisory reports submitted by intermediaries to the Bank of Italy with the comprehensive national credit registry and detailed bank and firm balance sheet characteristics. Hence, in our final data set, we observe *all* outstanding loans to firms with a balance above €30,000 and holdings of *all* securities held by banks located in Italy, thus obtaining an unprecedented view of banks' balance sheets.

[3]The stated goal was to provide "credit support measures to support bank lending and liquidity in the euro area money market". The press release is available at www.ecb.europa.eu/press/pr/date/2011/html/pr111208_1.en.html.

[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)).

The analysis of the pass-through of liquidity injections poses two empirical challenges. First, as firms are not randomly assigned to banks, we need to control for firm heterogeneity. In other words, if we observe an increase in credit granted by bank j to firm i following the intervention, it might not necessarily be the case that the bank is supplying more credit, as the firm might also be *demanding* more. To address this problem and isolate the supply of credit, 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 in our specifications (Khwaja and Mian (2008)).

Second, banks are not randomly hit by the wholesale funding shock and can *choose* how much to borrow from the central bank. Hence, using the bank-level uptake of ECB liquidity 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 proceed in two steps. First, we use bank reliance on the foreign wholesale market in June 2011, prior to the June 2011 to December 2011 dry-up, as a measure of differential bank exposure to the funding shock (Iyer et al. (2014)). Second, we exploit a regulatory intervention that expands the definition of ECB eligible collateral, together with data on collateral, to link the actual bank-level uptake of central bank liquidity to bank credit supply.

In the first step, we compare the credit supply to the same firm of banks that are differently exposed to the foreign wholesale market, during both the funding dry-up and the period after the ECB intervention. The following example clarifies our exercise. We consider firm F that borrows from bank H and bank L. 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 H to firm F and the stock of credit granted by bank L to firm F during (i) the "normal" period (December 2010 to June 2011) when funding markets are well functioning, (ii) the "dry-up" period (June 2011 to December 2011) when we observe a dry-up in bank foreign wholesale funding, and (iii) the "intervention" period (December 2011 to June 2012) after the central bank steps in to provide 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 with banks with a smaller exposure. Our results are robust to the inclusion of bank-firm fixed effects and key time-varying bank balance sheet controls, which control for the nonrandom composition of bank funding (more exposed banks tend to be larger and more levered in our sample). We find that during the dry-up period, credit granted by banks with high exposure to the dry-up (top decile of the exposure distribution) dropped about 1 percentage point more than credit granted by banks with low exposure (bottom decile of the exposure distribution). During the intervention period, banks with high exposure to the dry-up *increased* their credit supply compared with banks with low exposure, undoing the credit contraction observed during the dry-up period.

In the second step, having documented the time-series evolution of credit supply for banks with different exposure to the dry-up, we link the actual bank-level uptake of central bank liquidity to credit supply. The LTRO was an opportunity not to be missed: We observe that the attractive pricing of the ECB liquidity facility successfully induced almost all banks to tap the facility, *regardless* of their exposure to the dry-up. Hence, to corroborate our narrative, we need to reconcile the observation that the banks hit by dry-up restored credit supply after the LTRO with the observation that the *endogenous* uptake of the LTRO is uncorrelated with the initial funding shock.

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 securities *otherwise ineligible* at the ECB. As the central bank accepts all government-guaranteed assets as collateral, the program effectively gave banks a technology to "manufacture" collateral and therefore increase their borrowing capacity at the central bank. The regulatory change was successful as the newly government-guaranteed assets backed 57% of the total borrowing of our sample banks at the LTRO. We show that, on the one hand, banks hit by the dry-up *self-selected* in the government guarantee program to access the ECB liquidity, having eroded their holdings of collateral during the dry-up; on the other hand, banks relatively unaffected by the dry-up borrowed at the LTRO pledging their own collateral, thus avoiding the payment of the fee.[5]

Consistent with our previous analysis, we find that the uptake of LTRO liquidity backed by government-guaranteed securities drove the restoration of private credit supply. Moreover, we find that banks less affected by the dry-up, and which mainly pledged their own collateral, used the central bank liquidity injection to buy securities in the form of high yield government bonds. These securities were particularly attractive, thanks to their high yield, zero regulatory risk weights, and collateral eligibility at the ECB.

Banks exposed to the dry-up invested, for every euro borrowed at the LTRO, €0.13 in private credit and €0.44 in government bonds. Banks relatively less exposed purchased exclusively public debt, investing €0.83 in government bonds for every euro borrowed at the LTRO. Overall, we find that, of the €181.5 billion borrowed at the LTRO by our sample banks, €22.6 billion was invested in credit to firms and €82.7 billion was invested in government bonds. The effect on private credit supply is nevertheless sizable: In a counterfactual exercise, we find that without the LTRO, private credit would have contracted 5.6% in the intervention period, instead of the observed 3.6%.

We then analyze the heterogeneity across firms and banks. In the cross section of banks, we find that high-leverage banks drive the increase in credit supply, consistent with expansionary monetary policy working mainly through constrained banks (Kashyap and Stein (1995)). 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 channel (Jimenez et al. (2014)).

Finally, we examine firm borrowing behavior. In a frictionless world, firms are able to

[5]The stated goal of regulatory intervention by the national government was exactly to "allow banks to restore their medium-long term funding capacity" in conjunction with the LTRO liquidity injection.

switch lenders during bad times effectively "undoing" the credit crunch. In addition, central bank interventions do not necessarily affect firm borrowing, as firms might not be constrained as a result of the bank credit contraction. We collapse our data set at the firm-level and find that firms (i) are unable to completely substitute missing credit from exposed banks with new credit from non-exposed banks during the dry-up and (ii) increase total borrowing after the intervention.[6]

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), Stein (1998)) stresses the importance of credit market frictions for a funding shock to cause a credit supply contraction. While the first contributions to the empirical literature focused on time series (Bernanke and Blinder (1992), Bernanke (1983)) and cross-sectional (Gertler and Gilchrist (1994), Kashyap et al. (1994), Kashyap and Stein (2000), Ashcraft (2006)) analyses, in more recent work, researchers use within borrower estimation, sometimes together with quasi-exogenous liquidity shocks, to disentangle the effects of credit supply and 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 funding shock causes banks to reduce their credit supply and then we contribute to the literature by showing how a positive funding shock — namely the central bank liquidity injection — can *restore* bank credit supply.

Since the recent U.S. financial and eurozone sovereign debt crises, many researchers have

[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)).

studied the transmission of these asset market disruptions on credit supply through bank balance sheets. In the U.S. context, the effect of the crisis on credit supply and real outcomes has been analyzed by, among others, Chodorow-Reich (2014b), Ivashina and Scharfstein (2010), Benmelech et al. (forthcoming), and Puri et al. (2011). In the eurozone context, Bocola (2016) analyzes, using a general equilibrium model, the pass-through of sovereign credit risk on intermediated credit. The related empirical literature (Popov and van Horen (2015), De Marco (2015), Gennaioli et al. (2016), Cingano et al. (2016), Bofondi et al. (forthcoming), Acharya et al. (2016a), Beltratti and Stulz (2015), Bottero et al. (2017), Del Giovane et al. (2013)) almost unanimously confirms the negative spillover. Our paper complements these applied studies by analyzing how the ECB liquidity injection helped undo the ongoing credit crunch.

Second, we contribute to 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. (2016a) for credit to households). In particular, we analyze unconventional monetary policy (Chodorow-Reich (2014a), Di Maggio et al. (2016b), Goldstein et al. (2016), Kandrac and Schlusche (2017), Darmouni and Rodnyansky (forthcoming)) 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 private credit supply and increased holdings of high-yield 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 the ECB interventions during the recent crisis is analyzed in Casiraghi et al. (2013), van der Kwaak (2015), Krishnamurthy et al. (2015), Garcia-de Andoain et al. (2016), Crosignani et al. (2017), Daetz et al. (2016), Alves et al. (2016), Andrade et al. (2015), and Garcia-Posada and Marchetti (2015). The last four papers also study the effect of ECB liquidity on bank private credit supply. Compared with these contributions, we analyze the effect of the central bank intervention following a bank funding dry-up allowing us to study the eventual restoration of credit supply following a credit crunch. Moreover, compared with these papers that simply rely on banks' endogenous uptake of ECB liquidity as a source of variation, we identify the causal effect of the liquidity injection and analyze the joint transmission to bank private credit supply and holdings of securities.

The remainder of the paper is structured as follows. In Section 2, we describe the empirical setting and the data set and provide summary statistics. We analyze the effect of the central bank intervention on bank credit supply and holdings of securities in Section 3. In Section 4, we examine the heterogeneity of the effects across banks and firms. In Section 5, we analyze firms' borrowing behavior 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. In this section, we first describe the Italian macroeconomic picture during our sample period and then show that Italian banks are hit by a dry-up in their (foreign) wholesale funding during the six-month period before the ECB LTRO, making this intervention a textbook case of a central bank liquidity injection following a negative bank funding shock. We conclude by describing our unique security- and loan-level data set obtained by combining several supervisory data sources at the Bank of Italy.[7]

[7] As Italian banks are among the largest users of the LTRO and Italian firms are heavily dependent on bank credit, our analysis sheds light on the effectiveness of this unprecedented intervention.

2.1 Macroeconomic Picture

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

The crisis in Italy started in 2009 and can be divided into two phases. During the first phase, from 2009 to mid-2011, Italian government bond prices fell by about 25% while sovereign CDS spreads doubled to reach approximately 200 basis points 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 involving the private sector in Greek debt restructuring led to contagion in Italy.

During the second phase, from June 2011 to December 2011, investors suddenly started demanding very large risk premiums and sovereign CDS spreads and bond yields started increasing very sharply, reaching a record high in November 2011.[8] As concerns about the 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 a "quiet run" by Chernenko and Sunderam (2014).

[8]Greece was downgraded five times by the three main credit rating agencies in June and July. As documented in Bofondi et al. (forthcoming), 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.

2.2 Bank Funding During the Crisis

During the first phase of the crisis, from January 2008 to June 2011, retail funding slightly increased whereas wholesale funding dropped by 3 percentage points. Short-term central bank liquidity partially substituted this drop, reaching 2.2% of total assets in June 2011. During the second phase of the crisis, in just six months from June 2011 to December 2011, wholesale funding declined by 5 percentage points. This drain in funds was offset by short-term central bank liquidity, which, at the end of 2011, represented 5.7% of total assets.

This drastic decline in wholesale funds was driven by a sharp reduction in *foreign* funding, mainly caused by sudden drops in certificates of deposits and commercial paper held by U.S. 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 collapse in wholesale funding stopped as the ECB announced its three-year Long Term Refinancing Operation.[9]

The ECB started providing extraordinary liquidity to banks as early as October 2008, when it switched to a "fixed-rate full-allotment" mode for its refinancing operations. This change means that eurozone banks can obtain unlimited *short-term* liquidity from the central bank at a fixed rate provided that they pledge sufficient collateral. The ECB applies a haircut that depends on the asset class, residual maturity, rating, and coupon structure of the pledged security. There is no limit on how much a bank can borrow provided that it pledges sufficient collateral.[10]

[9]In Figure B.2 in the Appendix, we illustrate the time series evolution of household deposits, firm deposits, domestic interbank funding, and bond financing. 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 detail.

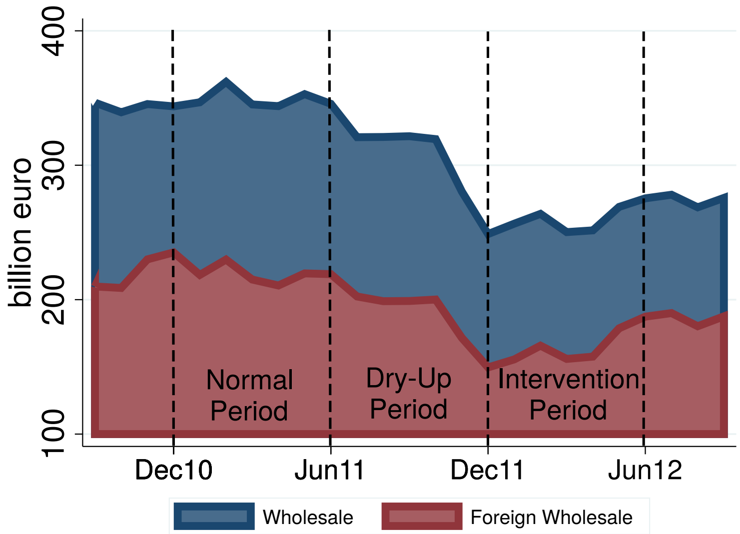

Figure 1: Foreign Wholesale Funding Dry-Up. This plot shows the total wholesale market funding (foreign and domestic wholesale, excluding bond financing) and the foreign wholesale market funding of our sample banks. The total wholesale funding corresponds to the sum of the blue and red areas. See Figure B.2 in the Appendix for the time series evolution of additional funding sources. Quantities are in billion euro. Source: Bank of Italy.

The LTRO On December 8, 2011, the ECB increased its support to the eurozone banking sector even further, announcing the provision of two three-year maturity loans, the three-year 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 three-year maturity. The interest rate and haircut did not change compared to previous standing operations.[11]

Note that, in a frictionless world with no uncertainty, the LTRO is a redundant tool and

[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 short-term loans. In addition, no major changes were made on the haircuts or eligibility of collateral securities, with the exception of selected asset-backed securities (ABS). In December 2011, the ECB started in fact accepting ABS with a second-best rating of at least "single A". The ECB also allowed national central banks to temporarily accept selected 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. Banks had the option to repay the LTRO loans early, after one year.

should not attract banks as they would be indifferent between borrowing at the central bank at a three-year maturity and borrowing at the central bank at, say, a two-week maturity and then rolling over bi-monthly 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, likely the case at the end of 2011 as the continuation of the unlimited feature of the ECB liquidity provision and the future of the eurozone were both unclear.[12]

The LTRO intervention successfully attracted many banks. Basically all banks that are usually counterparty of the ECB open market operations tap this facility. Our sample banks obtained €181.5 billion, consisting of €88.4 billion at LTRO1 and €93.1 billion at LTRO2. It is an economically large quantity as the median uptake is 9.7% of total assets.[13] The large uptake is perhaps not surprising: the LTRO was an opportunity not to be missed for banks, as the ECB provided long-term liquidity at more favorable terms compared to the private market. In peripheral countries like Italy the combination of haircuts and interest rate was, indeed, generally more attractive compared with prices in the private markets.[14]

[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, the LTRO was not protecting banks against changes in collateral eligibility or haircuts, as the central bank makes margin calls, if the value of collateral drops (or the haircuts increase) during the loan period. Marketable assets used as collateral are marked to market daily.

[13] The average is 10.9% of total assets. Banks' enthusiasm in tapping LTRO is also confirmed by the observation that more than 95% of banks that are usually counterparty of the ECB open market operations borrow tap the LTRO. For more descriptive statistics of LTRO borrowing by banks operating in Italy, see Bank of Italy (2012).

[14] Consistent with the observation that the ECB liquidity provision to banks was particularly attractive 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.

2.3 Data

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

We combine information from various sources. First, at the (i, j, t) firm-bank-period level, we obtain data on all outstanding loans with a balance 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 (most of them biannually), detailed funding sources, and the LTRO uptake from the Supervisory and Statistical Reports submitted by intermediaries to the Bank of Italy.

Third, at the (s, j, t) security-bank-period level, we observe holdings of each marketable security held by Italian banks from Supervisory Reports. 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 the 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 with the 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 reports deposited to the Italian Chamber of Commerce (Cebi-Cerved database). We lose approximately 45% of observations 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

Bank-Level		**Jun10**	**Dec10**	**Jun11**	**Dec11**	**Jun12**	**Dec12**
Total Assets	€billions	37.3	36.7	36.6	36.4	37.5	37.7
Leverage	Units	11.9	12.3	12.2	12.2	13.2	13.5
Tier 1 Ratio	Units	19.0	15.2	14.3	13.9	13.8	13.4
Risk-Weighted Assets	%Assets	69.3	69.0	68.3	67.8	62.2	60.5
Non-performing Loans	%Loans	8.2	8.5	9.1	9.9	11.7	12.7
Private Credit	%Assets	59.5	62.8	65.2	66.8	67.6	69.4
- Credit to Households	%Assets	16.3	17.5	18.2	18.7	19.2	19.9
- Credit to Firms	%Assets	38.4	40.5	42.2	43.4	43.6	44.6
Securities	%Assets	17.4	16.9	16.3	17.3	24.2	23.7
- Government Bonds	%Assets	5.6	6.5	8.0	9.1	16.6	19.6
Cash Reserves	%Assets	0.4	0.5	0.5	0.5	0.4	0.5
ROA	Profits/Assets	0.1	0.3	0.1	0.0	0.1	0.1
Central Bank Borrowing	%Assets	0.9	2.0	2.2	5.7	12.5	13.5
Household Deposits	%Assets	33.0	32.0	30.8	30.3	29.3	29.8
Wholesale Funding	%Assets	8.1	8.5	8.4	7.7	8.0	8.5
Bond Financing	%Assets	18.6	18.5	19.2	18.0	16.3	14.8

Loan-Level	**Loan Type**	*Normal Period* **Dec10-Jun11**	*Dry-Up Period* **Jun11-Dec11**	*Intervention Period* **Dec11-Jun12**
ΔCreditDrawn	All Types	6.2%	-2.1%	-3.1%
ΔCreditGranted	All Types	4.7%	-2.2%	-3.6%
ΔCreditDrawn	Credit Lines Only	8.7%	-1.6%	-1.6%
ΔCreditGranted	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 from June 2010 to December 2012. The bottom panel shows bank firm credit growth during the December 2010 - June 2011 period, the June 2011 - December 2011 period, and the December 2011 - June 2012 period. The table shows changes (difference in log stocks) in (i) total credit on term loans and drawn from revolving credit lines and loans backed by account receivables, (ii) total credit on term loans and committed on revolving credit lines and loans backed by account receivables, (iii) total credit drawn from revolving credit lines, and (iv) total credit committed on revolving credit lines. Source: Bank of Italy.

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 small discretion margins. Third, our final sample does not include mutual banks nor their central institutes, as in most cases the latter tapped the

ECB liquidity and then redistributed funds among the former, 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. Given our focus on the LTRP, we then restrict our analysis to banks that were counterparties of the Bank of Italy at least once in the sample period. Thus, our final sample consists of 74 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) an increase in holdings of securities and government bonds between December 2011 and June 2012, and (iii) two jumps in central bank borrowing in correspondence with the two LTRO allotments (December 2011 and February 2012). The bottom panel shows changes in firm credit. Total credit drawn is defined as the sum of term loans and credit drawn from revolving credit lines and loans backed by account receivables. Total credit granted 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 wholesale funding dry-up.

3 Dry-Up and LTRO: Effects on Bank Credit Supply

In this section, we analyze the effect of the funding dry-up and the effect of the central bank liquidity injection on bank credit supply. In the ideal experimental setting, we would (i) make the firm-bank match random and (ii) randomly assign funding dry-ups and subsequent central bank liquidity injections to banks.

As there would not be systematic differences in the match between lenders and borrowers, we would be able to estimate the causal effect the dry-up on bank credit using the cross-sectional heterogeneity in dry-ups as a source of variation. Similarly, using the cross-sectional heterogeneity in central bank liquidity injections, we would be able to estimate the causal effect of central bank liquidity on bank credit. Thanks to the firm-bank random match, the effects would be fully attributable to changes in bank credit supply, as opposed to changes in firm credit demand. Unfortunately, as these conditions are not satisfied in our setting, we face two empirical challenges.

The first empirical challenge comes from the observation that 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)).[15] Using this subsample, we can fully control for firm observed and unobserved heterogeneity using firm fixed effects. In other words, we can compare how the same firm's loan growth from one affected bank changes relative to the loan growth from another less affected bank.

The second empirical challenge comes from the non-random nature of funding dry-ups and banks' endogenous choice of LTRO borrowing. In the remainder of this section, we tackle this empirical challenge and present our main results. In Section 3.1, we discuss our strategy to measure banks' differential exposure to the wholesale funding shock. In Section 3.2, we show that banks more exposed to the funding dry-up reduced their credit supply during the dry-up and restored it after the central bank intervention, compared with less exposed banks. In Section 3.3, we illustrate our strategy to link the endogenous bank-level uptake of ECB liquidity to bank portfolio choice. Finally, we estimate the effect of the central bank liquidity injection on bank private credit supply and bank holdings of securities in Section

[15] Our sample includes approximately 1.4 million observations at any given date. In most of our analysis we focus on firms with multiple relationships. We make sure that such subsample, which includes approximately 0.7 million observations (approximately 275,000 unique firms at any given time), is comparable to the full sample. Approximately 170,000 firms have two relationships at any given date. More than two relationships is also relatively common: at any given date, of the 275,000 unique firms, approximately 60,000 have three relationships, 24,000 have four relationships, and 21,000 have five or more relationships.

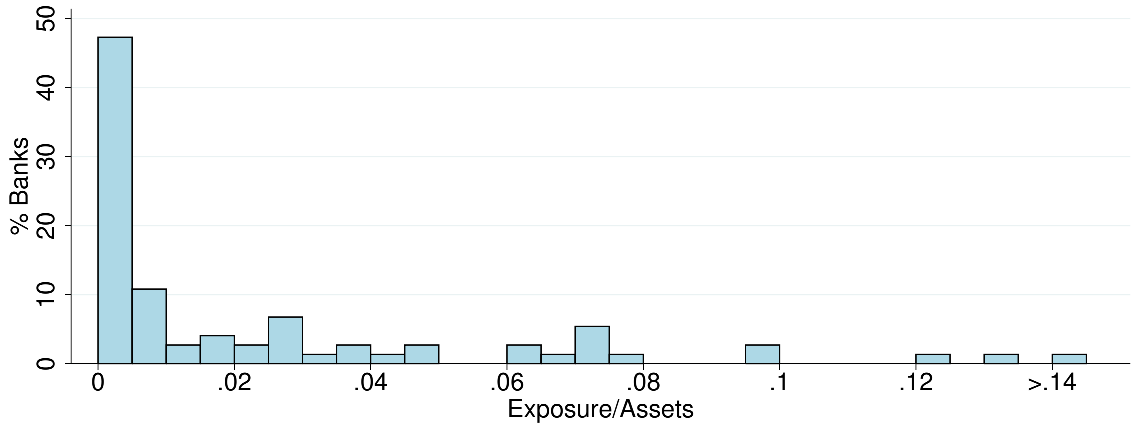

Figure 2: Bank Exposure to the Wholesale Funding Dry-Up. This histogram shows bank-level exposure to the foreign wholesale funding market defined in (1). The y-axis is the share of sample banks. Source: Bank of Italy.

3.4 and Section 3.5, respectively.

3.1 Exposure to the Wholesale Funding Dry-Up

We use banks' reliance on the foreign wholesale funding in June 2011 as a measure of bank exposure to the June 2011-December 2011 dry-up (Iyer et al. (2014)). The intuition, confirmed by our data, is that banks with high exposure to the foreign wholesale funding are more affected by the dry-up compared with banks with low exposure.[16] We define bank j's exposure as the foreign wholesale funding normalized by total assets in June 2011, just before the dry-up:

$$Exposure_{j,Jun11} = \frac{ForeignWholesale_{j,Jun11}}{TotalAssets_{j,Jun11}} \tag{1}$$

[16] In Table C.1 in the Appendix, we show that the exposure to the foreign wholesale market explains the funding shock (both in total wholesale funding and in foreign wholesale funding), controlling for several bank balance sheet characteristics.

where $ForeignWholesale$ is the sum 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.[17]

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 market in June 2011. Exposed banks (above median exposure) tend to be larger, more levered, and more reliant on wholesale funding compared with non-exposed banks (below median exposure). The difference in observables is intuitive. On the one hand, large banks obtain a sizable amount of funding through wholesale markets and have a non-negligible share of total funding coming from foreigners. However, small banks are usually present in local markets where they have a large and stable household deposit base. As will become clear from our main specification, we include bank balance sheet controls as well as stringent fixed effects to tackle the potential omitted variable bias originating from these differences in observables.

Our choice to use banks' exposure to (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 own financial health compared to lenders. In an economy populated by only uninformed lenders, following a shock, the lenders become concerned about the quality of borrowers and interest

[17]The 10th, 30th, 50th, 70th, and 90th percentiles of the distribution of the exposure variable across banks are 0.00%, 0.11%, 0.75%, 2.74%, and 7.57%, respectively.

		Exposed Banks	Non-Exposed Banks
Total Assets	€billions	11.0	1.3
Leverage	Units	13.2	10.8
Tier 1 Ratio	Units	9.1	11.4
Risk-Weighted Assets	%Assets	71.2	68.0
Nonperforming Loans	%Loans	8.6	8.7
Private Credit	%Assets	68.9	70.1
- Credit to Households	%Assets	17.1	20.0
- Credit to Firms	%Assets	43.7	47.0
Securities	%Assets	14.2	14.0
- Government Bonds	%Assets	7.1	6.2
Cash Reserves	%Assets	0.4	0.5
ROA	Profits/Assets	0.2	0.1
Central Bank Borrowing	%Assets	1.8	0.0
Household Deposits	%Assets	24.7	34.9
Wholesale Funding	%Assets	12.2	1.6
Bond Financing	%Assets	22.8	20.2

Table 2: Summary Statistics for Exposed and Non-Exposed Banks. 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) the median in June 2011. The table shows balance sheet characteristics (subsample medians). Source: Bank of Italy.

rates go up for *all* of them. High-quality borrowers then self-select out of the market, causing uninformed lenders to stop lending to *all* of them (Akerlof (1970)). However, if there are some informed lenders in the economy, they will stop lending to low-quality borrowers (Gorton and Pennacchi (1990), Calomiris and Kahn (1991), Dang et al. (2012)). In our empirical analysis, we include a set of controls that capture bank vulnerability (leverage, tier 1 ratio, non-performing loans ratio, ROA) to control for the potential selective withdrawals of informed lenders.[18]

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

3.2 Funding Dry-ups and the Evolution of Bank Credit Supply

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 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 after the ECB steps in to provide LTRO liquidity to banks.[19] In the next subsection, we illustrate the three-period difference-in-differences specification we adopt to (i) compare the stock of credit granted by bank j to firm i in the dry-up period to the same (i, j) stock of credit granted in the normal period and (ii) compare the stock of credit granted by bank j to firm i in the intervention period to the same (i, j) stock of credit granted in the dry-up period.[20]

In our baseline specification, we examine the time series evolution of bank credit supply during the dry-up and intervention periods using the following model:

$$\Delta CreditGranted_{ijt} = \alpha + \beta_1 Exposure_{j,Jun11} \times \mathbb{I}_{DU,LTRO} + \beta_2 Exposure_{j,Jun11} \times \mathbb{I}_{LTRO} + \mu_{it} + \gamma_{ij} + \phi' X_{ijt} + \epsilon_{ijt} \tag{2}$$

where observations are at the (i, j, t) firm-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 firm i at time t.[21] $Exposure_{Jun11}$ is bank j's exposure to

[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 mark-to-market gains on bank holdings of government bonds and other risky securities (see Acharya et al. (2016b)).

[20] By "stacking" two difference-in-differences specifications, we estimate the time-invariant fixed effects on the entire sample period.

[21] Credit granted and total credit are not necessarily equivalent for revolving credit lines and loans backed by account receivables, as the former is the total credit committed, i.e. sum of drawn and undrawn credit.

the foreign wholesale market in June 2011 defined in (1). $\mathbb{I}_{DU,LTRO}$ is a dummy equal to one in the dry-up and the intervention periods and $\mathbb{I}_{LTRO}$ is a dummy equal to one in the intervention period. We add bank-firm fixed effects to absorb any bank-firm time-invariant characteristics, including any time-invariant bank characteristic. We also plug in 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 firm-bank relationship variables, in the vector X_{ijt}, to control for the fact that the same firm might have a different relationship over time with exposed banks compared with 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 to committed credit (measuring how close firm i is from exhausting its borrowing capacity from bank j), and (iii) the share of overdraft credit by firm i with respect to bank j (measuring the extent of an eventual over-borrowing).

Intuitively, as in a standard difference-in-differences setting, the coefficient β_1 captures the difference in credit growth between more exposed banks and less exposed banks during the dry-up period relative to the normal period. Similarly, the coefficient β_2 captures the difference in credit growth between more exposed banks and less exposed banks during the intervention period relative to the dry-up period.[22] 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 during the intervention period in the absence of the ECB intervention.[23] Because bank

As the amount drawn from a credit line is likely driven by firm demand, we choose to use, in line with the literature using credit registry data, credit granted as our dependent variable.

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

[23]In Figure B.3 in the Appendix, we show non-parametrically the time-series evolution of our outcome variable for exposed (exposure above median) and non-exposed (exposure below median) banks and find that credit to firms by exposed banks decreases during the dry-up period and increases during the intervention

exposure is not randomly assigned to 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, return on assets, tier 1 ratio, non-performing loans ratio, and a dummy equal to one if a bank belongs to the large and internationally diversified banking groups.[24]

In Table 3, we show the 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 effect of the dry-up on bank credit supply and a positive effect of the intervention on bank credit supply.

Note that the results are basically unchanged when we include firm-time fixed effects, suggesting that firms borrowing from more exposed banks do not systematically demand more or less credit during the dry-up period and more or less credit during the intervention period compared with less exposed banks. 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 ($Share$, $Overdraft$, $Drawn/Granted$) to account for time-varying bank-firm relationship 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

period, compared with credit to firms by non-exposed banks.

[24] In Table C.2 in the Appendix, we show the time series evolution of several bank balance sheet variables, including pre-trends starting in June 2010, for exposed and non-exposed banks.

	$\Delta CreditGranted$					
	(1)	(2)	(3)	(4)	(5)	(6)
$Exposure_{Jun11} \times \mathbb{I}_{DU,LTRO}$	-0.092**	-0.127***	-0.129***	-0.128***	-0.132***	-0.114***
	(0.041)	(0.045)	(0.037)	(0.037)	(0.040)	(0.031)
$Exposure_{Jun11} \times \mathbb{I}_{LTRO}$	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)
$LEV_{Jun11} \times \mathbb{I}_{DU,LTRO}$						0.141
						(0.207)
$LEV_{Jun11} \times \mathbb{I}_{LTRO}$						0.244
						(0.158)
$ROA_{Jun11} \times \mathbb{I}_{DU,LTRO}$						-0.038*
						(0.020)
$ROA_{Jun11} \times \mathbb{I}_{LTRO}$						0.027
						(0.044)
$T1R_{Jun11} \times \mathbb{I}_{DU,LTRO}$						0.396**
						(0.155)
$T1R_{Jun11} \times \mathbb{I}_{LTRO}$						0.362***
						(0.127)
$NPL_{Jun11} \times \mathbb{I}_{DU,LTRO}$						-0.321*
						(0.185)
$NPL_{Jun11} \times \mathbb{I}_{LTRO}$						0.222**
						(0.101)
$Large \times \mathbb{I}_{DU,LTRO}$						-0.647
						(0.943)
$Large \times \mathbb{I}_{LTRO}$						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: Bank Credit Supply During the Dry-Up and the Intervention Periods. This table presents the results from specification (2). 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. $\mathbb{I}_{DU,LTRO}$ is a dummy equal to one in the dry-up and intervention periods. $\mathbb{I}_{LTRO}$ 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 firm i and bank j, LEV is leverage, ROA is return on assets, $T1R$ is the Tier 1 Ratio, NPL is non-performing loans ratio, 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. Source: Bank of Italy.

they are most exposed to. In column (5) we substitute bank fixed effects with the more stringent bank-firm fixed effects to exploit the variation within the same firm-bank pair over time, thereby controlling for any time-invariant relationship characteristics. Again, affected banks' credit supply contraction during the dry-up relative to unaffected banks is offset by an approximately equivalent increase during the intervention period.[25]

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 1 percentage point less than credit granted by banks with low exposure to the dry-up (bottom decile of the exposure distribution). However, during the intervention period, we observe an offsetting credit supply expansion by high-exposure banks that undoes the contraction during the dry-up period.[26]

Moreover, we find that, during the dry-up period, banks with low regulatory capital and high non-performing loans ratio reduce credit supply compared to other banks. During the intervention period, banks with high non-performing loans ratio on their balance sheets increase their credit supply compared with banks with low non-performing loans ratio, suggesting that the intervention might have also helped low-quality banks that suffered withdrawals from informed lenders during the dry-up.[27]

[25]When we include bank-firm fixed effects, the number of observations shrinks from approximately 2.32 million to 2.17 million. While with bank fixed effects the sample includes firms that have multiple relationships at each date t, with bank-firm fixed effects the sample includes only observations about the *same* bank-firm relationship over time.

[26]In Section 4.2, we aggregate these within firm-bank estimation results to quantify the aggregate effects.

[27]This finding raises the possibility that the central bank liquidity injection might have been allotted to illiquid *and insolvent* banks. However, disentangling bank solvency and illiquidity is beyond the scope of this paper.

3.3 Dissecting the Transmission Channel

We have just documented that banks more exposed to the foreign wholesale market reduce their credit supply during the dry-up and restore their credit supply after the central bank intervention, compared with less exposed banks. We now include the actual bank-level uptake of central bank liquidity in the analysis and discuss the transmission channel. We face an empirical challenge as the uptake of liquidity is not randomly assigned to banks. Banks can in fact *choose* the amount of cash loans they want to obtain from the ECB. Hence, using the heterogeneity of banks' LTRO borrowing as a source of variation, we would probably capture other bank characteristics and our results would suffer from an omitted variable bias.[28]

Interestingly, we find no heterogeneity in banks' uptake of ECB liquidity: banks tap liquidity for approximately 10% of total assets, *regardless* of their exposure to the dry-up. In other words, banks more affected by the funding shock do not tap the liquidity facility more compared with less affected banks. We illustrate this finding in Figure 3, where we divide banks in quartiles according to their exposure to the dry-up and show their LTRO uptake normalized by total assets. We find that bank exposure to the dry-up and bank LTRO uptake are uncorrelated, raising the possibility that the effect on bank credit supply is unrelated to the central bank liquidity injection.

To reconcile the observation that banks with high exposure to the dry-up restored their credit supply after the intervention with the observation that almost every bank took advantage of the attractive ECB liquidity, we exploit a regulatory intervention by the Italian government. Soon after the announcement of the LTRO, the Italian government offered

[28]The existing papers on the transmission of the LTRO simply use banks' endogenous uptake of ECB liquidity as a source of variation (Andrade et al. (2015), Alves et al. (2016), Daetz et al. (2016), Garcia-Posada and Marchetti (2015)). Compared with these analyses, we better identify the causal effect of central bank liquidity on bank portfolio choice and discuss the transmission to both private credit supply and holdings of securities.

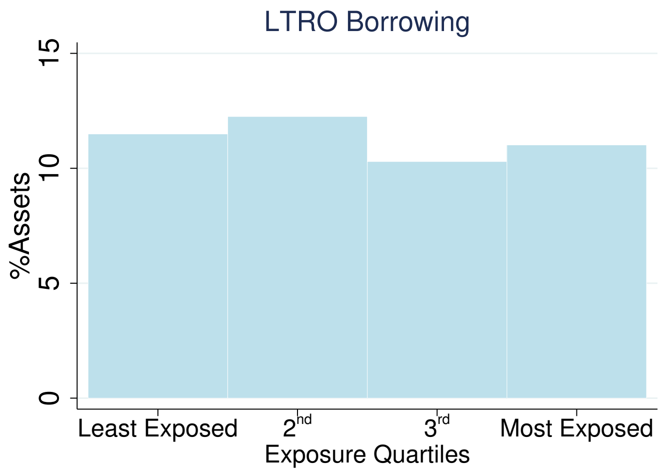

Figure 3: LTRO Uptakes by Bank Exposure Quartile. This histogram shows, for each dry-up exposure quartile, mean LTRO uptakes, normalized by assets in June 2011. Banks are divided in quartiles according to their exposure to the foreign wholesale market in June 2011. Source: Bank of Italy.

banks a guarantee on securities *otherwise ineligible* at the ECB by paying a fee.[29] As the ECB accepts all government-guaranteed assets as collateral, the program effectively gave banks a technology to "manufacture" collateral and therefore increase their borrowing capacity at the central bank.[30]

The use of the government program was sizable as 28 banks created, in aggregate, haircut-adjusted collateral worth €102.8 billion, equivalent to 57% of the total borrowing at the LTRO. The government program, explicitly motivated by the need to help banks with scarce

[29]The government intervention was aimed at increasing the stock of ECB eligible collateral on banks' balance sheets.

[30]Banks could obtain the government guarantee on zero-coupon, senior, unsecured, euro-denominated bank bonds. In the period between the announcement and the second LTRO allotment, banks took advantage of this law by issuing *and retaining* unsecured bank bonds. A retained issuance is effectively a self-issuance as banks do not allow the bonds to go on the market or to investors, but keep them on the asset side of the balance sheet. Paying a 1% fee to the Treasury, banks could then obtain a government guarantee on these newly created bonds (called Government Guaranteed Bank Bonds) so that they became 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. Using our security-level data set, we confirm that these government guaranteed securities are used as collateral at the ECB.

collateral access ECB liquidity, was mainly used by banks hit by the dry-up. For example, government guaranteed collateral backed 68% of LTRO liquidity for banks in the top quartile of the dry-up exposure distribution and only 17% of LTRO liquidity for banks in the bottom quartile of the dry-up exposure distribution.

Our interpreation is intuitive. During the dry-up, between June 2011 and December 2011, we observe that banks affected more by the funding shock eroded their available collateral by pledging it either in the private market or at the central bank to obtain short-term funding.[31] As a result, the Italian government intervened effectively giving banks access to a technology to create eligible collateral by paying a fee to the Treasury. On the one hand, banks hit by the dry-up *self-selected* in the government guarantee program to increase their borrowing capacity at the LTRO. On the other hand, banks relatively unaffected by the dry-up borrowed at the LTRO pledging their own collateral, thus avoiding the payment of the fee.[32]

More formally, we check whether this observation is robust by running, in the sample of banks that borrow at the ECB before the LTRO, the following cross-sectional regression:

$$\Delta Uptake_j = \alpha + \beta Exposure_{j,Jun11} + \mu X_{j,Jun11} + \epsilon_j \tag{3}$$

where $Uptake$ is the bank-level uptake of LTRO liquidity normalized by total assets and the independent variables are the exposure to the dry-up ($Exposure_{Jun11}$) and the usual set of

[31] In Figure B.4 in the Appendix, we show that banks more exposed to the foreign wholesale market eroded their available collateral during the dry-up compared with less exposed banks.

[32] Our findings suggest that, absent the fee, all banks would have chosen to secure additional collateral using the government guarantee program. This setting is similar, in spirit, to Rothschild and Stiglitz (1976) as banks that *self-selected* in the costly collateral option had little collateral because of the dry-up. In the Online Appendix we provide anecdotal evidence, from banks' annual reports, that the fee was high enough to discourage relatively unaffected banks to use the government program.

	$Uptake^{Total}$	$Uptake^{GovtGuarantee}$
$Exposure_{Jun11}$	-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 4: Use of the Government Guarantee Program. This table presents the results from specification (3). The dependent variable in column (1) is the total LTRO uptake. The dependent variable in column (2) is the LTRO uptake backed by government guaranteed collateral. The independent variables are the exposure to the dry-up defined in (1), leverage, return on assets, tier 1 ratio, non-performing loans ratio, and a dummy equal to one if a bank has total assets greater than €500. Sample banks have non-zero borrowing at the ECB in November 2011, before the LTRO. All variables are measured in June 2011. *** p<0.01, ** p<0.05, * p<0.1. Source: Bank of Italy.

bank characteristics measured in June 2011 (vector X_{Jun11}). We show estimation results in Table 4. In column (1), the dependent variable is bank *total* borrowing at the LTRO. Consistent with the non-parametric evidence in Figure 3, we confirm that the bank exposure to the dry-up is uncorrelated with the uptake of LTRO liquidity, even after controlling for bank balance sheet characteristics. In column (2), the dependent variable is bank borrowing at the LTRO collateralized by securities backed by the government guarantee program. The estimation result shows that bank LTRO borrowing backed by the government guaranteed collateral is positively correlated with the exposure to the dry-up.

3.4 Effect on Private Credit Supply

Having provided evidence consistent with the LTRO loans backed by the government program being driven by the dry-up, we next estimate a standard difference-in-differences specification where we simply compare the dry-up (pre-LTRO) period and the intervention (post-LTRO) period, using banks' LTRO uptake as a source of variation. We distinguish between (i) bank total LTRO uptake, (ii) bank LTRO uptake backed by the government guarantee, and (iii) bank LTRO uptake backed by standard (i.e., not guaranteed by the government) collateral. More formally, we estimate the following model:

$$\Delta CreditGranted_{ijt} = \alpha + \beta_1 Uptake_j \times \mathbb{I}_{LTRO} + \mu_{it} + \gamma_{ij} + \phi' \Gamma_{jt} + \epsilon_{ijt} \qquad (4)$$

where the dependent variable is the change in log (stock of) credit granted by bank j to firm i at time t. We compare the dry-up period (June 2011-December 2011) and the intervention period (December 2011-June 2012), using a time dummy $\mathbb{I}_{LTRO}$ 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.

In Table 5, we show the estimation results. In columns (1) and (2), $Uptake^{Total}$ is defined as total bank LTRO uptake. In the second column, we drop bank fixed effects to include more restrictive bank-firm fixed effects. The coefficient on the interaction term between $Uptake^{Total}$ and the time dummy is close to zero and not significant suggesting that banks that tapped more LTRO liquidity did not increase their credit supply during the intervention period more compared with banks that tapped less LTRO liquidity, relative to the dry-up period. Of course, as banks *choose* how much to borrow at the LTRO, the result should not be interpreted as causal.

In columns (3) and (4), the regressor of interest is the interaction between the bank uptake of LTRO liquidity backed by government guaranteed collateral ($Uptake^{GovtGuarantee}$) and the

	$\Delta CreditGranted$					
	(1)	(2)	(3)	(4)	(5)	(6)
$Uptake^{Total} \times \mathbb{I}_{LTRO}$	-0.066	-0.042				
	(0.131)	(0.144)				
$Uptake^{GovtGuarantee} \times \mathbb{I}_{LTRO}$			0.228**	0.249**		
			(0.111)	(0.122)		
$Uptake^{StandardCollateral} \times \mathbb{I}_{LTRO}$					-0.275**	-0.269*
					(0.131)	(0.142)
$LEV \times \mathbb{I}_{LTRO}$	0.538***	0.618***	0.520***	0.596***	0.498***	0.576***
	(0.184)	(0.200)	(0.164)	(0.179)	(0.181)	(0.197)
$ROA \times \mathbb{I}_{LTRO}$	0.029	0.031	0.057	0.061	0.054	0.054
	(0.063)	(0.070)	(0.063)	(0.070)	(0.063)	(0.070)
$T1R \times \mathbb{I}_{LTRO}$	0.720**	0.805**	0.564**	0.633**	0.557*	0.644*
	(0.338)	(0.362)	(0.274)	(0.296)	(0.305)	(0.329)
$NPL \times \mathbb{I}_{LTRO}$	0.474***	0.547***	0.435***	0.497***	0.355**	0.425**
	(0.158)	(0.168)	(0.139)	(0.152)	(0.155)	(0.164)
$Large \times \mathbb{I}_{LTRO}$	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 5: Bank LTRO Liquidity Uptake and Credit Supply. This table presents the results from specification (4). The dependent variable is the difference in log (stock of) credit granted. $Uptake^{Total}$ is the total LTRO uptake divided by assets in June 2011. $Uptake^{StandardCollateral}$ is the LTRO uptake backed by standard collateral, divided by assets in June 2011. $Uptake^{GovtGuarantee}$ is the LTRO uptake backed by the government guarantee program, divided by assets in June 2011. $\mathbb{I}_{LTRO}$ is a dummy equal to one in the intervention period, LEV is leverage, ROA is return on assets, $T1R$ is the tier 1 ratio, NPL is non-performing loans ratio, and $Large$ is a dummy equal to one if the bank has assets above €500 billion. 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. Source: Bank of Italy.

time dummy. Similarly, in columns (5) and (6), the regressor of interest is the interaction between bank uptake of LTRO backed by standard collateral ($Uptake^{StandardCollateral}$) and the time dummy. We find that banks that borrowed more at the ECB pledging government guaranteed collateral increased their credit supply more during the intervention period compared with 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 the ECB.[33] Hence, we find that LTRO liquidity backed by the government guarantee explains the restoration of credit supply, consistent with banks hit by the dry-up *self-selecting* in the costly government guarantee program.

Admittedly, these 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 the central bank, our analysis suggests that the LTRO *long-term* maturity provision 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 the ECB and might have even been a necessary condition for the transmission.[34]

3.5 Effect on Government Bond Holdings

Our analysis of the transmission of central bank liquidity leaves one open question. While all banks borrow at the LTRO, the restoration of bank private credit supply occurs 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 the government bonds around the LTRO intervention stands out: government bond holdings increase from 9.1% to 16.6% of total assets between

[33] 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 coefficients on the interaction variable of interest in columns (3) and (4) and in columns (5) and (6) are mechanically symmetric.

[34] 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 a cost is beyond the scope of this paper.

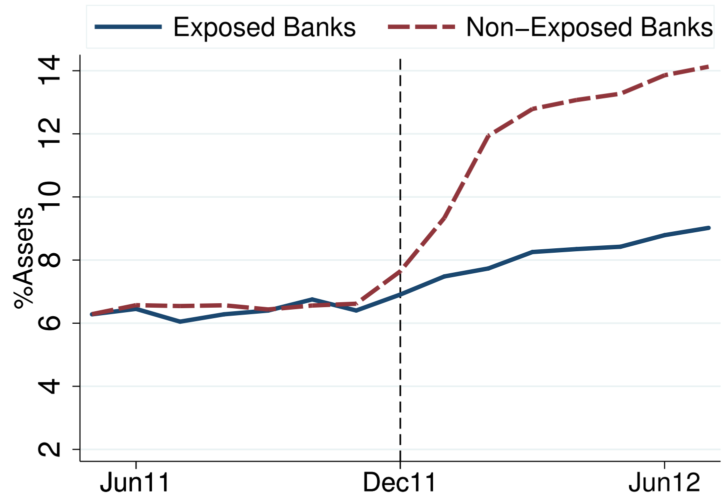

Figure 4: Government Bond Holdings and Exposure to the Dry-up. This figure shows total government bond holdings, normalized by total assets in June 2011, by exposed and non-exposed banks in our sample. Exposed (Non-exposed) banks have dry-up exposure, defined in (1), above (below) median. Source: Bank of Italy, Bloomberg, Datastream.

December 2011 and June 2012, whereas we observe almost no changes before December 2011 and after June 2012. In Figure 4, we document the evolution of government bond holdings for the two subsamples of exposed (above median exposure) and non-exposed (below median exposure) banks and 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 liquidity to increase their private credit supply more compared with less exposed banks. More formally, we estimate the following model in the period from June 2011 to June 2012:

$$Govt_{jt} = \alpha + \beta Exposure_{j,Jun11} \times \mathbb{I}_{LTRO} + \Gamma_{jt} + \eta_t + \gamma_j + \epsilon_{j,t} \tag{5}$$

where the unit of observation is at the bank-month level and the dependent variable is holdings of government bonds by bank j in month t normalized by total assets in June

	$Govt$	$Govt^{Domestic}$	$Govt^{GIIPS}$	$Govt^{GIPS}$	$Govt^{Core}$
$Exposure_{Jun11} \times \mathbb{I}_{LTRO}$	-0.169**	-0.169**	-0.170**	-0.001	-0.004
	(0.072)	(0.077)	(0.076)	(0.004)	(0.004)
$LEV_{Jun11} \times \mathbb{I}_{LTRO}$	0.033	0.036	0.032	-0.005	0.006*
	(0.111)	(0.114)	(0.113)	(0.003)	(0.003)
$ROA_{Jun11} \times \mathbb{I}_{LTRO}$	-1.583	-1.532	-1.641	-0.108	0.012
	(1.724)	(1.756)	(1.741)	(0.097)	(0.054)
$T1R_{Jun11} \times \mathbb{I}_{LTRO}$	0.087***	0.088***	0.086***	-0.001	0.001
	(0.027)	(0.027)	(0.027)	(0.001)	(0.002)
$NPL_{Jun11} \times \mathbb{I}_{LTRO}$	2.839	3.088	3.022	-0.066	-0.112
	(7.574)	(7.560)	(7.542)	(0.083)	(0.117)
$Large_{Jun11} \times \mathbb{I}_{LTRO}$	-0.655	-0.623	-0.589	0.034	-0.017
	(0.827)	(0.877)	(0.854)	(0.055)	(0.019)
Observations	949	949	949	949	949
R-squared	0.866	0.860	0.861	0.606	0.645

Table 6: Effect on Holdings of Government Bonds. This table presents the results from specification (5). The dependent variable in column (1) is the total holdings of government bonds. The dependent variables in columns (2) through (5) are holdings of domestic, GIIPS (Greece, Italy, Ireland, Portugal, Spain), GIPS (Greece, Ireland, Portugal, Spain), and core (U.S., Germany, France) government bonds, respectively. All dependent variables are normalized by total assets in June 2011. The independent variables are the exposure to the dry-up defined in (1), a time dummy $\mathbb{I}_{LTRO}$ equal to one in the intervention period, leverage, return on assets, tier 1 ratio, non-performing loans ratio, 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 includes only securities matched with Bloomberg or Datastream issuer county variable and runs from June 2011 to June 2012. *** p<0.01, ** p<0.05, * p<0.1. Source: Bank of Italy, Bloomberg, Datastream.

2011.[35] The independent variables include time fixed effects, bank fixed effects, the exposure to the dry-up defined in (1) interacted with the time dummy $\mathbb{I}_{LTRO}$ equal to one in the intervention period, and balance sheet characteristics (vector Γ) also interacted with the same time dummy.

We show the estimation results in Table 6. In the first column, the dependent variable is total holdings of government bonds, normalized by assets. We find that the increase

[35] 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.

in holdings of government bonds banks recorded between the dry-up and the intervention period was significantly larger for relatively less exposed banks compared with relatively more exposed ones. In columns (2) through (4), the dependent variables are holdings of domestic, peripheral (Greece, Ireland, Italy, Portugal, Spain), and peripheral non-domestic (Greece, Ireland, Portugal, Spain) government bonds normalized by total assets, respectively. We find that *domestic* government bonds drive the increase in total sovereign bond holdings. These securities are particularly attractive during this period as they carry a zero regulatory risk weight, have a high yield, and, compared to other (non-domestic) high-yield eurozone bonds, can be used for risk-shifting purposes.[36]

The coefficient of interest in the last column, where the dependent variable is holdings of core (U.S., Germany, France) sovereign bonds normalized by total assets, suggests that banks did not increase their holdings of safe government securities, consistent with a reaching-for-yield behavior. These results confirm the theoretical findings in Acharya and Plantin (2017) who show that monetary easing can induce carry trades by financial intermediaries and the empirical findings in Crosignani et al. (2017) who find that Portuguese banks purchased short-term high-yield (domestic) government bonds in 2012, funding their position by borrowing at the LTRO.[37]

To sum up, in the last two subsection we find that (i) banks exposed to the dry-up

[36]The roles of risk-shifting and government moral suasion on domestic government bond holdings during the euro crisis are analyzed by, among others, Crosignani (2016) and Ongena et al. (2016), respectively. Our sample banks display a large home bias in their government bond portfolio, even before the LTRO. In June 2011, the share of domestic securities in the banks' aggregate government bond portfolio is 93.8%.

[37]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 three-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)), a combination of risk-shifting and moral suasion (Altavilla et al. (2016)), or the interplay between a regulator and a common central bank (Uhlig (2013)).

(that used the government guarantee program the most) drive the restoration of private credit supply and (ii) banks relatively less exposed to the dry-up use the attractive central bank loans to reach-for-yield buying domestic government bonds. In particular, exposed banks invested, for every euro borrowed at the LTRO, €0.13 in private credit and €0.44 in government bonds. Banks relatively less exposed purchased exclusively public debt, investing €0.83 in government bonds for every euro borrowed at the LTRO. Overall, we find that the banks in our sample, of the €181.5 billion borrowed at the LTRO, invested €22.6 billion in credit to firms and €82.7 billion in government bonds.[38]

4 Credit Supply Across Banks and Firms

In this section, we check whether the effect of the dry-up and the effect of the central bank intervention on bank credit supply vary across banks and firms and further discuss the channels at work.

4.1 Credit Supply Across Banks

To answer whether the effect of the dry-up and the effect of the intervention on bank credit supply vary across bank fundamentals, we interact our two key independent variables with bank balance sheet characteristics measured in June 2011. For example, we interact the two key difference-in-differences independent variables in our baseline specification (2) with leverage to check whether high-leverage banks reduced their credit supply more compared with low-leverage banks during the dry-up period and, similarly, to check whether high-leverage banks restored their credit supply more compared with low-leverage banks during

[38] In Table C.3 in the Appendix, we show the estimation results that back these quantitative claims.

	$\Delta CreditGranted$					
	(1)	(2)	(3)	(4)	(5)	(6)
$Exposure_{Jun11} \times \mathbb{I}_{DU,LTRO}$	-0.114***	-0.741	-0.099***	-0.475***	0.019	0.846**
	(0.031)	(0.667)	(0.035)	(0.135)	(0.437)	(0.335)
$Exposure_{Jun11} \times \mathbb{I}_{LTRO}$	0.115**	-1.306***	0.090	0.374**	-0.163	-0.358
	(0.053)	(0.444)	(0.065)	(0.186)	(0.608)	(0.513)
$Exposure_{Jun11} \times \mathbb{I}_{DU,LTRO} \times LEV_{Jun11}$		0.039				
		(0.042)				
$Exposure_{Jun11} \times \mathbb{I}_{LTRO} \times LEV_{Jun11}$		0.088***				
		(0.027)				
$Exposure_{Jun11} \times \mathbb{I}_{DU,LTRO} \times ROA_{Jun11}$			2.853***			
			(1.073)			
$Exposure_{Jun11} \times \mathbb{I}_{LTRO} \times ROA_{Jun11}$			-2.056			
			(1.626)			
$Exposure_{Jun11} \times \mathbb{I}_{DU,LTRO} \times T1R_{Jun11}$				-0.014		
				(0.046)		
$Exposure_{Jun11} \times \mathbb{I}_{LTRO} \times T1R_{Jun11}$				0.030		
				(0.064)		
$Exposure_{Jun11} \times \mathbb{I}_{DU,LTRO} \times NPL_{Jun11}$					-0.078***	
					(0.027)	
$Exposure_{Jun11} \times \mathbb{I}_{LTRO} \times NPL_{Jun11}$					0.038	
					(0.040)	
$Exposure_{Jun11} \times \mathbb{I}_{DU,LTRO} \times Large$						-0.523
						(0.323)
$Exposure_{Jun11} \times \mathbb{I}_{LTRO} \times Large$						0.799
						(0.745)
Relationship Controls	✓	✓	✓	✓	✓	✓
Firm-Time FE	✓	✓	✓	✓	✓	✓
Bank-Firm FE	✓	✓	✓	✓	✓	✓
Double Bank-Time Interactions	✓	✓	✓	✓	✓	✓
Observations	2,171,749	2,171,749	2,171,749	2,171,749	2,171,749	2,171,749
R-squared	0.701	0.701	0.701	0.701	0.701	0.701

Table 7: Bank Credit Supply Across Banks. This table presents results from specification (2) augmented to include triple interactions with bank characteristics measured in June 2011. The dependent variable is the difference in log (stock of) credit granted. $Exposure_{Jun11}$ is the exposure to the foreign wholesale market defined in (1). $\mathbb{I}_{DU,LTRO}$ is a dummy equal to one in the dry-up and intervention periods. $\mathbb{I}_{LTRO}$ 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 firm i with respect to bank j), bank characteristics in June 2011 (leverage, return on assets, tier 1 ratio, non-performing loans ratio, and a dummy equal to one if the bank has assets above €500 billion), interacted with the two time dummies. LEV is leverage, ROA is return on assets, $T1R$ is the tier 1 ratio, NPL is non-performing loans ratio, 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. Source: Bank of Italy.

the intervention period.

We show the estimation results in Table 7. In column (1), we report our most conservative baseline specification illustrated in column (6) in Table 3. We then augment the specification with triple interactions in columns (2) through (6). During the dry-up, less profitable banks and banks with larger ratio of non-performing loans reduced credit supply more compared with relatively healthier banks. During the intervention period, high-leverage banks increased their credit supply more compared with low-leverage banks.

The evidence suggests that, holding the negative funding shock constant, high-leverage and low-profitability banks reduced their credit supply more compared with more solid banks. During the intervention period, high-leverage banks drive the restoration of credit supply. These findings are consistent with the literature showing that 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 (Bolton and Freixas (2006)).

4.2 Credit Supply Across Firms

We now examine to which firms banks reduced their credit during the dry-up period and restored their credit supply during the intervention period the most. To this end, we exploit firm-level information on profitability (EBITDA), size, leverage, and credit risk (Z-score). We re-run our most conservative baseline specification, interacting our two key independent variables with firm characteristics, measured in December 2010.[39]

[39] We lose 45% of observations by merging the firm-level data set from the Cebi-Cerved database with our bank-firm observations from the comprehensive national credit registry. However, we can still count on more than a million observations at any given date. As firm-level characteristics are available at an annual frequency, we choose to use firm characteristics measured in December 2010 (the last observation before the dry-up). We present firm summary statistics in the Online Appendix.

	$\Delta CreditGranted$				
	(1)	(2)	(3)	(4)	(5)
$Exposure_{Jun11} \times \mathbb{I}_{DU,LTRO}$	-0.114***	-0.117	-0.122***	-0.117***	-0.082*
	(0.031)	(0.268)	(0.041)	(0.038)	(0.045)
$Exposure_{Jun11} \times \mathbb{I}_{LTRO}$	0.115**	-0.424***	0.144**	0.121**	0.075
	(0.053)	(0.148)	(0.059)	(0.056)	(0.048)
$Exposure_{Jun11} \times \mathbb{I}_{DU,LTRO} \times FirmSize_{Dec10}$		-0.000			
		(0.019)			
$Exposure_{Jun11} \times \mathbb{I}_{LTRO} \times FirmSize_{Dec10}$		0.036***			
		(0.011)			
$Exposure_{Jun11} \times \mathbb{I}_{DU,LTRO} \times FirmProfitability_{Dec10}$			0.058		
			(0.202)		
$Exposure_{Jun11} \times \mathbb{I}_{LTRO} \times FirmProfitability_{Dec10}$			-0.339***		
			(0.112)		
$Exposure_{Jun11} \times \mathbb{I}_{DU,LTRO} \times FirmLeverage_{Dec10}$				-0.018	
				(0.024)	
$Exposure_{Jun11} \times \mathbb{I}_{LTRO} \times FirmLeverage_{Dec10}$				0.012	
				(0.036)	
$Exposure_{Jun11} \times \mathbb{I}_{DU,LTRO} \times FirmRisky_{Dec10}$					-0.055**
					(0.027)
$Exposure_{Jun11} \times \mathbb{I}_{LTRO} \times FirmRisky_{Dec10}$					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 8: Bank Credit Supply Across Firms. This table presents results from specification (2) 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 defined in (1). $\mathbb{I}_{DU,LTRO}$ is a dummy equal to one in the dry-up and intervention periods. $\mathbb{I}_{LTRO}$ 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 firm i with respect to bank j), bank characteristics in June 2011 (leverage, return on assets, tier 1 ratio, non-performing loans ratio, 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). We do not observe the continuous Z-score variable and are therefore forced to use a dummy variable to measure firm risk. Standard errors double clustered at the bank and firm level in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Source: Bank of Italy Cebi-Cerved Database.

We show the estimation results in Table 8. Again, we report our baseline specification in column (1), as a reference. In columns (2) through (5), we include the triple interaction terms. For example, in column (2), we ask whether the effect of the dry-up and the effect of the intervention on credit supply change depending on firm size, where the variable $FirmSize_{Dec10}$ is the log of firm total assets in December 2010. Similarly, the last three columns include triple interactions with firm profitability, firm leverage, and a firm riskiness dummy. 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 reduced their credit supply more compared with safer clients. However, during the intervention period, banks more exposed to the the dry-up increased their credit supply especially to large, low-profitability, and risky firms, compared with banks less exposed to the dry-up.

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

5 Effect on Firm Borrowing

In this section, we examine the effect of the funding dry-up and the effect of the intervention on firm borrowing behavior and compute the aggregate effects. To this end, we analyze total firm borrowing, collapsing our bank-firm-time data set at the firm-time level.

For each firm, we compute the *indirect* exposure to the dry-up based on its banking relationships. Formally, the indirect exposure of firm i is given by the weighted average of its banks' exposures to the dry-up, where the weights are given by the total credit drawn from each bank in June 2011. For each firm i, we compute

$$\widetilde{Exposure}_{i,Jun11} = \frac{\sum_{j\in\mathcal{R}^i} Drawn_{ij,Jun11} Exposure_{j,Jun11}}{\sum_{j\in\mathcal{R}^i} Drawn_{ij,Jun11}} \tag{6}$$

where $\mathcal{R}^i$ is the subset of banks that have a relationship with firm i in June 2011 and $Exposure_{j,Jun11}$ is defined in (1).

5.1 Do Firms Switch Lenders?

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 by affected banks during the intervention period.

To clarify our question, consider the following example. Firm F borrows from bank H and bank L before the dry-up. Bank H is exposed to the dry-up and bank L is not. Even if bank H reduces its credit supply to firm F, firm F may still be able to undo the credit contraction by borrowing more from bank L. By looking at total firm credit (extended by all banks), we can check whether this substitution takes place during the dry-up and whether total firm borrowing increases following the intervention. More formally, we estimate the following model:

$$\begin{aligned} \Delta CreditDrawn_{it} = \alpha &+ \beta_1 \widetilde{Exposure}_{i,Jun11} \times \mathbb{I}_{DU,LTRO} + \beta_2 \widetilde{Exposure}_{i,Jun11} \times \mathbb{I}_{LTRO} \\ &+ \psi' \Lambda_{it} + \phi' \Gamma_{it} + \eta_t + \chi_i + \epsilon_{it} \end{aligned} \tag{7}$$

where observations are at the (i,t) firm-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) total firm i credit at time t and $\widetilde{Exposure}_i$ is the indirect exposure of firm i to the dry-up defined in (6). $\mathbb{I}_{DU,LTRO}$ and $\mathbb{I}_{LTRO}$ are the usual time dummies, η are time fixed effects, and χ are firm fixed effects.

We also saturate the regression with bank-level and firm-level controls. Bank characteristics (vector Λ) include the indirect exposure of firm i to each bank balance sheet control used in our baseline regression, following the definition illustrated in (6), interacted with the two time dummies. Firm characteristics (vector Γ_{it}) include the interaction between the two time dummies and a series of firm characteristics, namely (log of) total assets, profitability (EBITDA), leverage, and credit risk (Z-score). As firm balance-sheet variables are available at an annual frequency, we use observations in December 2010.

Similar to the baseline regression, the coefficient β_1 captures the extent to which the difference in bank credit growth between more and less exposed firms varies during the dry-up relative the normal period and the coefficient β_2 captures the extent to which the difference in bank credit growth between more and less affected firms varies during the intervention period relative to the dry-up period.

We show the estimation results in Table 9. In the first column, we find that the firms more exposed to the dry-up reduced their total credit from banks during the dry-up and restored it during the intervention period compared with firms less exposed to the dry-up. These results suggest that (i) firms were unable to completely undo the credit contraction and were therefore affected by the wholesale funding dry-up and (ii) the intervention helped firms re-access bank credit.

The inability to substitute sources 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 (Duffie and Strulovici (2012)). In the literature on information frictions, lenders have private information about their borrowers, and borrowers left looking for a new lender are adversely selected, preventing a full reallocation of credit (Darmouni (2016)).

In columns (2) through (5), we include triple interaction terms to ask which types of

	$\Delta CreditDrawn$				
	(1)	(2)	(3)	(4)	(5)
$\mathbb{I}_{DU,LTRO} \times \widetilde{Exposure}_{Jun11}$	-0.701***	-0.435	-0.671***	-0.707***	-1.060***
	(0.159)	(0.953)	(0.172)	(0.158)	(0.164)
$\mathbb{I}_{LTRO} \times \widetilde{Exposure}_{Jun11}$	0.812***	1.152	0.781***	0.812***	0.994***
	(0.190)	(1.085)	(0.202)	(0.196)	(0.188)
$\mathbb{I}_{DU,LTRO} \times \widetilde{Exposure}_{Jun11} \times FirmSize_{Dec10}$		-0.019			
		(0.068)			
$\mathbb{I}_{LTRO} \times \widetilde{Exposure}_{Jun11} \times FirmSize_{Dec10}$		-0.024			
		(0.076)			
$\mathbb{I}_{DU,LTRO} \times \widetilde{Exposure}_{Jun11} \times FirmProfitability_{Dec10}$			-0.492		
			(0.382)		
$\mathbb{I}_{LTRO} \times \widetilde{Exposure}_{Jun11} \times FirmProfitability_{Dec10}$			0.492		
			(0.331)		
$\mathbb{I}_{DU,LTRO} \times \widetilde{Exposure}_{Jun11} \times FirmLeverage_{Dec10}$				0.097	
				(0.123)	
$\mathbb{I}_{LTRO} \times \widetilde{Exposure}_{Jun11} \times FirmLeverage_{Dec10}$				-0.012	
				(0.251)	
$\mathbb{I}_{DU,LTRO} \times \widetilde{Exposure}_{Jun11} \times FirmRisky_{Dec10}$					0.552***
					(0.191)
$\mathbb{I}_{LTRO} \times \widetilde{Exposure}_{Jun11} \times FirmRisky_{Dec10}$					-0.283**
					(0.137)
Time FE	✓	✓	✓	✓	✓
Firm FE	✓	✓	✓	✓	✓
Bank-level Controls Λ_{it}	✓	✓	✓	✓	✓
Firm-level Controls 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: Effect on Firm Borrowing. This table presents the results from specification (7). 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 defined in (6). $\mathbb{I}_{DU,LTRO}$ is a dummy equal to one in the *dry-up* and *intervention* periods. $\mathbb{I}_{LTRO}$ 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). We do not observe the continuous Z-score variable and are therefore forced to use a dummy variable to measure firm risk. 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. Source: Bank of Italy, Cebi-Cerved Database.

firms were able to at least partially undo the credit crunch and which types of firms were able to benefit from the intervention the most. We find that risky firms were able to smooth the credit crunch as they drew down their credit during the dry-up. They also benefited less from the intervention by borrowing less in the intervention period compared with less risky firms. Our findings are consistent with Ippolito et al. (2016), who show that financially constrained firms increase the drawdown on their credit 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 with less constrained firms.

5.2 Aggregate Effect

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

We proceed in five steps. First, we estimate the firm-time fixed effects $\hat{\mu}_{it}$ from our baseline regression (2). 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 (6). In this way, we obtain both firm demand and firm exposure to the wholesale funding shock. Third, we plug the stored firm-time fixed effects $\hat{\mu}$ computed in the first step into the firm-level equation and estimate

$$\begin{aligned}\Delta CreditGranted_{it} = \alpha &+ \beta_1 \widetilde{Exposure}_{i,Jun11} \times \mathbb{I}_{DU,LTRO} + \beta_2 \widetilde{Exposure}_{i,Jun11} \times \mathbb{I}_{LTRO} \\ &+ \hat{\mu}_{it} + \psi' \Lambda_{it} + \phi' \Gamma_{it} + \eta_t + \chi_i + \epsilon_{it} \qquad (8)\end{aligned}$$

where the only differences with (7) are the dependent variable (we now use credit *granted* aggregated at the firm level) and the inclusion of the fixed effects $\hat{\mu}$ as an independent variable.

In the fourth step, we use the coefficients estimated in (8) and average exposures to the shock to predict the change in firm loan growth. In the last step, we aggregate at the period-level using a weighted average of firm-level loan growth, where the weights are given by firm-level granted credit in December 2011.

We then compare the world with no LTRO intervention with 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. In particular, the underlying assumption is that, absent the ECB intervention, the supply of credit granted would have decreased at the same rate of the dry-up period 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 bank credit 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 using the ECB three-year LTRO and the Italian economy as a laboratory. We show that the banks that experience a wholesale market dry-up before the intervention (i) reduce their credit supply during the period of funding stress and (ii) restore their credit supply once the central bank injects liquidity into the system. A large fraction of central bank liquidity is however transmitted to increased holdings of high-yield securities as banks relatively less affected by the wholesale funding dry-up use the central bank liquidity injection to reach-for-yield.

We contribute to the seminal lender of last resort literature by examining how a central bank can counter a credit contraction following a negative shock. While existing papers illustrate the negative effects of funding shocks or the positive effects of accommodative monetary policy on bank credit supply in isolation, we find that a central bank can counter an ongoing credit contraction by providing long-term collateralized liquidity to banks.

Our findings also open interesting avenues for future research on the design of the lender of last resort. The regulatory intervention by the national government used in our empirical strategy suggests that banks that need the liquidity injection the most are those that might be mechanically excluded from accessing central bank liquidity, as they might lack high quality collateral at the time of the intervention. In this sense, our results indicate that a temporary relaxation of collateral requirements might be instrumental for the pass-through. Hence, in designing the optimal collateral policy following a dry-up, policy makers face a trade-off between restoring bank intermediation and increasing ex ante moral hazard.

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Appendix A Specification

In this section, we consider the following simplified version of (2):

$$y_{jt} = \beta_0 + \beta_1 T_j + \beta_2 \mathbb{I}_{DU,LTRO} + \beta_3 T_j \times \mathbb{I}_{DU,LTRO} + \beta_4 \mathbb{I}_{LTRO} + \beta_5 T_j \times \mathbb{I}_{LTRO} + \epsilon_{it} \tag{A1}$$

where j is a bank and t is a date. T_j is a treatment dummy. There are three periods: the dummy $\mathbb{I}_{DU,LTRO}$ is equal to one in the second and third period. The dummy $\mathbb{I}_{LTRO}$ 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.

$$\begin{aligned}\beta_3 =& E(y_{jt}|\mathbb{I}_{DU,LTRO} = 1, \mathbb{I}_{LTRO} = 0, T_j = 1) - E(y_{jt}|\mathbb{I}_{DU,LTRO} = 0, \mathbb{I}_{LTRO} = 0, T_j = 1)\\ &- \big(E(y_{jt}|\mathbb{I}_{DU,LTRO} = 1, \mathbb{I}_{LTRO} = 0, T_j = 0) - E(y_{jt}|\mathbb{I}_{DU,LTRO} = 0, \mathbb{I}_{LTRO} = 0, T_j = 0)\big)\\ \beta_5 =& E(y_{jt}|\mathbb{I}_{DU,LTRO} = 1, \mathbb{I}_{LTRO} = 1, T_j = 1) - E(y_{jt}|\mathbb{I}_{DU,LTRO} = 1, \mathbb{I}_{LTRO} = 0, T_j = 1)\\ &- \big(E(y_{jt}|\mathbb{I}_{DU,LTRO} = 1, \mathbb{I}_{LTRO} = 1, T_j = 0) - E(y_{jt}|\mathbb{I}_{DU,LTRO} = 1, \mathbb{I}_{LTRO} = 0, T_j = 0)\big)\end{aligned}$$

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

$E(y_{jt}|\mathbb{I}_{DU,LTRO} = 0, \mathbb{I}_{LTRO} = 0, T_j = 0) = \beta_0$

$E(y_{jt}|\mathbb{I}_{DU,LTRO} = 0, \mathbb{I}_{LTRO} = 0, T_j = 1) = \beta_0 + \beta_1$

$E(y_{jt}|\mathbb{I}_{DU,LTRO} = 1, \mathbb{I}_{LTRO} = 0, T_j = 0) = \beta_0 + \beta_2$

$E(y_{jt}|\mathbb{I}_{DU,LTRO} = 0, \mathbb{I}_{LTRO} = 0, T_j = 1) = \beta_0 + \beta_1 + \beta_2 + \beta_3$

$E(y_{jt}|\mathbb{I}_{DU,LTRO} = 1, \mathbb{I}_{LTRO} = 1, T_j = 0) = \beta_0 + \beta_2 + \beta_4$

$E(y_{jt}|\mathbb{I}_{DU,LTRO} = 1, \mathbb{I}_{LTRO} = 1, T_j = 1) = \beta_0 + \beta_1 + \beta_2 + \beta_3 + \beta_4 + \beta_5$

$\Rightarrow (y_{jt}|\mathbb{I}_{DU,LTRO} = 1, \mathbb{I}_{LTRO} = 0, T_j = 1) - E(y_{jt}|\mathbb{I}_{DU,LTRO} = 0, \mathbb{I}_{LTRO} = 0, T_j = 1)$

$- \big(E(y_{jt}|\mathbb{I}_{DU,LTRO} = 1, \mathbb{I}_{LTRO} = 0, T_j = 0) - E(y_{jt}|\mathbb{I}_{DU,LTRO} = 0, \mathbb{I}_{LTRO} = 0, T_j = 0)\big) = \beta_3$

$\Rightarrow E(y_{jt}|\mathbb{I}_{DU,LTRO} = 1, \mathbb{I}_{LTRO} = 1, T_j = 1) - E(y_{jt}|\mathbb{I}_{DU,LTRO} = 1, \mathbb{I}_{LTRO} = 0, T_j = 1)$

$- \big(E(y_{jt}|\mathbb{I}_{DU,LTRO} = 1, \mathbb{I}_{LTRO} = 1, T_j = 0) - E(y_{jt}|\mathbb{I}_{DU,LTRO} = 1, \mathbb{I}_{LTRO} = 0, T_j = 0)\big) = \beta_5$

□

Appendix B Additional Figures

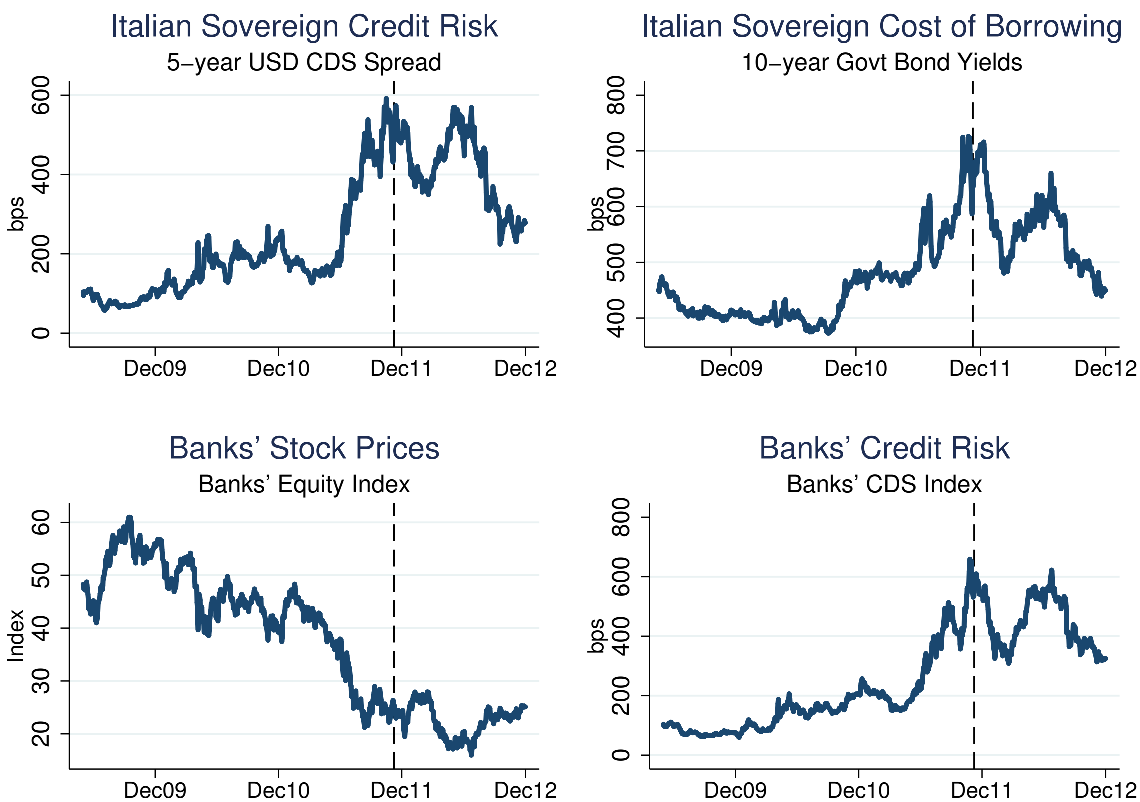

Figure B.1: Italian Bank and Sovereign Credit Risk. The top left figure shows the Italian sovereign 5-year USD-denominated CDS spread. The top right figure shows the Italian 10-year government bond yield. The bottom left figure shows Italian banks' equity prices (MSCI Italian Financials Index). The bottom right figure shows mean Italian banks' CDS spread using data on the six major banks with CDS spreads available on Bloomberg for the entire sample. The vertical dashed line corresponds to the LTRO announcement on December 8, 2011. Source: Bloomberg.

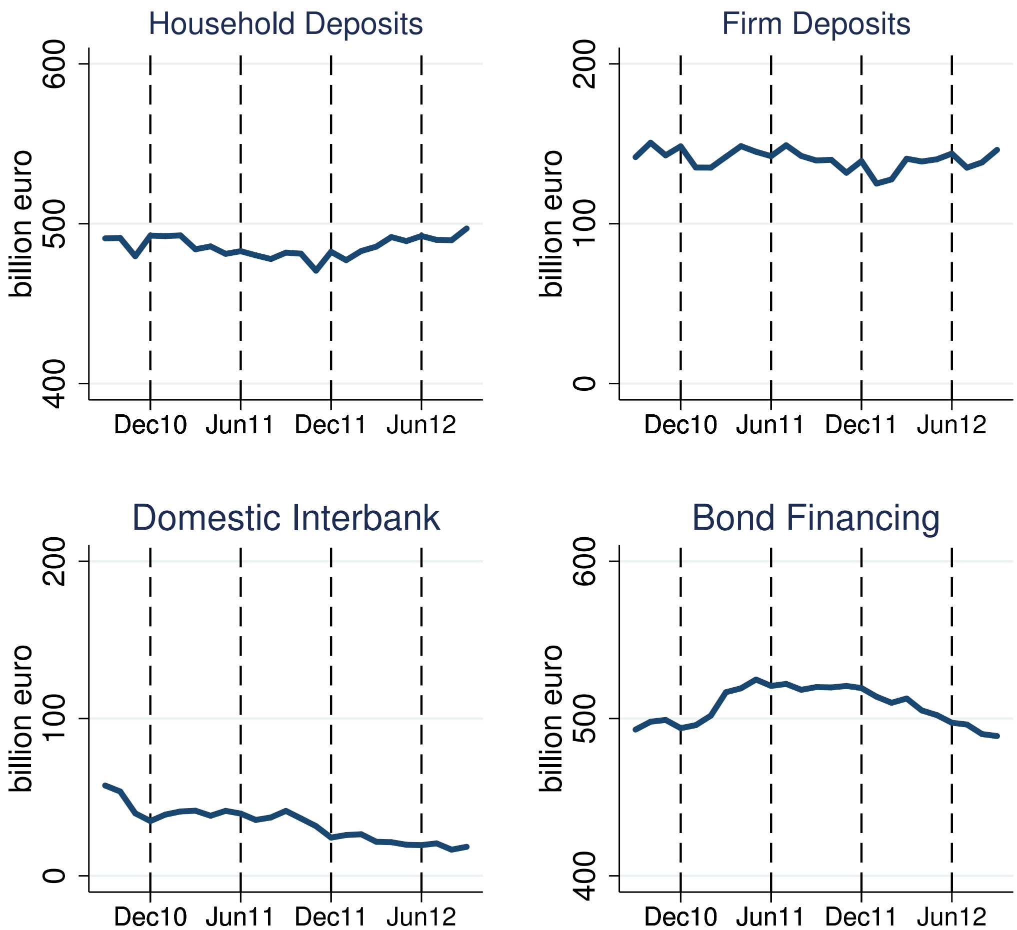

Figure B.2: Bank Funding Sources. This figure shows the time series evolution of various sources of bank funding during our sample period. The dashed vertical lines correspond to December 2010, June 2011, December 2011, and June 2012. They delimit the normal, dry-up, and intervention periods. The four panels show household deposits, firm deposits, domestic interbank funding, and bond financing, respectively. Quantities are in billion euro. Source: Bank of Italy.

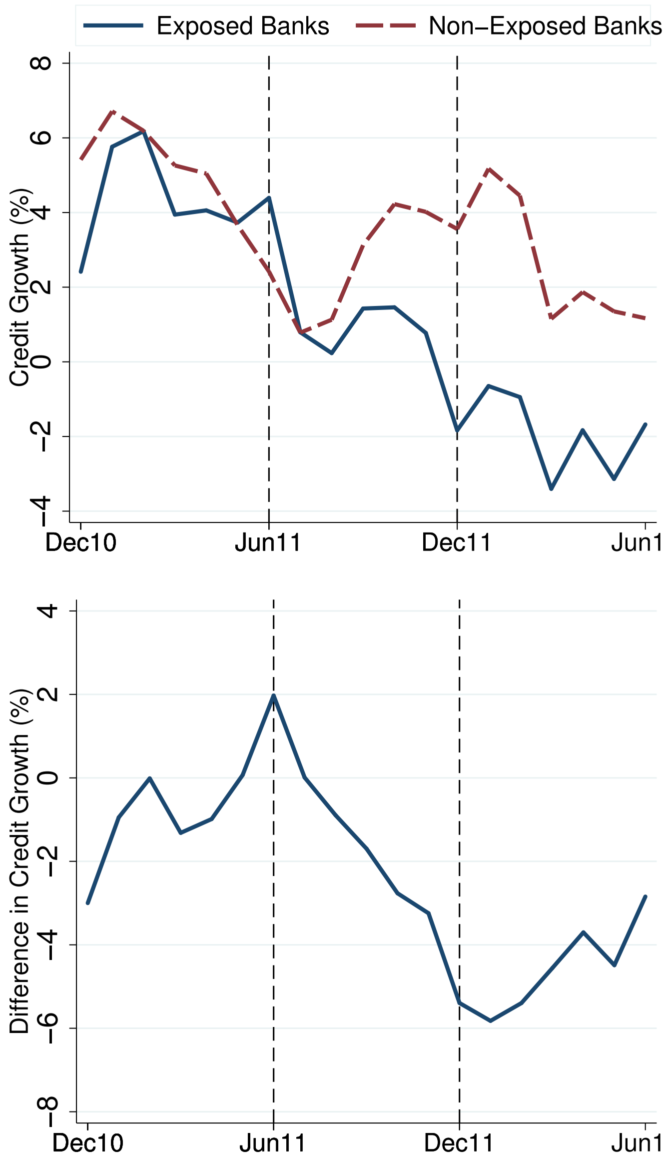

Figure B.3: Outcome Variable: Time-Series Evolution. This figure shows the time-series evolution of our outcome variable during the normal, dry-up, and intervention periods. The top panel shows the time-series evolution of the change in (six-month) credit growth to firms by exposed and non-exposed banks. Exposed (non-exposed) banks have exposure to the dry-up above (below) median. The bottom panel shows the difference between the two time-series in the left panel during the same sample period. Source: Bank of Italy.

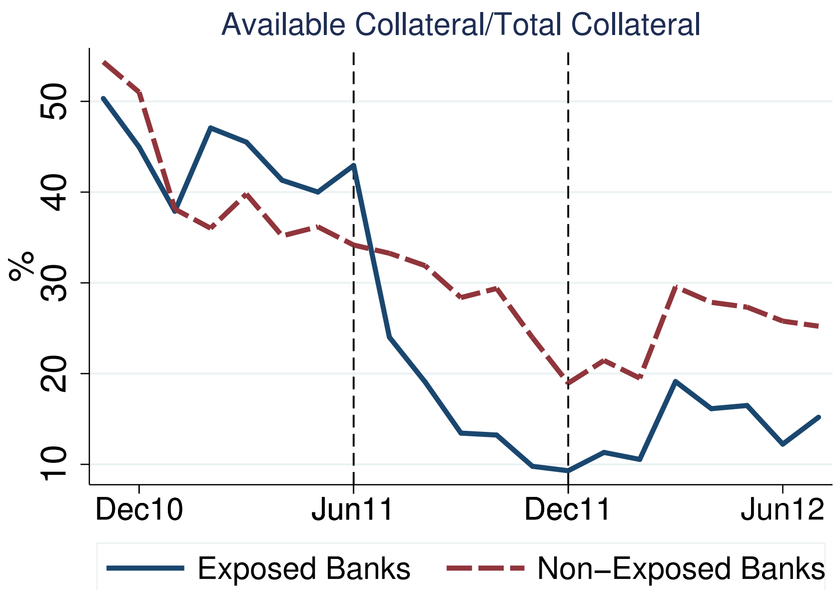

Figure B.4: Erosion of ECB Eligible Collateral During the Dry-Up. This plot shows the time-series evolution of available (not pledged) ECB eligible collateral divided by total ECB eligible collateral. The solid (dashed) line shows the share of available ECB eligible collateral from December 2010 to June 2012 for exposed (non-exposed) banks. Exposed (non-exposed) banks have exposure to the dry-up above (below) median. The two vertical dashed lines delimit the dry-up period. Collateral (in percentages on the y-axis) is haircut adjusted. Source: Bank of Italy.

Appendix C Additional Tables

Panel A	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

Panel B	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.1: Wholesale Market Exposure and Dry-up. These two panels present the results from two cross-sectional regressions. In the top panel, the dependent variable is the change in wholesale market funding between June 2011 and December 2011 (normalized by total assets in June 2011). In bottom top panel, the dependent variable is the change in foreign wholesale market funding between June 2011 and December 2011 (normalized by total assets in June 2011). In both panels, the independent variables are the exposure to the foreign wholesale market defined in (1), leverage, return on assets, tier 1 ratio, non-performing loans ratio, and a dummy equal to one if a bank belongs to a banking group with assets greater than €500. Only 73 of our 74 sample banks are alive in this period. All independent variables are measured in June 2011. *** p<0.01, ** p<0.05, * p<0.1. Source: Bank of Italy.

Panel A Exposed Banks		**Jun10**	**Dec10**	**Jun11**	**Dec11**	**Jun12**	**Dec12**
Total Assets	€billions	10.2	10.5	11.0	11.4	12.9	12.9
Leverage	Units	13.5	14.2	13.2	13.4	14.0	13.9
Tier 1 Ratio	Units	8.9	8.7	9.1	9.4	10.4	10.8
Risk-Weighted Assets	%Assets	71.7	70.6	71.2	69.3	64.3	60.8
Non-performing Loans	%Liabilities	8.1	8.0	8.6	8.9	10.8	11.7
Private Credit	%Assets	64.7	66.8	68.9	69.1	69.4	69.4
- Credit to Households	%Assets	15.9	16.6	17.1	17.7	17.5	18.0
- Credit to Firms	%Assets	40.5	42.3	43.7	44.7	44.1	42.8
Securities	%Assets	13.9	13.6	14.2	14.9	20.0	18.5
- Government Bonds	%Assets	3.3	5.1	7.1	7.7	12.3	15.0
Cash Reserves	%Assets	0.4	0.4	0.4	0.4	0.4	0.5
ROA	Profits/Assets	0.2	0.3	0.2	0.2	0.2	0.1
Central Bank Borrowing	%Assets	0.4	3.1	1.8	7.2	11.0	10.8
Household Deposits	%Assets	27.4	26.6	24.7	25.5	24.5	25.0
Wholesale Funding	%Assets	11.0	10.9	12.2	11.5	11.7	10.9
Bond Financing	%Assets	19.3	20.6	22.8	19.3	16.9	16.5

Panel B Non-Exposed Banks		**Jun10**	**Dec10**	**Jun11**	**Dec11**	**Jun12**	**Dec12**
Total Assets	€billions	1.2	1.1	1.3	1.1	1.4	1.6
Leverage	Units	10.8	10.9	10.8	10.4	11.4	11.6
Tier 1 Ratio	Units	12.5	11.7	11.4	12.3	12.8	12.5
Risk-Weighted Assets	%Assets	68.4	70.1	68.0	69.8	65.7	64.3
Non-performing Loans	%Liabilities	8.3	8.5	8.7	9.2	10.9	11.9
Private Credit	%Assets	64.1	67.5	70.1	71.1	71.5	76.1
- Credit to Households	%Assets	18.8	19.3	20.0	19.7	19.6	20.2
- Credit to Firms	%Assets	42.4	45.0	47.0	49.1	48.8	51.2
Securities	%Assets	15.4	14.5	14.0	16.1	23.4	20.6
- Government Bonds	%Assets	4.7	5.6	6.2	7.9	15.8	15.5
Cash Reserves	%Assets	0.5	0.6	0.5	0.6	0.5	0.6
ROA	Profits/Assets	0.1	0.2	0.1	0.2	0.1	0.2
Central Bank Borrowing	%Assets	0.0	0.0	0.0	2.1	12.2	12.5
Household Deposits	%Assets	38.1	35.7	34.9	33.8	33.8	34.6
Wholesale Funding	%Assets	1.6	1.6	1.6	1.6	1.7	1.5
Bond Financing	%Assets	20.5	20.1	20.2	17.0	14.4	13.9

Table C.2: Exposed and Non-Exposed Banks: Time-Series Evolution. This table shows cross-sectional medians of selected balance sheet items during the period from June 2010 to December 2012.The top panel (bottom panel) shows medians 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 Table 2 to capture the time-series dimension. Source: Bank of Italy.

	Private Credit	Government Bonds	Private Credit	Government Bonds
$Uptake^{Total} \times \mathbb{I}_{LTRO}$	0.129**	0.442*	0.001	0.829***
	(0.054)	(0.244)	(0.127)	(0.089)
$LEV_{Jun11} \times \mathbb{I}_{LTRO}$	-0.101	-0.159	0.372	-0.433**
	(0.139)	(0.323)	(0.255)	(0.180)
$ROA_{Jun11} \times \mathbb{I}_{LTRO}$	-2.209	16.849**	-1.496	-3.269*
	(2.013)	(6.586)	(2.537)	(1.614)
$T1R_{Jun11} \times \mathbb{I}_{LTRO}$	0.050	-0.074	0.083**	-0.049*
	(0.082)	(0.295)	(0.038)	(0.025)
$NPL_{Jun11} \times \mathbb{I}_{LTRO}$	-29.796*	43.839	-9.423	-10.380**
	(15.659)	(34.931)	(11.085)	(5.033)
$Large_{Jun11} \times \mathbb{I}_{LTRO}$	1.903	-6.617		
	(1.192)	(4.069)		
Time FE	✓	✓	✓	✓
Bank FE	✓	✓	✓	✓
Sample	Exposed Banks	Exposed Banks	Non-Exposed Banks	Non-Exposed Banks
Observations	468	481	468	468
R-squared	0.994	0.875	0.954	0.937

Table C.3: Transmission of LTRO Liquidity by Exposed and Non-Exposed Banks. This table shows the results from a difference-in-differences regression during the period from June 2011 and June 2012. The unit of observation is at the bank-month level. $\mathbb{I}_{LTRO}$ is a dummy equal to one in the intervention period from January 2012 to June 2012. The independent variable in columns (1) and (3) is the total private credit normalized by total assets in June 2011. The independent variable in columns (2) and (4) is the holdings of government bonds normalized by total assets in June 2011. In columns (1) and (2) the sample includes banks with an exposure to the dry-up above median. In columns (3) and (4) the sample includes banks with an exposure to the dry-up below median. $Uptake^{Total}$ is the total LTRO uptake divided by assets in June 2011, LEV is leverage, ROA is return on assets, $T1R$ is the Tier 1 Ratio, NPL is non-performing loans ratio, and $Large$ is a dummy equal to one if the bank has assets above €500 billion. Standard errors clustered at the bank level in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Source: Bank of Italy.