

# Double Bank Runs and Liquidity Risk Management

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## **Abstract**

Banks provide liquidity to depositors and to credit-line borrowers, and are thus exposed to double runs. We identify this risk by exploiting the European interbank market freeze in August 2007 and the comprehensive Italian Credit Register. After the interbank shock, firms with multiple credit lines draw down especially from more affected banks, measured by higher pre-crisis interbank funding. This effect is not driven by different loan prices, is stronger for financially constrained firms and banks, and comes from the fear (confirmed ex-post) of a cut in granting new loan applications by banks with high interbank exposure. However, there are *no* double runs at the aggregate bank-level or credit-line runs at the loan-level, unless we control for firm selection (fixed effects or observables), which implies that banks with higher interbank funding do not suffer larger overall credit-line drawdowns. This is the result of ex-ante liquidity risk management, whereby more liability-fragile banks in the period before the crisis extend less credit lines to firms that draw more in crisis times.

*Keywords:* Credit lines; Liquidity risk; Financial crisis; Runs; Risk management.

*JEL Codes:* G01, G21, G28.

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# 1. Introduction

The financial crisis that started in 2007 was centered on wholesale liquidity problems at financial institutions. This was in stark contrast with previous financial crises in history, where bank runs were mainly coming from retail depositors (Gorton and Metrick, 2012; European Central Bank, 2012; Freixas, Laeven and Peydró, 2015). The financial crisis hit European markets on August 9, 2007 when the interbank market dried up. Therefore, banks more reliant on interbank funding suffered a severe (liability) funding liquidity shock. Moreover, there is some evidence that firms increased the drawdown on available credit lines after the failure of Lehman Brothers in September 2008 (Ivashina and Scharfstein, 2010), which implies a liquidity shock on the asset side of banks. In this paper we ask to what extent the drawdowns on credit lines are more intense for banks more exposed to the wholesale (interbank) funding liquidity shock, thereby leading to an asset and liability – double – bank run, and whether banks do ex-ante liquidity risk management to minimize this risk of double runs.

The provision of liquidity to both firms and depositors is at the heart of banking. Diamond and Dybvig (1983), among others, identify the existence of synergies between bank assets and liabilities. This explains why banks pair illiquid assets (loans), with liquid liabilities (retail and wholesale deposits) that are subject to runs. Kashyap, Rajan and Stein (2002) emphasize the parallel between deposits and credit lines as both are subject to runs. They argue that, as long as deposit withdrawals and credit lines drawdowns are imperfectly correlated, offering both products allows them to economize on costly liquidity buffers. Moreover, Hanson, Shleifer, Stein and Vishny (2014) argue that financial institutions with more fragile sources of funding (uninsured wholesale finance) should hold assets with lower liquidity risk, such as credit lines.<sup>1</sup> On the other hand, the opinion of many commentators and the implications of several theoretical models indicate that, in the presence of moral hazard, weaker banks with less stable funding are prone to excessive risk-taking, e.g. by minimizing liquidity risk management (Freixas and Rochet, 2008). This debate highlights the importance of an empirical analysis of correlated (double) asset-liability bank runs as a test of the existing theory, as well as for the design of prudential policy and for a better understanding of financial crises.

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<sup>1</sup> Other theory papers also examine the synergies between bank assets and liabilities. Diamond and Rajan (2001) show that the fragility of bank deposits disciplines bank management, enhancing the value of illiquid bank loans. Rochet and Vives (2004) also show that interbank runs can discipline banks in their choice of investments. Gennaioli, Shleifer, and Vishny (2013) emphasize asset-side diversification and tranching to back safe liabilities. Other papers highlight only one aspect of banks: (i) lending to opaque firms thanks to a bank's ability in monitoring and screening (e.g., Diamond, 1984; Dell'Ariccia and Marques, 2006); or (ii) the creation of bank deposits that are used as inside money (e.g., Gorton and Pennacchi, 1990; Stein, 2012).

In this paper we examine the following specific questions. Do banks suffer double runs? Do firms run on the credit lines granted by banks that are hit by a funding liquidity shock on their liabilities? And, before a liquidity shock, is there evidence of liquidity risk management by banks with more fragile liabilities in their granting of credit lines?

The empirical analysis of these questions presents serious challenges for a researcher. Identification requires the following three ingredients: a) a shock to bank funding liquidity that is exogenous and offers cross-sectional heterogeneity; b) a sample of firms with multiple simultaneous credit lines held at different banks, to isolate which bank a firm chooses to run on; c) an exhaustive credit register with the credit lines extended by banks, inclusive of relevant loan and firm variables (e.g., loan price and loan applications; firm leverage and size).

Our empirical strategy relies on the above three ingredients, each of which is critical for the identification of the effects that we investigate. As a shock to bank funding, we exploit the dry up of the European interbank market in August 2007. This shock was exogenous to the Italian banking system and heterogeneous across banks, because banks differed significantly in their pre-shock interbank funding.<sup>2</sup> As for data on credit lines, we have access to the comprehensive Italian Credit Register held at the Bank of Italy, which allows for a match between banks and firms at the level of each credit relationship. The depth and breadth of the database allows us to focus on firms with multiple credit lines simultaneously held at different banks. For these firms we can test whether a firm draws preferentially on the credit lines provided by banks that are affected more by the interbank shock. Although most firms have credit lines with more than one bank, for additional tests we also consider the broader spectrum of firms with a credit line from only one bank.

Before August 2007, spreads on unsecured interbank lending had remained stable at very low levels for several years. In August 2007, interbank spreads and volatility increased significantly, as shown in Figure 1. The interbank market dried up on August 9, which led the European Central Bank (ECB) to inject almost 100 billion euros in liquidity into the system on that day. However, in 2007 the ECB did not provide full liquidity allotment (ECB, 2012), which only became available after the collapse of Lehman Brothers in September 2008. The 2007 crisis originated in the U.S. and was triggered by the exposure of investors to sub-prime related securities. The crisis spread to the European markets when this sub-prime exposure led

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<sup>2</sup> Bank liquidity and fundamentals interact in bank runs (see Goldstein and Pauzner, 2005). Accordingly, in the analysis we use a pre-crisis measure of interbank funding, as change in interbank volume or pricing at the bank level after the shock may also be due to bank fundamentals.

BNP Paribas to suspend redemptions from three of its investment funds (Brunnermeier, 2009). This event caused a shock to the European interbank market. Notably, while in some European countries there were credit and housing price bubbles somewhat similar to the US ones, this was not the case in Italy.<sup>3</sup> The liquidity shock of August 2007 affected Italian banks with different intensities depending on their interbank funding. In our identification strategy, we exploit this heterogeneity in the cross-section of interbank funding before the crisis in conjunction with the time identification offered by the exogenous shock to the European interbank market.

The Credit Register of the Bank of Italy contains the credit lines granted to non-financial corporations in Italy. The richness of the database allows us to look at multiple credit lines that are extended simultaneously to one firm by different banks. The fact that simultaneous credit lines are common practice in Italy allows for the inclusion of firm fixed effects, which allows us to test whether a firm with multiple credit lines from different banks *chooses to draw down* from some specific banks (e.g., the banks with higher interbank funding). That is, whether the demand side (firm) chooses to withdraw from the supply side (banks), which is different from the credit supply literature (Khwaja and Mian, 2008).

The Italian Credit Register also contains data on loan pricing and on granting of loan applications, which are absent in most credit registers around the world. These additional loan characteristics are important to control for whether credit lines extended to a firm by different banks differ along potentially relevant dimensions (in particular prices). We match the data on credit lines to firm-level information on size, leverage, liquidity and Z-score, and to supervisory bank-level data on size, capital, return on assets, ownership and liquidity. Analyzing firm observables is crucial to test *ex-ante* (pre-crisis) liquidity risk management by banks that are more exposed to interbank borrowing. Controlling for bank characteristics is important because they may affect drawdowns, together with interbank funding.

We find the following robust results. After the European interbank shock, firms with multiple credit lines at different banks draw down more on the lines extended by banks with higher pre-crisis interbank funding. Comparing the period after the interbank shock to that before and controlling for firm fixed effects, we find a higher increase in the ratio of drawdowns over granted credit lines and in the (log of) drawdowns, for banks with higher pre-

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<sup>3</sup> Moreover, both the exposure to asset backed securities (see Bonaccorsi di Patti and Sette, 2012) and the exposure to the U.S. and European countries with real estate bubbles, such as Spain and Ireland (see BIS data [www.bis.org/statistics/](http://www.bis.org/statistics/)) was low overall.

crisis interbank funding. Therefore, the effect on drawdowns is present both as a percentage of granted credit and in absolute terms. We run placebo tests that go back to 2006, and show that these effects are not present before the shock. In addition, we control for credit line characteristics, and test whether credit lines of banks with different interbank funding have different lending conditions. We show that drawdowns on credit lines are driven neither by different pricing (in levels and changes), nor by other contractual conditions attached to the line of credit. Furthermore, banks with higher pre-crisis interbank funding experience a higher reduction of interbank deposits during the crisis. Taken together, this evidence suggests that an “asset-side” bank run (drawdown on credit lines) took place during the summer of 2007, and the run affected more those banks that were experiencing a simultaneous run on their liabilities (interbank deposits).

The results suggest that the credit-line run on banks is justified by the fear – subsequently realized – that banks with higher interbank funding may restrict the supply of credit to firms. Borrowers do not experience an immediate reduction in the supply of credit lines but, in the months following August 2007, banks with higher pre-crisis interbank funding tighten relatively more than other banks the supply of loans to *new* applicants. This result is obtained by analyzing firms that are applying for loans to multiple banks simultaneously. Moreover, our main result on higher credit line runs on banks with higher pre-crisis interbank funding is reinforced when firms are more leveraged and smaller, and when banks are less liquid and smaller. Thus, the credit line run was common to all firms and banks, but it was relatively stronger for financially constrained firms, and for banks with fewer refinancing options.

Next, we shift our attention to how banks manage the risk of double runs. Do banks with higher interbank funding take ex-ante actions to contain the risk of asset side runs? Our results indicate that they do, and that liquidity risk management can neutralize the impact of correlated double runs. More specifically, during the interbank shock, if we run a regression that controls for only firm observable characteristics (but not for firm fixed effects), we still find that banks with higher interbank funding suffer larger drawdowns during the crisis as compared to other banks (as in the regression with firm fixed effects). However, in the regression without firm fixed effects (but only observables) the effect of interbank funding on drawdowns is half of that of a regression that contains firm fixed effects, and it is not statistically significant. If we do not control for any firm selection (firm observable and unobservable characteristics), the coefficient of interbank funding drops to zero, thus losing any economic and statistical significance.

To provide additional evidence on this point, we collapse our analysis at the bank level and account for all firms in the sample, including those with only one credit line. We then run a regression in which all credit line drawdowns from a bank are regressed on the interbank funding of that bank. In this regression (without firm controls) we also find that the coefficient of interbank funding is not significantly different from zero. This shows that, in the aggregate, banks with higher interbank funding do not suffer higher drawdowns during the crisis.

Taken together, all these results indicate that (unconditionally) banks with higher pre-crisis interbank funding do not suffer larger credit line runs than the average bank. However, conditionally on borrower (observable and unobservable) characteristics, higher interbank funding leads to larger drawdowns on credit lines.

One way to read the above results is that banks are aware of the risk of double bank runs, and, therefore, banks actively manage the risk of asset side liquidity shocks by selectively offering credit lines to borrowers (on both unobservable and observable characteristics) that are less prone to drawdowns in crisis times. To corroborate this interpretation, we analyze the period before the crisis and find that banks with higher interbank funding: a) grant fewer credit lines in general (extensive margin), and even less so to financially constrained firms (that run more in crisis times); b) conditionally on granting a line, offer lower amounts (intensive margin). In summary, our results indicate that banks effectively manage the risk of double runs through the granting of credit lines.

We contribute to the literature in three ways. Firstly, we test empirical predictions of the theoretical literature studying the synergies between bank assets and liabilities, in particular related to liquidity risk. The existing literature on this topic has analyzed bank liquidity risk at the bank or firm level. We show that proper identification requires an analysis at the credit line level. Kashyap, Rajan and Stein (2002) show that banks that rely more on demand deposits are able to grant more credit lines to borrowers.<sup>4</sup> Gatev, Schuermann, and Strahan (2009) find a diversification benefit between the two activities: bank-stock return volatility increases with unused commitments, but the increase is smaller for banks with high levels of demand deposits. Gatev and Strahan (2006) show that when market liquidity dries up and commercial paper rates rise, banks may experience deposit inflows. However, due to deposit insurance, funding liquidity risk for banks is mostly associated with wholesale deposits, rather than with demand deposits (Brunnermeier, 2009; European Central Bank, 2012).

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<sup>4</sup> Acharya, Almeida, and Campello (2013) and Acharya, Almeida, Ippolito and Perez (2014) find that firm characteristics matter for access to credit lines.

An insightful recent paper, Santos (2014), analyses credit line drawdowns at the loan level. He finds that during a recession banks with higher net charge-offs in a given year, experience credit line drawdowns and deposit withdrawals in the following year. Our paper differs from Santos along two dimensions: 1) we address a related but different question; 2) we use a different identification strategy and a more comprehensive data set. In this paper we investigate how liquidity risk stems from both sides of a bank's balance sheet and how banks manage this risk. Santos does not identify purely liquidity risk and does not analyze risk management. As a measure of bank shock, Santos uses the change in bank losses. Therefore, his analysis of runs is not purely on liquidity risk, but more generally on bank fundamentals. Instead, in our paper the shock to a bank comes from an exogenous Europe-wide shortage of interbank funding. Our shock is exogenous to a bank's balance sheet and it is strictly related to liquidity. Further on the issue of identification, Santos does not use firm fixed effects in his analysis, which we show to be very important to address the effects of endogenous matching between borrowers and lenders: banks with higher net charge-offs may have lent to riskier borrowers that draw more on credit lines in a recession, because they are more financially constrained. Moreover, our results show that firm fixed effects are crucial for identifying from which bank a firm chooses to withdraw on their different lines at any given time, which in turn is necessary to properly identify runs.<sup>5</sup>

The second contribution to the literature is to provide evidence that banks are aware of the risk of a double-liquidity shock and manage this liquidity risk by selecting ex-ante borrowers that run less during a crisis. This finding is consistent with the recent theoretical work of Hanson, Shleifer, Stein and Vishny (2014), who show that financial institutions with less stable sources of funding select assets with lower liquidity risk. Our results are not consistent with the prevailing moral hazard view in banking that predicts risk shifting (e.g. by carrying out minimum level of risk management) by more fragile banks (see Freixas and Rochet (2008) for an overview). The absence of bank-level results may be interpreted as evidence of lack of correlation between runs on a bank's assets and liabilities. However, our identification and results show that this is not the case and that the absence of bank-level results is due to effective risk management by banks.

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<sup>5</sup> In terms of data, Santos (2014) uses the Shared National Credit (SNC) database, which contains only syndicated loans over 20 million dollars and yearly data that is not ideal for the analysis of a short-term phenomenon like a run. Moreover, with yearly data one cannot accurately compute the evolution of the ratio of drawn to granted credit, because the amount of the granted credit may be subject to unobservable renegotiations during the year.

Third, we contribute to the recent literature that examines credit supply by banks using firm fixed effects in loan-level data (Khwaja and Mian, 2008). Differently from this literature, firm fixed effects in our setting imply that the firm (the credit demand side) – having credit lines from several banks (the supply) – chooses to draw down from the banks with higher interbank funding. Importantly, we show that banks with higher liability risk grant fewer credit lines to firms with higher liquidity risk. This implies that banks (the supply side of credit) with different fundamentals (interbank exposure) are endogenously matched with firms that have different liquidity needs (the demand side). This explains why the inclusion/exclusion of firm fixed effects dramatically affects our results, whereas in most papers about credit supply, firm fixed effects do not matter much for the key results (see Khwaja and Mian, 2008; Schnabl, 2012; Cingano, Manaresi, and Sette, 2014, among others).

The rest of the paper is organized as follows. Section 2 describes the data. Section 3 explains the identification strategy. Section 4 provides the empirical results. Section 5 concludes and highlights the implications for prudential policy.

## **2. Data**

We construct our sample by merging data from three sources: a) the Italian Central Credit Register which is a supervisory, centralized dataset managed by the Bank of Italy, the supervisor of the Italian banking system, that records the credit exposure of resident banks to non-financial borrowers, including credit volume and, uniquely, price and loan applications; b) the Italian Supervisory Reports which contain data on individual and consolidated balance sheets for Italian banks; c) Cerved which contains the accounting data on Italian non-financial corporate borrowers.<sup>6</sup> Borrowers are reported in the Central Credit (CR) Register if they have loans of at least 75,000 euros, including guarantees. Credit granted and credit disbursed (drawn) are disaggregated by loan type (loans backed by account-receivables, term loans, credit lines). In our sample we consider all bank-firm relationships recorded in the CR as of June 2007. We then obtain data on credit granted and drawn within these bank-firm relationships in June 2007, September 2007, December 2007 and in March 2007 and December 2006 for the pre-crisis period.

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<sup>6</sup> Cerved collects official balance sheet data deposited by firms to the Chambers of Commerce, as required by the Italian law. Cerved is a member of the European Committee of Central Balance-Sheet Data Offices.

In the sample we mainly include firms that have at least two outstanding (drawn or not) credit lines from two different banks.<sup>7</sup> Out of the total credit given to the corporate sector, the share of credit given to firms who borrow from at least two banks is above 85%. This yields a sample of 472,153 firm-bank relationships in 2007, which corresponds to 137,078 firms. Conditional on having credit lines from at least two banks, firms in our sample have on average credit lines with 3.4 banks. We aggregate all the credit lines that a firm has with the banks of the same group. This step is necessary for three reasons: first, lending policies are typically decided at the group level; second, interbank borrowing is usually conducted by one or few entities within a group, and funds are redistributed to the rest of the group through the internal capital market; third, regulatory capital ratios are imposed also at the group level.<sup>8</sup> Table 1 reports descriptive statistics of our variables. Variables are defined in the Appendix.

### ***Credit Lines Variables***

We build our measure of “run” on credit lines by constructing the ratio of drawn over granted credit for each credit line, and compute the difference in this ratio between June and September 2007. To test whether the dynamics of the drawn-to-granted ratio is driven by drawn credit or by granted credit, we also compute growth rates of the two raw variables. Growth rates of drawn (granted) credit lines are computed as changes in the log of drawn (granted) between June and September. Panel A of Table 1 reports descriptive statistics for the 472,153 credit lines included in the sample. The descriptive statistics in the table reveal that on average there was an increase in drawdowns on credit lines after the liquidity shock. We discuss these statistics in greater detail in the section dedicated to results.

In Panel B, we also compute a set of bank-firm relationship variables as of June 2007. We compute the share of credit of bank  $j$  out of total credit to firm  $i$  (*share*). This is a measure of the exposure of a bank to a firm, and of the relative importance of a lender as a funding source for a firm. We compute a dummy variable equal to 1 if firm  $i$  has past-due loans with bank  $j$  (*past due*). For the credit line granted to firm  $i$  by bank  $j$ , we consider also the drawn-to-granted ratio at the beginning of the period (*drawn/granted*).

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TABLE 1 about here

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<sup>7</sup> When we look at aggregate effects at bank level, we also include firms with a credit line from only one bank.

<sup>8</sup> We also control for M&As to keep track of credit lines when bank identifiers change.

### ***Firm Characteristics***

Credit line data are then matched to firm accounting variables obtained from Cerved. The data for firms refer to the fiscal year 2006. This is to ensure that firm data are not affected by the shock of August 2007, and to guarantee that such data were observable to banks in June 2007. The firm characteristics that we consider include *size*, *risk*, *liquidity* and *leverage*. Panel C of Table 1 shows descriptive statistics of the 137,078 firms included in the sample.<sup>9</sup> The firms in our sample have on average about 9.86 million euros in assets, with a large standard deviation, because most of them are of small and medium size by international standards (the median is about 2.13 million euros). Risk is measured with Altman's Z-Score. The average Z-score is 5.59. The percentage of liquid assets in the balance sheet is 6.85%. Finally, firms in our sample have an average leverage ratio of 26.29%.

### ***Bank Characteristics***

Data on the balance sheet of banks are obtained from the Supervisory Reports filed with the Bank of Italy and are measured at the beginning of each period. If the bank belongs to a banking group, we use the data of the corresponding consolidated top-tier entity.<sup>10</sup> Our proxy for bank exposure to the liquidity shock of August 2007 is the share of gross interbank funding (*interbank*), measured as the ratio of total borrowing from other banks to total assets. In the definition, we include deposits and repos from other banks, but we exclude deposits from the ECB or other national central banks. We compute interbank borrowing at the group level for banks that belong to the same group, meaning that flows among entities of the same group are netted out. We use gross interbank borrowing, instead of net borrowing, as the former better captures the extent to which a bank is exposed to a run on its liabilities during the crisis.

To isolate the effect of a bank's exposure to the interbank market from other channels, we control for several other bank characteristics. We compute the return on assets (*ROA*) as net income divided by total assets. *ROA* is potentially an important control, because when market conditions are unfavorable banks find it costly to raise external capital, which means that equity increases primarily through retained earnings. We compute a bank's *capital ratio* as equity divided by total assets. Equity is defined as equity (shares subscribed, book value of equity)

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<sup>9</sup> For each variable we have different number of firms depending on the availability of data.

<sup>10</sup> We exclude branches of foreign banks from the sample, because we do not observe the data for the parent company.

plus retained earnings. Other forms of capital, like subordinated convertible securities, are excluded. We compute a bank's *liquidity ratio* as the sum of cash holdings and sovereign bonds divided by total assets. Bank size is measured by the logarithm of total assets (*log assets*). We also include a dummy variable that equals one if the bank is a mutual financial institution (*mutual bank*), and zero otherwise.

Panel D of Table 1 reports descriptive statistics for the 531 banks included in the sample.<sup>11</sup> We weight each bank by the number of bank-firm relationships. The average interbank funding is 13.36%. The percentage of liquid assets in the balance sheet is 6.22%, the percentage of equity is 7.49%, and the average ROA is 1.42%. The size of banks varies substantially, as we have both large multinational groups and local banks. The share of credit with mutual institutions is 9.10%.

### ***Loan Applications***

We obtain data on loan applications by potential borrowers to banks from the records of information requests held at the Credit Register, which contains data on the applicant's overall outstanding debt and default status within the banking system. The Credit Register records the request together with a code that identifies new applications, as first information requests, and only banks facing a loan application can request this information. We compute each first information request submitted by each bank to each firm in the Credit Register. There is no field indicating whether the bank subsequently granted a loan or not. To obtain a measure of the granting of loan application, we check in the Credit Register if the bank granted any credit to the applicant in the three months following the loan application.

We distinguish before and after the liquidity shock of Summer 2007. For the period before the shock, we record a loan application as granted if it was submitted to a bank between January and April 2007, and if we observe that the bank grants credit to the applicant between January and July 2007. For the period after the shock, we follow the same procedure but look at applications between September and December 2007, and granting decisions between September 2007 and March 2008.<sup>12</sup> Panel E of Table 1 shows descriptive statistics of the loan applications included in the sample. We find that there is a similar percentage rate of granting

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<sup>11</sup> The number of banks increases from 529 in December 2006 to 531 in June 2007 due to the entry of 2 banks in the market. These two banks did not post balance sheet data in December 2006 since they were not active in 2006.

<sup>12</sup> We use monthly rolling windows. For example, for the applications that take place in September, we look at the decision to grant credit in the period between September and December.

of applications in the two sub-periods (27.65% in the post-crisis and 27.57% in the pre-crisis period).

### 3. Identification Strategy

In this paper we first address the following question: do firms with multiple credit lines from different banks draw down preferentially from some banks rather than others, when a liquidity shock hits the banks? In particular, we expect firms to draw down preferentially from the banks that suffer the most from the liquidity shock, in anticipation of a more severe credit tightening by these institutions. When addressing this question, there are two main identification challenges.

First, bank liquidity problems could stem from worse fundamentals, in particular related to the asset side of the balance sheet. Therefore, it is necessary to have an exogenous shock to bank liquidity that is unrelated to fundamentals. In addition, it is important to use a shock for which there is sufficient cross-sectional heterogeneity in how it affects banks, to exploit an identification strategy based on differences-in-differences: before versus after the shock, with respect to banks more or less affected by the shock.

Second, one needs an exhaustive credit database, which covers all the existing credit lines extended by different banks to each firm. Only with this level of completeness in the data, it is possible to examine on which line a firm chooses to draw down. This implies that the analysis must be carried out at the credit line level, accounting for firm fixed effects. In our setting, borrower fixed effects have a different interpretation than in the literature on credit supply (Khwaja and Mian, 2008). In our case, conditioning on firm fixed effects, the coefficient of the variable *interbank* captures the specific change in demand of credit by a borrower, rather than the supply of credit by a bank, because the choice to draw down on a credit line is initiated by borrowers, not by banks. It is also important to control for the observable characteristics of the credit line, as credit lines could have different contractual terms, and most importantly different pricing (measured as spread over base rate). These contractual differences could drive the firm's choice to draw down on one line rather than another, and hence it is a channel that we need to control for (for example, by checking whether for the same firm at the same time, the credit lines from banks with different interbank exposure have different level (or change in) loan pricing). It is also important to employ data at quarterly rather than yearly frequency, as to better identify the timing of the drawdown decision by the firm.

Italy offers an excellent setting for our empirical analysis, because it allows us to examine the effects of the freeze out of the European interbank market in August 2007 in a country that was not experiencing a credit or a real estate bubble, and that has a unique and exhaustive dataset contained in the Italian Credit Register, itself matched to bank- and firm-level data.

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FIGURE 1 about here

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### ***A Shock to Wholesale (Interbank) Funding***

As a measure of liquidity shock at the bank level, we use the interbank funding ratio (*interbank*). This source of wholesale funding for banks dried up abruptly in the aftermath of the events that took place at the beginning of August 2007. The illiquidity in this market was mainly driven by a sharp increase in perceived counterparty risk (Brunnermeier, 2009; Iyer, Peydró, da-Rocha-Lopes and Schoar, 2014). Figure 1 shows that the spread between the rate on unsecured interbank transactions (Euribor) and that on secured ones (Eurepo) increased sharply in August 2007, marking the start of the financial crisis. The spread between the two rates increased dramatically from 10 basis points, until it reached 70 basis points.

The immediate cause of the shock that affected the European interbank market was the decision of BNP-Paribas to renege capital redemptions by investors from two of its investment vehicles that were exposed to the U.S. sub-prime mortgage market (Brunnermeier, 2009). This event was related to adverse developments in the market for securitized sub-prime mortgages. However, importantly for our identification strategy, neither were the developments in the sub-prime market related to the conditions of the assets held by Italian banks or to the Italian economy more generally, nor did Italy have a credit or real estate bubble as Ireland or Spain. The events of August 2007 represented an unexpected shock to wholesale markets for liquidity, as argued in several accounts of the crisis (Brunnermeier, 2009; Rajan, 2011; Gorton, 2012; ECB, 2012; among others).<sup>13</sup> Moreover, the European Central Bank did not provide unlimited provision of public liquidity in August 2007, as it did in mid October 2008 during the post-Lehman financial crisis, and hence problems in the private market of liquidity could not be perfectly neutralized with public liquidity.

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<sup>13</sup> See also Bonaccorsi di Patti and Sette (2012) for an account of the impact of the crisis in Italy.

Next, we test whether banks that relied more on interbank funding before the shock were hit harder by the liquidity shock of August 2007. In Table 2 we run regressions at the bank level for the change in interbank funding between June and December 2007 (crisis time) and between December 2006 and June 2007 (pre-crisis time), as a function of bank characteristics (respectively observed in June 2007 and in December 2006).<sup>14</sup> Our results show that after the liquidity shock of August 2007 the banks that were more exposed to the shock in interbank funding markets experienced a drop in interbank deposits. However, we do not observe a drop in interbank deposits in the pre-crisis period.

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TABLE 2 about here

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Having identified the source of the liquidity shock to banks, we then need to relate it to the behavior of borrowers. The main variable of interest is the change in the ratio between the amount of credit line drawn by the firm and the amount granted to the firm by the bank. We explore whether the change in the ratio is higher for the credit lines granted by banks with higher exposure to the interbank market. Our period of interest is between July and September 2007. These months span over the exogenous interbank liquidity shock that took place in August 2007.

Our working hypothesis is that, after August 2007, firms became worried that credit would be reduced as a result of the liquidity problems that banks were facing due to their exposure to the interbank market. This is based on the assumption that firms were able to identify banks with more fragile funding structures. We believe that this hypothesis is plausible for the following reasons. First, the exposure to the interbank market is easily obtainable from the balance sheet of both listed and non-listed banks, because banks publish their financial accounts on their websites. Second, in its coverage of the crisis, the Italian press repeatedly stressed the role of interbank funding as a source of fragility for banks.<sup>15</sup> Iyer and Peydró

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<sup>14</sup> Data on bank balance sheet variables are available semi-annually.

<sup>15</sup> Media coverage of the crisis stressed the role of interbank funding as a source of fragility for banks. According to “La Repubblica”, the second best selling newspaper in Italy: “The implosion of Northern Rock shakes even the final certainties.... The only fragility of Northern Rock is that it relied on interbank funding, i.e. on loans from other banks”, 17/9/2007. L’Espresso, a widely read magazine, wrote: “this is the first severe crisis in which the interbank market is the main character”, 21/9/2007. Il Sole 24 Ore, the leading financial newspaper, reports: “Italian banks are not immune to the crisis... The dry-up of liquidity in interbank markets...the sharp rise in the cost of funding are symptoms of a contagious disease which hit the banking system”, 14/9/2007. Finally, according

(2011) provide an example of a bank run in India, which shows that even relatively financially unsophisticated retail depositors are able to identify even the interbank exposure of their banks to a failed bank.<sup>16</sup> This evidence suggests that, at the time of the crisis, it is reasonable to believe that firms were, or became aware, of the fragility of their lenders due to exposure to the interbank market.

### ***The Empirical Model***

Formally, we estimate the following model:

$$\Delta\left(\frac{\text{Drawn}}{\text{Granted}}\right)_{i,j} = \beta_1 \text{interbank}_j + \alpha_i + X'_j \beta_2 + Z'_{i,j} \beta_3 + \varepsilon_{i,j} \quad (1)$$

The dependent variable in the regression is the change in the ratio of drawn to granted for a credit line by bank  $j$  to firm  $i$  between June and September 2007, for credit lines that were already granted in June. If firms draw down preferentially on the credit lines granted by banks that are more exposed to the liquidity shock, the coefficient of *interbank*,  $\beta_1$ , should be positive and significant. As we will discuss in more detail below, the potential run requires that the increase in the ratio of drawn to granted is driven by an increase in the numerator, rather than by a decrease in the denominator. In other words, the run requires a change that is driven by the demand for credit by firms, rather than by a reduction in supply of credit by banks. Additionally, we expect  $\beta_1$  to be significant only in the immediate aftermath of the shock and not before.

A key feature of our identification strategy is the inclusion of firm fixed effects ( $\alpha_i$ ). Firm fixed effects can only be accounted for if one examines firms with multiple simultaneous credit lines granted by different banks. Accounting for firm fixed effects in the sample of firms with multiple credit lines allows us to control for relevant, yet unobservable, characteristics that may affect a firm's behavior with respect to drawdowns, and that are unrelated to bank characteristics (for example, lower cash flows or higher investment opportunities and thus higher need of external funding). Note that in a model without firm fixed effects, the estimate of  $\beta_1$ , which we refer to as  $\hat{\beta}_1^{OLS}$ , is unbiased only if the correlation between the exposure of a bank to the interbank market and the unobservable firm characteristics that may drive

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to "Il Mondo", a financial magazine: "Interbank rates skyrocketed after the Subprime crisis...and this may translate into higher cost of funding for banks", 28/9/2007.

<sup>16</sup> In Iyer and Peydró (2011) depositors know about the interbank exposure of their bank to a failed bank partially through voluntary disclosure by banks, partially through monitoring (Calomiris and Kahn, 1991), and partially via rumors and word-of-mouth (Kelly and Grada, 2000; Iyer and Puri, 2012).

drawdowns is zero. More precisely, the estimated coefficient  $\hat{\beta}_1^{OLS}$  is biased upward if the above correlation is positive, and downward otherwise. Notice that the correlation is negative when banks with higher interbank funding are matched to firms with lower liquidity needs, possibly because these banks grant more credit lines to these types of firms to reduce double liquidity risk. The estimate of  $\beta_1$  in a model with firm fixed effects,  $\hat{\beta}_1^{FE}$ , provides an unbiased estimate of whether a firm in a given quarter chooses to draw down more from banks with higher interbank borrowing.

In our specification, we also include several bank controls,  $X_j$ , such as a bank's liquid assets, its capital ratio, its size and a dummy for whether the bank is a mutual institution (*liquidity*, *capital ratio*, *log assets* and *mutual bank*). These bank-level controls are meant to isolate the effect of a bank's exposure to the interbank market from other possibly relevant bank characteristics that may be related to drawdowns. The model also includes the relationship firm-bank variables,  $Z_{i,j}$  (*share*, *past-due* and *drawn/granted*) between banks and firms, which we have described in the previous section. These controls include the share of credit lines that a firm has outstanding from each of bank, whether a firm has credit past its maturity, and the ratio of drawn to granted on credit lines that a firm has in June 2007. These are important controls because firms may draw down differently from the banks with which they have a stronger relationship, or if they have committed previous credit delinquencies.

One possible concern when using the specification provided in equation (1) is that the ratio of drawn to granted for credit lines can increase for two reasons: because a firm draws down on the credit lines during the period June-September, or because during this period the amount of credit granted to a firm drops. To disentangle these two dynamics, we also run equation (1) using as dependent variables  $\Delta \log (drawn)_{i,j}$  (and, then,  $\Delta \log (granted)_{i,j}$ ), which is the change in the logarithm of the amount drawn by firm  $i$  from bank  $j$  between June and September 2007 (and respectively the change in granted credit lines by bank  $j$  to firm  $i$ ). If the increase in the ratio of drawn to granted is due to an acceleration of drawdowns by firms, we expect the coefficient of *interbank* to be positive and significant in the specification with  $\Delta \log (drawn)_{i,j}$  as a dependent variable. Given our main interest in interbank funding and the variation in the data, we double cluster standard errors at the bank and firm level. Another possible concern when using the specifications with logarithms is that we do not include in the sample the credit lines where the amount granted is zero in either June or September. Therefore, for robustness, we also measure the increase in drawn amounts by looking at the amount of drawn credit divided by the total assets of the firm.

In the second part of the paper (Section 4.2), we explore the extent to which banks manage the risk of a double liquidity squeeze. For this purpose, we run a set of regressions that are similar to the ones described in this section, with the only difference that we exclude firm fixed effects ( $\alpha_i$ ). The difference in the coefficient between this last specification and the one with fixed effects will show whether banks select firms with different liquidity risk. In an intermediate step, we exclude firm fixed effects, but include observable firm characteristics (*size, risk, leverage and liquidity*) to check whether the difference in results comes from either (both) observable or (and) unobservable firm characteristics. We estimate these different loan-level specifications using Ordinary Least Squares and Weighted Least Squares (with more weight to larger credit lines). Finally, we also run regressions of credit line drawdowns aggregating at the bank level, including both firms with credit lines from multiple banks and firms with a credit line from only one bank.

## 4. Results

In this section, we present the results both on the runs of credit lines and on liquidity risk management by banks, using both data from the crisis and from the period before the crisis.

### 4.1 Evidence of Runs on Credit Lines

#### *Average Effects of Runs on Credit Lines*

The descriptive statistics in Table 1 reveal that, on average, banks suffered an increase in the drawdowns on credit lines after the liquidity shock. Between June and September 2007 the mean change of the drawn-to-granted ratio is 4.56%, which corresponds to more than 10% of the average quarterly drawn-to-granted ratio prior to the crisis. As a term of comparison, the mean change of the drawn-to-granted ratio between June and March 2007 is -0.21%. The increase in the drawn-to-granted ratio after August 2007 is due to an increase in the drawn amount: between June and September 2007 the mean increase in the logarithm of drawn amount is 16.70% (which corresponds to a percentage change in the underlying variable of 18.17%), while in the three months before the increase was 2.04% (which corresponds to a percentage change in the underlying variable of 2.06%). On the contrary, the change in the granted amounts is close to zero in both periods.

Table 3 contains the results of our main tests on a run on credit lines. Across all columns, the main variable of interest is *interbank*, which captures the effect that the borrowing exposure to the interbank market has on credit line usage and issuance. In column 1, the dependent variable is the change in the ratio of drawn to granted between June and September 2007, expressed in percentage points. The coefficient of *interbank* is statistically significant with a positive sign. This means that during the period between June and September 2007, for a firm with two (or more) lines provided by different banks, the firm draws down (the percentage of drawn to granted increases relatively) more from the bank with higher exposure to the interbank market.

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TABLE 3 about here

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The effect is economically significant. A two-standard deviation increase in *interbank* (19.96%) leads to an increase in the drawn-to-granted ratio of 1.08%, which is about one quarter of the average change during this period (4.56%). To fully appreciate the economic significance of this result, it is worth noting that the median change in the drawn-to-granted ratio between June and September 2007 is zero.

The results of column 1 are silent on whether the effect of a higher exposure to the interbank market is driven by a higher usage of the credit lines by firms or by a reduction in the granted amount by banks. To examine this issue in more detail, in the other columns of Table 3 we examine drawdowns and granted amounts separately. The dependent variable in column 2 is the difference between the logarithm of drawn credit in September versus that in June, expressed in percentage points. We find that *interbank* is significantly associated with a positive amount of drawdowns. This means that firms preferentially choose to draw down on the credit lines provided by the banks with higher interbank exposure. To assess the economic significance of the coefficient of *interbank* in column 2, a two-standard deviation change in *interbank* leads to a 20% increase in the mean change in the drawn amount. Since a substantial number of credit lines are not used with the logarithmic transformation we lose all the bank-firm relationships where the drawn amount is zero in at least one of the period. Hence, as a robustness check, in column 3 we use an alternative definition of the change in drawdowns: the change in the drawn amounts divided by the assets of the firm in 2006. Results are consistent across different definitions.

In column 4 we examine the relation between the change in the amount of credit lines granted and the exposure to the interbank market, where the change in granted is computed as the change in logarithms between June and September 2007. Given the definition of the variable, this applies only to firm-bank relationships with an outstanding credit line before the crisis. The regression results show that banks with higher interbank funding do not reduce the granted amount of credit lines for existing firm-bank relationships over this period significantly more than other banks. All these results confirm the finding that the increase in the drawn-to-granted ratio is due to drawdowns by firms of credit lines granted by banks with higher interbank funding, rather than to a reduction in granted amounts.<sup>17</sup>

In the Appendix in Table A1, we report placebo tests for the main result of Table 3. Table A1 provides results for the change in drawn amount and in the ratio of drawn to granted over the two quarters before the crisis (December 2006-March 2007 and March-June 2007). In these tests, the coefficient of *interbank* is never significant. The exposure to the interbank market is not a predictor of drawdowns outside the time of the liquidity crisis of August 2007. In the Appendix in Table A2, we examine how the pricing of credit lines relates to interbank exposure. We find that there are no significant differences in pricing terms – level before the crisis and change during the crisis – for credit lines granted by banks with different exposure to the interbank market.<sup>18</sup> This suggests that firms do not draw down on the credit lines granted by banks with higher interbank exposure because the credit lines granted by these banks are cheaper before the crisis, or because they become cheaper during the first quarter of the crisis.<sup>19</sup>

### *Heterogeneous Effects on Firm and Bank Characteristics*

In the previous section we have shown that firms on average draw down more from banks with higher interbank funding. In this section we explore whether this average effect is heterogeneous across firms (Panel A of Table 4), and also whether it depends on other bank

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<sup>17</sup> Also note that (in Table 3) the coefficient of *ROA* is negative and significant across the first three columns (and not significant in the fourth column). This finding suggests that drawdowns are associated with banks with lower fundamentals, which is consistent with the theoretical literature that focuses on runs based on bank fundamentals (Rochet and Vives, 2004; Goldstein and Puzner, 2005; Allen, Carletti, Goldstein and Leonello, 2013).

<sup>18</sup> Data on interest rates comes from a subsection of the Credit Register that covers more than 80% of total bank lending in Italy. We winsorize the two dependent variables (levels in June and changes in September-June) at 5%. Results are similar if we do not winsorize.

<sup>19</sup> We also run the main regressions in Table 3 including also the level of interest rates on the credit lines and their initial size among the control variables and results are very similar. In addition, results of Table 3 are very similar if we measure *interbank* as the exposure to interbank borrowing in December 2006. The correlation between the variable *interbank* calculated in June 2007 and in December 2006 is 0.899.

characteristics (Panel B of Table 4). In particular, we address two questions: first, whether the effects on drawdown behavior associated with interbank exposure are stronger for certain firms (e.g., smaller or more leveraged) than for others; second, whether drawdowns on banks with higher interbank market are different depending on bank fundamentals (e.g., size or liquidity).

Panel A of Table 4 shows results of firm cross-sectional heterogeneity. We define four dummy variables that capture different aspects of a firm financial strength with respect to leverage, liquidity, default risk and size (*high leverage, low liquidity, high risk, small*). See the exact definitions in the Appendix. Each dummy equals one if the firm is above the 75th percentile for leverage and risk, and below the 25th percentile for liquidity and size. In each column of Panel A of Table 4 we run a regression for the change in the drawn-to-granted ratio between June and September 2007 using the same specification of column 1 in Table 3, but adding an interaction term of *interbank* with one of the firm dummies discussed above from column 1 to 4 (in column 5, we include all interactions). A positive and significant coefficient on the interaction term indicates that a given firm characteristic is associated with a higher effect of interbank exposure on drawdown behavior.

Panel A of Table 4 shows that smaller and more leveraged firms draw down more from banks with high interbank funding. According to Bernanke, Gertler and Gilchrist (1996) and Farre-Mensa and Liungqvist (2013), among many others, leverage and size are good proxies for financial constraints in firms. This is consistent with survey-based evidence of Campello, Graham and Harvey (2010) that shows that during the sub-prime crisis, CFOs of financially constrained firms “drew more heavily on lines of credit for fear banks would restrict access in the future”.

We then turn our attention to whether certain bank characteristics reduce or amplify the run by firms on credit lines granted by banks with high interbank funding. Panel B of Table 4 examines this issue. The regressions are the same as in column 1 of Table 3 but now they include interactions between *interbank* funding and bank characteristics (*capital, liquidity, ROA* and *log assets*). Our results show that the coefficients of bank size and liquidity are significant. As for size, this means that the effect of an increase in drawdowns from banks with high interbank funding is significantly lower for bigger banks. This is consistent with larger banks being less financially constrained, as for example due to too-big-too-fail (TBTB) status, which implies easier access to wholesale finance (O’Hara and Shaw, 1990; Flannery and Sorescu, 1996). Firms draw down relatively less from large banks possibly because these banks are more likely to be bailed out in case of failure or they can obtain more easily further liquidity given

their TBTF status or because they are less financially constrained. The interaction with bank *liquidity* is also significant and negative, which indicates that firms run more on banks that are less liquid. This finding again reinforces the idea that firms run on credit lines preferentially from more fragile banks, because these banks are more likely to cut credit in the future.

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TABLE 4 about here

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All in all, Table 4 shows that the impact of interbank exposure on drawdowns on credit lines is stronger from more financially constrained firms (more leveraged and smaller) and for more financially constrained banks (less liquid and smaller), which reinforce the result of Table 3 that runs on credit lines occur more in banks with funding problems.

#### *Did Banks with Higher Interbank Exposure Reduce Credit Supply?*

In this section we investigate if the freeze of the interbank market bore real consequences in terms of lending behavior by banks. Our results of the change in granted indicate that in the Summer of 2007, borrowers did not experience an immediate reduction in the supply of credit lines. Here, we examine the provision of credit to new applicants between September 2007 and March 2008. We look at multiple loan applications by a firm to different banks, and analyze how the probability that a firm's loan application is granted depends on the bank's interbank borrowing.<sup>20</sup>

To assess the impact of the shock of the interbank market on credit supply, we estimate a linear probability model in which the dependent variable is equal to 1 if a loan application is granted from bank  $j$  to firm  $i$ , and zero otherwise. The linear probability model allows for the inclusion of firm fixed effects, which act as controls for firm unobserved characteristics.<sup>21</sup> The inclusion of firm fixed effects reduces the sample by more than half because it requires at least

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<sup>20</sup> Loan applications have been studied in the context of monetary policy transmission (Jiménez, Ongena, Peydró and Saurina, 2012 and 2014), and in the transmission of financial shocks to borrowers (Bonaccorsi di Patti and Sette, 2012; Bofondi, Carpinelli and Sette, 2013). This measure of credit supply is unaffected by concerns about the effect of bank-firm specific demand for credit. The intensive margin may also be affected by the problem of ever-greening or by other unobservable bank-firm characteristics.

<sup>21</sup> Probit or Logit models with firm fixed effects imply that a firm with all applications granted or with all applications not granted are captured by the firm fixed effects, and thus are not used in the regression.

two applications by each firm in the same period. The average number of applications per firm in September-December 2007 is 1.24, and the probability of granting an application is 27.65%.

The results are reported in Table 5. We want to analyze whether higher exposure to interbank funding leads to a lower level of granting of loan applications, and study how this relation varies before and after the interbank shock. Thus, we run two sets of separate regressions, one for the applications posted before the interbank shock, and the other for the applications posted after the shock. Column 1 and 4 of Table 5 do not include fixed effects, whereas column 2 and 5 include firm fixed effects interacted with time (month), and column 3 and 6 include only firm fixed effects. For the applications posted before the shock, we find that there is no effect associated with interbank exposure. On the other hand, for the period that follows the liquidity shock of August 2007, we observe that loan applications posted to banks with higher interbank exposure are less likely to be granted. Taken together, the results of Table 5 suggest that the tensions in the interbank market in August 2007 bore consequences in terms of lending to the real sector. Banks that were more exposed to the interbank market reduced their supply of credit to new applicants.

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TABLE 5 about here

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## 4.2 Liquidity Risk Management

In this section we present the results on liquidity risk management by banks, and explore both the time of the crisis and the period before the crisis.

### *Data during the Crisis: Aggregate Effects*

The inclusion of firm fixed effects ( $\alpha_i$ ) in our main specification allows us to show that if a firm has multiple credit lines with different banks, it chooses to draw down more from the banks that are more exposed to the shock. The firm fixed-effect model is crucial to properly identify runs on credit lines. However, it is silent about aggregate effects, as banks with more fragile funding (higher interbank exposure) may manage their liquidity risk by lending to firms that draw down less in a crisis (screening).

In this section, we replicate the results of Table 3, alternatively including and excluding firm fixed effects and firm observable characteristics. The results are reported in Panel A of Table 6. The dependent variable in all specifications is the change in the drawn-to-granted ratio between June and September 2007. The first column reports a basic firm fixed-effects specification identical to that of column 1 of Table 3.<sup>22</sup> In the second column we run the same specification as in column 1, but we remove firm fixed effects and include a set of observable firm characteristics. In column 3 we exclude all firm controls (observable and unobservable). Column 4-6 report the same specifications as in column 1-3 using Weighted Least Squares (WLS) rather than Ordinary Least Squares (OLS), where the weights are the logarithm of the granted amount of credit line. WLS are important to gauge aggregate effects at the bank level considering that larger credit lines matter more.

A comparison across column 1-3 (respectively, 4-6) shows that there are significant differences in the coefficient of *interbank*. Only in the model with firm fixed effects the coefficient of *interbank* is significantly different from zero. In the model that controls only for observable firm characteristics (column 2 and 4), the coefficient of *interbank* is positive, but not significant, and its size drops to around 50% of that of column 1. In the model without any firm controls (column 3 and 6), the coefficient is not significant and very close to zero. The non-significance of the coefficients in the models without firm fixed effects shows that fixed effects are capturing selection effects for firms towards banks with different interbank exposure. Taken together, these findings suggest that banks select firms based both on observable and unobservable firm characteristics.

The sign and significance of the coefficients of the observable firm characteristics are all intuitive. Higher drawdowns during the liquidity shock of August 2007 come from firms with higher leverage and risk, and lower liquidity and size. Insofar as these characteristics capture the extent of firm's financial constraints, we conclude that more financially constrained firms increased the drawdown on their credit lines more than the average firm. One possible interpretation of this finding is that financially constrained firms face stiffer consequences in case of a reduction of credit by their banks, because they have few or no other sources of funding that they can turn to. For this reason, the results suggest that financially constrained firms utilize their credit lines while they are still available.

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<sup>22</sup> The number of observations in Panel A of Table 6 is smaller than in Table 3, because the included firm-level controls are not available for all the firms in the sample.

The implications of Panel A of Table 6 are not merely of technical nature, but bear important implications for the effectiveness of risk management by banks. The fact that the coefficient of *interbank* loses significance when we exclude firm fixed effects and observable controls indicates that banks with higher interbank exposure did not suffer a larger increase in drawdowns on their credit lines than the average bank.

To provide additional empirical support to the hypothesis that firm selection neutralizes the effect of interbank exposure, in Panel B of Table 6 we aggregate our results at the bank level. We now include all observations in the tests, rather than only firms with multiple credit lines. For each bank we calculate the change in the logarithms of the drawn amounts of *all* the credit lines offered to its borrowers.<sup>23</sup> Changes are computed over the period June 2007-September 2007 and March 2007-June 2007. The coefficient of *interbank* in both columns of Panel B of Table 6 is not significantly different from zero. This implies that – in the *aggregate* – banks with higher interbank exposure did not suffer a higher level of drawdowns during the crisis than other banks in the sample.

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TABLE 6 about here

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Table 6 suggest that banks with high interbank did not suffer a larger increase in drawdowns on their credit lines than the average bank. We interpret this result to show that the ex-ante selection effects on firms – extending credit lines to firms with a low rate of drawdowns in crisis times – neutralizes the impact of interbank exposure. In the next section, we test this hypothesis analyzing the data before the crisis.

#### *Data before the Crisis: Ex-Ante Screening*

In Table 7, we examine the decision of a bank to grant a credit line during the months before the liquidity shock, and show how this choice relates to a bank's exposure to the interbank market. Panel A of Table 7 is dedicated to the extensive margin, while Panel B looks at the intensive margin. In both panels, we interact *interbank* with firm leverage and size,

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<sup>23</sup> In this panel the number of banks is higher (538 instead of 531) because there are 7 banks offering credit lines only to firms with just one bank relationship.

because in Table 4 on firm heterogeneity we found that these two firm characteristics matter the most for drawdowns. We also control for firm fixed effects.

Column 1 and 2 of Panel A of Table 7 indicate that on average banks with high interbank funding grant fewer credit lines both in March and June 2007. Additionally, columns 3 through 5 show that in June, the coefficient on the interaction of *interbank* and firm size is negative and significant. This means that banks with higher interbank exposure grant relatively fewer credit lines to small firms.<sup>24</sup> These firms are likely to be financially constrained and, according to Table 4, are more likely to draw on their credit lines when liquidity is scarce.<sup>25</sup>

In Table A3 in the Appendix, we re-run the regressions of column 3 to 5 for March 2007. We find that the coefficient of *interbank* is still negative and significant, as shown also in Panel A of Table 7 column 1, but the coefficient of the interaction between *small* and *interbank* is smaller than that estimated using data from June. A possible interpretation is that in March 2007 the effects of the sub-prime crisis had not yet been factored in by market participants, and banks were less cautious in screening firms according to their likelihood of running on the available credit lines. In April 2007, the first signs of the Subprime Crisis in the U.S. began to appear, when several banks announced losses related to subprime loans and on April 2 the largest subprime lender, New Century Financial, filed for Chapter 11. Increasing concerns about future liquidity conditions might have pushed the banks with less stable funding sources to reduce their exposure to the risk of runs on the credit lines.

In Panel B of Table 7 we examine the intensive margin of the provision of credit lines, and confirm the result that the screening of firms became tighter in the months that immediately preceded the crisis. We run a set of regressions in which the dependent variable is the logarithm of the amount of the granted credit line in March (column 1) and in June (column 2-5). We find that in March banks were granting credit lines of similar amounts (conditional on controls), irrespectively of their exposure to the interbank market. Instead, in June we find that banks with higher interbank funding were granting a lower amount of credit lines. All in all, our results suggest that, thanks to these ex-ante actions, banks were able to reduce (in fact, neutralize) the double-liquidity squeeze when the interbank market problems appeared in August 2007.

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<sup>24</sup> Note that this result is not due to a different matching between firm size and interbank, as we control for firm fixed effects.

<sup>25</sup> The coefficient on leverage has also the same interpretation, but given the standard errors, it is not statistically significant.

## 5. Conclusions

Banks provide liquidity not only to depositors, but also to firms via the extension of credit lines. These simultaneous activities expose banks to the risk of correlated double runs on their assets (credit lines) and on their liabilities (wholesale uninsured deposits). In this paper, we analyze the unfolding of this risk during the recent financial crisis. Relatedly, we investigate whether banks mitigate their exposure to double runs by means of ex-ante liquidity risk management in the granting of credit lines. In our empirical strategy, we exploit the shock to bank funding liquidity that came from the dry up of the European interbank market in August 2007, in conjunction with exhaustive credit line data held at the Italian Credit Register.

We find that, after the shock to the interbank market, firms with multiple credit lines draw more on the lines offered by banks with greater funding exposure to the shock. In particular, controlling for firm fixed effects, we find that a firm with credit lines from at least two different banks draws more from the banks with higher pre-crisis interbank funding. The impact of interbank funding on drawdowns is stronger for financially constrained firms and banks. Our results suggest that firms run on banks with higher interbank funding not because their credit lines are cheaper, but in anticipation of future credit supply restrictions. In the aftermath of the crisis, banks with higher interbank funding tighten their supply of credit to new applicants more than other banks. Moreover, banks with higher pre-crisis interbank funding experience a larger drop in interbank deposits during the crisis. Overall, this evidence is consistent with the presence of a double run on both assets and liabilities of banks.

The relation between drawdowns and interbank funding is however present only if one controls for firm selection (by including observable and unobservable corporate borrower characteristics). It disappears both at the (aggregate) bank-level and at the loan-level when firm controls are excluded. This shows that, unconditionally, banks with higher pre-crisis interbank funding do not suffer overall larger credit line runs; but, conditioning on borrower characteristics (including firm identity), credit line runs are associated with banks with higher interbank exposure. This evidence suggests that banks with higher interbank funding select firms that run less in the crisis. To further test this hypothesis, we analyze the period before the crisis, and show that banks with higher liability risk reduce their fragility by extending fewer credit lines, especially to financially constrained firms (extensive margin) that tend to run more

in crisis times. Moreover, conditional on extending a line, banks with higher liability risk offer lower amounts (intensive margin). These results suggest ex-ante screening on both observable and unobservable borrower characteristics mitigates ex-post (crisis) liquidity risk. In fact, our results show that such ex-ante liquidity risk management neutralizes the effect of double runs during the crisis.

Taken together, the above results are evidence of effective liquidity risk management by banks, and are inconsistent with the prevailing view in banking that predicts risk shifting (e.g. by minimizing risk management) by more fragile banks. Our findings are more in line with the idea that financial institutions with more fragile sources of finance select assets with lower liquidity risk (Hanson, Shleifer, Stein and Vishny (2014)). Considering that the provision of liquidity to both firms and depositors is at the heart of the banking business, we contribute to the theory of banking by showing that asset and liability liquidity risk in banks becomes correlated in times of crisis, and that there is liquidity risk management by banks.

Our results bear important implications for prudential policy. A key component of the new Basel III framework is the introduction of liquidity requirements, which penalize both credit lines provision and interbank funding. In this paper, we show that both items are subject to simultaneous runs. Therefore, our results suggest that the new liquidity requirements for credit lines and interbank funding are important. But our results also suggest that these requirements should not be set independently because the risk of interbank funding and credit line withdrawals are correlated. Moreover, our results suggest that banks are aware of this risk and actively manage it. Since risk mitigation occurs by selecting firms along observed and unobserved characteristics, the design of prudential supervision should rely on evidence from exhaustive micro data on credit lines.

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Figure 1: Interbank Spreads on Euro Market (Euribor – Eurepo)

The figure shows the series of spreads between the Euribor (Euribor is the average interest rate for unsecured Euro term deposits, the reference rate in the short-term unsecured interbank market) for three different maturities and the corresponding Eurepo (the average interest rate for secured money market transactions in the euro area). Values are reported in basis points. Source: Thomson Datastream.

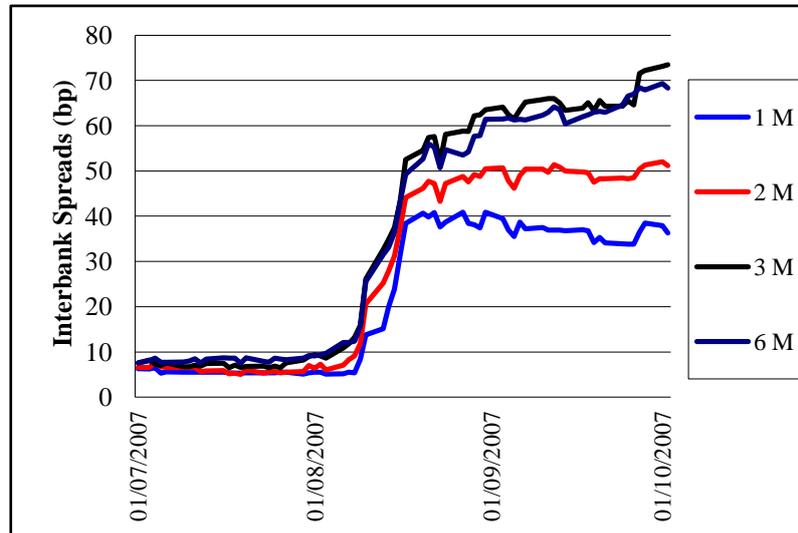


Table 1: Descriptive Statistics

The table shows descriptive statistics of the main variables employed in our analysis. The main sample covers the period June-September 2007, and it contains 472,153 bank-firm relationships reported in the Italian Credit Register. The sample includes only firms that as of June 2007 had at least two outstanding credit lines granted by different banks. Bank characteristics are calculated by weighting each bank by the number of outstanding bank-firm relationships. All variables are defined in the Appendix.

	Mean	Median	St. Dev.	Observations
<i>Panel A: Credit Lines Variables</i>				
$\Delta$ Drawn/Granted Jun/Sep 2007 (%)	4.56	0.00	38.27	472,153
$\Delta$ Log Drawn Jun/Sep 2007 (%)	16.70	5.13	133.50	203,018
$\Delta$ Drawn/Assets Jun/Sep 2007 (%)	0.16	0.00	1.77	462,302
$\Delta$ Log Granted Jun/Sep 2007 (%)	0.75	0.00	36.75	472,153
$\Delta$ Drawn/Granted Mar/Jun 2007 (%)	-0.21	0.00	36.76	455,545
$\Delta$ Log Drawn Mar/Jun 2007 (%)	2.04	1.03	134.51	189,148
$\Delta$ Drawn/Assets Mar/Jun 2007 (%)	-0.01	0.00	2.83	439,642
$\Delta$ Log Granted Mar/Jun 2007 (%)	0.05	0.00	37.63	456,304
$\Delta$ Cost of credit Jun/Sep 2007 (%)	0.10	0.23	2.04	349,430
Cost of credit June 2007 (%)	11.14	9.82	4.73	399,237
<i>Panel B: Relationship-Level Controls</i>				
Share of Credit June 2007 (%)	26.72	21.42	19.80	472,153
Drawn/Granted June 2007 (%)	34.62	3.28	47.13	472,153
Dummy Past-Due in June 2007	0.03	0.00	0.18	472,153
<i>Panel C: Firm Characteristics</i>				
Leverage (%)	26.29	25.02	21.98	132,148
Risk	5.59	5.00	6.46	132,016
Liquidity (%)	6.85	2.85	9.50	125,055
Size	9.86	2.13	273.13	132,439
<i>Panel D: Bank Characteristics</i>				
Interbank (%)	13.36	13.04	9.98	472,153
Liquidity (%)	6.22	4.69	5.04	472,153
Capital Ratio (%)	7.49	7.90	2.73	472,153
ROA (%)	1.42	1.06	0.90	472,153
Log Assets	10.95	11.62	2.31	472,153
Mutual Bank (Dummy)	0.09	0.00	0.29	472,153
<i>Panel E: Loan Applications</i>				
Dummy for Granting a Credit Line Post-crisis (%)	27.65	0.00	44.73	188,408
Dummy for Granting a Credit Line Pre-crisis (%)	27.57	0.00	44.68	247,842

Table 2: The Shock to Interbank Funding

The table shows regressions of the change in the interbank funding ratio (*interbank*), measured as the ratio of total borrowing from other banks to total assets, as a function of a set of bank characteristics. Changes are computed over the period June 2007-December 2007 for the regression in column 1, and over the period December 2006-June 2007 for the regression in column 2. The sample in column 1 includes 531 banks operating in Italy, while that in column 2 includes 529 banks, because 2 banks started operating in 2007 and did not post a balance sheet in December 2006. All variables are defined in the Appendix. Bank-level variables used in the regression shown in column 1 are as of June 2007, while those in column 2 are as of December 2006. Robust standard errors are reported in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

	$\Delta$ Interbank	
	(1) Jun 2007- Dec 2007	(2) Dec 2006-Jun 2007
Interbank	-0.189** (0.092)	-0.002 (0.103)
Liquidity	-0.027*** (0.009)	0.0159 (0.012)
Capital Ratio	-0.033 (0.026)	-0.059 (0.070)
ROA	-0.111 (0.156)	0.169 (0.441)
Log Assets	0.018 (0.132)	0.262* (0.139)
Mutual Bank	-0.505** (0.239)	-0.365 (0.317)
Constant	1.610 (0.985)	-0.802 (0.973)
Observations	531	529
R-Squared	0.132	0.075

Table 3: Drawdowns on Credit Lines

The table shows a set of regressions based on the specifications presented in Section 3. The main variable of interest is the interbank funding ratio (*interbank*), measured as the ratio of total borrowing from other banks to total assets. The dependent variables are the change in the ratio of drawn to granted credit lines (column 1), the change in the logarithm of drawn credit lines (column 2), the change in drawn credit lines normalized by firm assets (column 3), the change in the logarithm of granted credit lines (column 4). Changes are computed over the period June 2007-September 2007. The sample includes 472,153 bank-firm relationships from the Italian Credit Register. All variables are defined in the Appendix. All regressions include firm fixed effects and bank-firm relationship controls (see section on Empirical Model). Standard errors are double clustered at the bank and firm level and are reported in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

	(1) Δ Drawn/ Granted	(2) Δ Log(Drawn)	(3) Δ Drawn/ Assets	(4) Δ Log(Granted)
Interbank	0.054** (0.022)	0.163* (0.097)	0.001** (0.001)	-0.008 (0.015)
Liquidity	0.055 (0.037)	0.346** (0.147)	0.003*** (0.001)	0.046 (0.036)
Capital Ratio	0.043 (0.077)	0.848*** (0.260)	0.000 (0.002)	-0.068 (0.043)
ROA	-0.645** (0.298)	-3.817*** (1.444)	-0.013* (0.008)	-0.033 (0.210)
Log Assets	-0.476*** (0.135)	-0.379 (0.586)	-0.011** (0.004)	0.221* (0.129)
Mutual Bank	-1.759*** (0.535)	-6.332** (2.634)	-0.032 (0.026)	0.190 (0.598)
Firm FE	Y	Y	Y	Y
Relationship-Level Controls	Y	Y	Y	Y
Observations	472,153	203,018	462,302	472,153
R-Squared	0.561	0.595	0.543	0.309

Table 4: Firm and Bank Heterogeneity

Panel A shows regressions of the change in the ratio of drawn to granted credit lines on the interbank funding ratio (*interbank*), measured as the ratio of total borrowing from other banks to total assets, and other firm-level characteristics interacted with *interbank*. Changes in the ratio of drawn to granted are computed over the period June 2007-September 2007. Regressions include interactions between *interbank* and the following firm-level dummies: *high leverage* which is equal to 1 if firm leverage is in the top quartile of the distribution; *high risk* which is equal to 1 if a firm's Z-score is above 7; *low liquidity* which is equal to 1 if a firm's liquidity is in the bottom quartile of the distribution; *small* which is equal to 1 if a firm's assets are in the bottom quartile of the distribution. Panel B shows regressions of the change in the ratio of drawn to granted credit lines on interbank funding (*interbank*), measured as the ratio of total borrowing from other banks to total assets, and other bank-level characteristics interacted with *interbank*. Regressions include interactions between *interbank* and the following bank-level characteristics: *liquidity*, *capital ratio*, *ROA*, and *size*. All regressions include bank controls, firm fixed effects and bank-firm relationship controls (see section on Empirical Model) (see section on Empirical Model). The last columns includes all interactions. Standard errors are double clustered at the bank and firm level and are reported in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Panel A: Firm Heterogeneity

	$\Delta$ Drawn/Granted				
	(1)	(2)	(3)	(4)	(5)
Interbank	0.043** (0.021)	0.049** (0.022)	0.050** (0.021)	0.039* (0.022)	0.0375* (0.0203)
Interbank* High Leverage	0.022* (0.013)				0.0226* (0.0137)
Interbank* High Risk		-0.027 (0.030)			-0.0471 (0.0307)
Interbank* Low Liquidity			-0.008 (0.016)		-0.00583 (0.0155)
Interbank* Small				0.054*** (0.016)	0.0526*** (0.0164)
Bank Controls	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y
Relationship-Level Controls	Y	Y	Y	Y	N
Observations	414,386	414,386	414,386	414,386	414,386
R-Squared	0.561	0.561	0.561	0.561	0.561

Panel B: Bank Heterogeneity

	$\Delta$ Drawn/Granted				
	(1)	(2)	(3)	(4)	(5)
Interbank	0.073*** (0.024)	-0.024 (0.072)	0.080* (0.046)	0.738*** (0.223)	0.830*** (0.290)
Interbank* Liquidity	-0.008* (0.004)				-0.019*** (0.005)
Interbank* Capital Ratio		0.009 (0.006)			0.019** (0.009)
Interbank* ROA			-0.017 (0.020)		-0.012 (0.030)
Interbank* Size				-0.064*** (0.020)	-0.083*** (0.023)
Bank Controls	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y
Relationship-Level Controls	Y	Y	Y	Y	Y
Observations	472,153	472,153	472,153	472,153	472,153
R-Squared	0.561	0.561	0.561	0.561	0.561

Table 5: Supply of Credit to New Applicants

The table shows a set of linear probability model regressions of the probability of a loan being granted before and after the liquidity shock, as a function of the interbank funding ratio (*interbank*), measured as the ratio of total borrowing from other banks to total assets. More precisely, we regress a dummy variable that is equal to 1 if a loan application is granted within 90 days, on the interbank funding ratio (*interbank*) of the bank that receives the application, controlling for a set of bank-level controls, and including firm-time fixed effects in column 2 and 5, and firm fixed effects in column 3 and 6. The regressions that refer to the period after the liquidity shock (column 1, 2, and 3) include loan applications posted between September and December 2007. For these applications, credit is to be granted in the period September 2007-March 2008. The regressions that refer to the period before the liquidity shock (column 4, 5, and 6) include loan applications posted between January and April 2007. For these applications, credit is to be granted in the period January 2007- July 2007. All variables are defined in the Appendix. Standard errors are double clustered at the bank and firm level, and are reported in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

	Probability of a Loan Application being Granted					
	(1)	(2)	(3)	(4)	(5)	(6)
	After the Shock			Before the Shock		
Interbank	-0.409*** (0.082)	-0.260*** (0.060)	-0.258*** (0.060)	-0.083 (0.174)	0.026 (0.058)	-0.004 (0.070)
Bank Controls	Y	Y	Y	Y	Y	Y
Firm FE	N	N	Y	N	N	Y
Firm* Time FE	N	Y	N	N	Y	N
Observations	188,162	35,054	95,453	247,704	52,341	138,738
R-Squared	0.013	0.913	0.776	0.006	0.900	0.743

Table 6: Aggregate Effects

Panel A contains a set of regressions of the change in the drawn-to-granted ratio over the period June-September 2007, as a function of the interbank funding ratio (*interbank*), measured as the ratio of total borrowing from other banks to total assets, and bank controls, firm fixed effects and bank-firm relationship controls (see section on Empirical Model) in column 1 and 4. We exclude firm fixed-effects in column 2 and 5. We exclude firm fixed-effects and relationship-level controls in column 3 and 6. Column 1-3 show Ordinary Least Squares (OLS) estimates, while columns 4-6 show Weighted Least Squares (WLS) estimates, using as weights the logarithm of granted amount of credit line. Panel B shows regressions of the change in the logarithms of drawn amount of all outstanding credit lines at the bank level as a function of a set of bank characteristics. Changes are computed over the period June 2007-September 2007 for the regression shown in column 1 (“After the Shock”), and over the period March 2007-June 2007 for the regression shown in column 2 (“Before the Shock”). The sample includes all banks offering credit lines to firms (538 banks). Here the number of banks is higher than in the main sample because there are 7 banks offering credit lines only to firms with just one bank relationship. Bank-level variables used in the regression shown in column 1 are as of June 2007, while those in column 2 are as of December 2006. All variables are defined in the Appendix. Standard errors are double clustered at the bank and firm level and are reported in parentheses in Panel A. Robust standard errors are reported in parentheses in Panel B. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Panel A: Loan- Level Regressions

	$\Delta$ Drawn/Granted					
	(1)	(2)	(3)	(4)	(5)	(6)
		OLS			WLS	
Interbank	0.048** (0.022)	0.023 (0.020)	-0.006 (0.015)	0.046** (0.021)	0.023 (0.019)	-0.006 (0.014)
Firm Leverage		0.259*** (0.007)			0.250*** (0.007)	
Firm Risk		4.611*** (0.387)			4.421*** (0.357)	
Firm Liquidity		-0.302*** (0.012)			-0.299*** (0.012)	
Firm Size		-1.307*** (0.063)			-1.266*** (0.067)	
Bank Controls	Y	Y	Y	Y	Y	Y
Firm FE	Y	N	N	Y	N	N
Relationship-Level Controls	Y	Y	N	Y	Y	N
Observations	414,386	414,386	414,386	414,386	414,386	414,386
R-squared	0.536	0.143	0.000	0.532	0.140	0.000

Panel B: Bank- Level Regressions

	$\Delta$ Drawdowns	
	(1)	(2)
	After the shock	Before the Shock
Interbank	0.002 (0.008)	0.001 (0.005)
Bank Controls	Y	Y
Observations	538	538
R-squared	0.070	0.102

Table 7: Screening of Borrowers

Panel A reports a set of linear probability model regressions of the probability that a credit line is granted to a firm, as a function of the interbank funding ratio (*interbank*), measured as the ratio of total borrowing from other banks to total assets, and other firm-level characteristics (leverage and size) interacted with *interbank*. The dummy for granting a credit line takes value one if a bank is granting a line as of March 2007 in column 1 and as of June 2007 in columns 2 through 5. Panel B reports a set of regressions where the dependent variable is the logarithm of the granted amount of credit line in March (column 1) and in June (column 2-5), as a function of the interbank funding ratio (*interbank*), measured as the ratio of total borrowing from other banks to total assets and other firm-level characteristics (leverage and size) interacted with *interbank*. *High Leverage* is a dummy that is equal to one if a firm's leverage is in the top quartile of the distribution. *Small* is a dummy that is equal to one if a firm's assets are in the bottom quartile of the distribution. In the last column we include both interactions. All regressions include bank controls, firm fixed effects and bank-firm relationship controls (see section on Empirical Model). Standard errors are double clustered at the bank and firm level and are reported in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Panel A: Extensive Margin

	Dummy for Granting a Credit Line				
	(1)	(2)	(3)	(4)	(5)
	March 2007	June 2007			
Interbank	-0.788*	-0.283**	-0.277*	-0.276*	-0.271*
	(0.415)	(0.141)	(0.143)	(0.143)	(0.144)
Interbank*High Leverage			-0.029		-0.026
			(0.032)		(0.031)
Interbank* Small				-0.073*	-0.071*
				(0.038)	(0.037)
Bank Controls	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y
Relationship-Level Controls	Y	Y	Y	Y	Y
Observations	569,488	576,008	576,008	576,008	576,008
R-Squared	0.438	0.450	0.450	0.450	0.450

Panel B: Intensive Margin

	Logarithm of Granted Amount of Credit Line				
	(1)	(2)	(3)	(4)	(5)
	March 2007	June 2007			
Interbank	0.000	-0.007**	-0.007**	-0.007**	-0.007**
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Interbank* High Leverage			-0.001		-0.001
			(0.001)		(0.001)
Interbank* Small				0.000	0.000
				(0.002)	(0.002)
Bank Controls	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y
Relationship-Level Controls	Y	Y	Y	Y	Y
Observations	411,392	414,386	414,386	414,386	414,386
R-Squared	0.700	0.717	0.717	0.717	0.717

## Appendix

Table A1: Placebo Tests

This table replicates the main results of Table 3 for the regressions on the change in the ratio of drawn to granted credit lines ( $\Delta$  Drawn/Granted) and the change in the logarithm of drawn credit lines ( $\Delta$  Log(Drawn)) on data from periods before June 2007. In particular, the changes are computed over the period December 2006-March 2007 (column 1-2) and March 2007-June 2007 (column 3-4). The interbank funding ratio (*interbank*) is calculated here as of December 2006. All regressions include bank controls (calculated as of December 2006), firm fixed effects and bank-firm relationship controls (calculated as of December 2006 in the regressions shown in column 1-2 and as of March 2007 in the regressions shown in column 3-4). Standard errors are double clustered at the bank and firm level and are reported in parentheses. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

	December 2006-March 2007		March 2007-June 2007	
	(1) $\Delta$ Drawn/ Granted	(2) $\Delta$ Log(Drawn)	(3) $\Delta$ Drawn/ Granted	(4) $\Delta$ Log(Drawn)
Interbank	0.034 (0.022)	0.122 (0.083)	0.048 (0.038)	-0.133 (0.145)
Bank Controls	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y
Relationship-Level Controls	Y	Y	Y	Y
Observations	448,751	184,592	454,170	189,148
R-squared	0.322	0.154	0.583	0.593

Table A2: Cost of Credit Lines

This table reports regressions of the cost of credit lines in June 2007 (column 1) and the change in the cost of credit lines between September and June 2007 (column 2) as a function of the interbank funding ratio (*interbank*) and a set of firm fixed effects and bank controls (*capital*, *liquidity*, *ROA* and *size*). Both dependent variables are winsorized at the 5% level. All regressions include bank controls and firm fixed effects. Standard errors are double clustered at the bank and firm level and are reported in parentheses. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

	(1)	(2)
	Cost of Credit in June	$\Delta$ Cost of Credit September- June
Interbank	0.007 (0.013)	-0.000 (0.002)
Cost in June		-0.190*** (0.004)
Bank Controls	Y	Y
Firm FE	Y	Y
Observations	399,237	349,430
R-squared	0.713	0.567

Table A3: Liquidity Risk Management in March 2007: Extensive Margin

The table reports a set of linear probability model regressions of the probability that a credit line is granted to a firm, as a function of the interbank funding ratio (*interbank*), measured as the ratio of total borrowing from other banks to total assets, and other firm-level characteristics (leverage and size) interacted with *interbank*. The dummy for granting a credit line takes value one if a bank grants a line as of March 2007. *High Leverage* is a dummy that takes the value one if a firm's leverage is in the top quartile of the distribution. *Small* is a dummy that takes the value one if a firm's assets are in the bottom quartile of the distribution. In the last column we include all interactions. All regressions include bank controls, firm fixed effects and bank-firm relationship controls (see section on Empirical Model). Standard errors are double clustered at the bank and firm level and are reported in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

	Dummy for Granting a Credit Line			
	(1)	(2)	(3)	(4)
Interbank	-0.788*	-0.780*	-0.786*	-0.778*
	(0.415)	(0.417)	(0.423)	(0.424)
Interbank* High Leverage		-0.043		-0.0422
		(0.050)		(0.0485)
Interbank* Small			-0.028	-0.0241
			(0.095)	(0.0941)
Bank Controls	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y
Relationship-Level Controls	Y	Y	Y	Y
Observations	569,488	569,488	569,488	569,488
R-Squared	0.438	0.438	0.438	0.438

## Description of variables

The table describes the main dependent and control variables we use in the paper.

<i>Credit Lines Variables</i>	<i>Description</i>	<i>Source</i>
$\Delta$ Drawn/Granted	Change in the ratio of drawn to granted credit line, in percentage	Central Credit Register
$\Delta$ Log Drawn	Change in the logarithm of drawn amount of credit line, in percentage	Central Credit Register
$\Delta$ Log Granted	Change in the logarithm of credit line granted, in percentage	Central Credit Register
$\Delta$ Drawn/Assets	Change in the ratio of drawn amount of credit line to firm assets, in percentage	Central Credit Register
Cost of credit	Interest rate gross of fees and commissions, paid on each credit line, in percentage	Central Credit Register
<i>Relationship-Level Controls</i>		
Share of Credit	Share of credit of bank $j$ out of total credit provided to firm $i$	Central Credit Register
Drawn/Granted	Drawn-to-granted ratio of credit line granted by bank $j$ to firm $i$ , in percentage	Central Credit Register
Past-Due	Dummy variable equal to 1 if firm $i$ had past due loans with bank $j$	Central Credit Register
<i>Firm Characteristics</i>		
Leverage	Debt to asset ratio, in percentage	Cerved
Risk	Z-score. It measures the likelihood of a firm's default within one year (Altman, 1968). The score takes values between 1 (least likely to default) and 9 (most likely to default)	Cerved
Liquidity	Sum of cash and equivalents divided by total assets, in percentage	Cerved
Size	Total assets in millions of euros	Cerved
<i>Bank Characteristics</i>		
Interbank	Ratio of total borrowing from other banks to total assets, inclusive of deposits and repos from other banks, exclusive of deposits from the ECB or other national central banks, in percentage	Supervisory Reports
Liquidity	Sum of cash holdings and sovereign bonds divided by total assets, in percentage	Supervisory Reports
Capital Ratio	Equity (shares subscribed, book value of equity plus retained earnings) divided by total assets, in percentage	Supervisory Reports
ROA	Net income divided by total assets, in percentage	Supervisory Reports
Log Assets	Logarithm of total assets	Supervisory Reports
Mutual Bank	Dummy equal to 1 if the bank is a mutual financial institution	Supervisory Reports
<i>Loan Applications</i>		
Dummy for Granting a Credit Line	Dummy equal to 1 if a bank posted a request of information to the Credit Register about a firm and the bank grants credit to the firm in the 3 months following the request of information (multiplied by 100)	Central Credit Register