The Transmission of Liquidity Shocks to the Real Economy *

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Abstract

This paper uses the $2007 - 2009$ financial crisis as a negative liquidity shock on banks to analyze their lending behavior and study the differences between US and euro-area banks. When faced with a negative liquidity shock, US banks transmitted the liquidity shock to the real economy by reducing the amount of loans, whereas euro-area banks did not show any decline in their lending. The main difference between US and euro-area banks is the ability of finding alternative financing. Euro-area banks were able to issue short-term debt, whereas US banks seemed unable to do so. This difference in the access to alternative financing sources may be explained by different monetary policy responses. (JEL G21, G28, E52, E58)

Keywords: Financial Crisis, Bank Liquidity Shocks, Credit Supply Shocks, Bank Lending Channel.

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1 Introduction

The financial crisis has highlighted the importance of a smoothly functioning credit supply for economic activity. Traditionally, the main source of credit is the banking sector in the euro area whereas it is non-bank financial markets in the US. This difference in the financial structures has led to different monetary policy responses to the crisis. The Federal Reserve's policy action has been characterized by an emphasis on non-bank financial markets, such as the commercial paper market or the market for asset-backed securities, both of which play major roles in the extension of credit in the US (Bernanke, 2009). On the other hand, the European Central Bank's (ECB) response has focused on the banking sector supporting the loan supply from the banking system to households and firms (Trichet, 2009). One important question in finance is whether negative liquidity shocks are transmitted to the real economy by a decline in banks' loan supply. If monetary policy measures affect the loan supply, one expects to see differences in the transmission of liquidity shocks to the real economy between the US and the euro area.

The goal of this paper is to analyze the transmission of liquidity shocks to the real economy, highlighting the difference between the US and the euro area. More precisely, it examines the question whether financial institutions reduce their loan supply when they face an adverse liquidity shock. During a recession, the decline in the loan demand could be mitigated by the downward pressure on interest rates without a decline in the loan supply. However, the decline in the loan supply puts upward pressure on interest rates and leads to a dramatic fall in lending, which implies that the decline in the loan supply has important implications for economic activity.

To investigate the effects of liquidity shocks on banks' loan supply, the $2007 - 2009$ financial crisis is used as a negative liquidity shock. To provide compelling evidence on the transmission of liquidity shocks, several challenges need to be addressed.

The first challenge is that liquidity shocks are systemic shocks that affect many banks at the same time. It is important to identify a setting in which similar banks have different exposures to the same liquidity shock. Therefore, in this paper, the ex-ante heterogeneity in the fraction of long-term debt maturing during the period from January 2008 until the end of 2009 is used to measure bank-specific exposure to the liquidity shock.[1] The banks with larger fractions of their long-term debt maturing during the crisis are more exposed to a negative liquidity shock than otherwise similar banks with smaller fractions. This is due to the fact that the price of short and long-term debt for banks increased dramatically during the crisis. According to Almeida et al. (2010), Citigroup's investment-grade spreads increased sharply from 1% in September 2007 to 3% in early 2008. The collapse of Lehman Brothers aggravated this effect further to around 7% at the end of 2008. Similarly, high-yield spreads, which had been around 3% in early 2007, approached 8% in 2008 and reached the level of around 17% shortly after September 2008. This means that the banks with larger fractions of their long-term debt maturing during the crisis were affected more by the high interest rates compared to otherwise similar banks.

The second challenge is to establish a clear link between financial constraints and the quantity of bank lending. Banks decide on their debt maturity structure and amount of lending simultaneously, which makes it difficult to identify the causality between maturing debt and the change in the quantity of lending. To address this challenge, long-term debt that is pre-determined at the time of the liquidity shock, is used. More precisely, the amount of long-term debt maturing during the financial crisis that is issued before the end of 2006 is calculated. The assumption here is that banks did not anticipate the crisis before the end of 2006, so this is the debt that is issued without the anticipation of the coming financial crisis. This ensures that the ex-ante heterogeneity in the fraction of long-term debt falling

[1] Almeida et al. (2010) use this framework to show the effect of financial contracting on firms' investment decisions. They find that firms whose long-term debt largely matured after the third quarter of 2007 cut their investment-to-capital ratio by 2.5 percentage points more than otherwise similar firms.

due during the crisis is exogenous.

The third challenge is to disentangle the demand and supply side effects. Similar economic forces leading to negative liquidity shocks may have a direct adverse effect on the investment opportunities of firms. This may decrease the aggregate demand for loans in the economy. The difference-in-differences matching estimation approach is used to account for the demand side effect by choosing banks that have similar loan demands. To analyze this further, the same experiment is replicated for the time period $2004-2005$ before the crisis and it is shown that the estimated treatment effect is statistically indistinguishable from zero, so the average change in the amount of loans is the same for both treated and control banks. Repeating the difference-in-differences analysis on pre-event years is one of the robustness tests (Roberts & Whited, 2011). This ensures that the observed change in loan supply is more likely due to the treatment, which is the crisis itself, as compared to other forces.

The results show that affected US banks, with a large fraction of their long-term debt maturing during the crisis, reduced the amount of their loans by an average 5.37% of their total assets, which is both statistically and economically significant, relative to otherwise similar control banks with lower fractions of their long-term debt maturing during the crisis. In other words, affected US banks transmitted liquidity shocks to the real economy by cutting their lending during the $2007-2009$ financial crisis. In the euro area, the average change in the amount of loans is the same for both affected and control banks, which means that there was no transmission of negative liquidity shocks to the real economy during the crisis.

To investigate the reason underlying this difference between US and euro-area banks, the change in the amount of long-term and short-term debt is further analyzed. The results demonstrate that affected US banks did not change the amount of their long-term debt significantly relative to control banks. This indicates that affected US banks issued new long-term debt when large fractions of their long-term debt matured during the crisis. On the other hand, affected euro-area banks reduced the amount of their long-term debt significantly

by an average 4.84% of their total assets relative to control banks. This shortfall coming from the reduction in their long-term debt was covered by issuing new short-term debt, which increased their short-term debt significantly by an average 3.09% of their total assets. In this way, the transmission of the liquidity shocks to the real economy was avoided in the euro area.

We can explain the difference between US and euro-area banks by their ability of accessing alternative financing sources. The results suggest that US banks were not able to find alternative financing during the crisis; they rolled the maturing long-term debt over by issuing new long-term debt with high interest rates. Contrary to US banks, euro-area banks issued short-term debt to cover their shortfall from maturing long-term debt. This raises the question of how affected euro-area banks were able to access short-term debt financing during the financial crisis whereas the US counterparts seemed unable to do so. As inter-bank markets also dried up in the euro area at the onset of the financial crisis similar to the US, this may be explained by a central bank support that focused on the provision of short-term liquidity. The possible explanation lies in the differences between the monetary policy responses to the crisis.

Further analysis to differentiate the effects of different policy measures is hindered by the limited availability of data. The information on banks participating in the Troubled Asset Relief Program (TARP) and the amount of capital received were published by the US Treasury, while the ECB did not publish data on banks participating in the Long Term Refinancing Operation (LTRO), in which EUR one trillion was channeled into banks (Gros et al., 2012). As there is no published data, an analysis of the effect of receiving refinancing from the ECB on the transmission of liquidity shocks in the euro area is not possible. Contrary to the situation in the euro area, with the available data on recipient banks in the US, the effect of TARP capital on the transmission of liquidity shocks in the US can be examined.

TARP was established by the US Treasury under the Emergency Economic Stabilization

Act of 2008 after the bankruptcy of Lehman Brothers and aimed at stabilizing the banking system and encouraging loan supply in the economy. The analysis shows that US banks' receiving TARP capital did not mitigate the reduction in the amount of their loans. This means that affected US banks cut their lending although they received TARP capital during the financial crisis, i.e. TARP capital was not used to issue new loans to their customers. This indicates that TARP was not successful in encouraging banks to continue lending in order to support economic activity.

Overall, the results of this paper show that banks in the US transmitted negative liquidity shocks to the real economy by cutting their lending contrary to the euro area where there was no transmission. This suggests that differences in monetary policy responses led to differences in the transmission of liquidity shocks to the real economy.

The relevant existing literature is discussed in Section 2 while Section 3 proceeds with a demonstration of the empirical methodology used throughout the paper and describes the data. The main results about the effects of liquidity shocks on banks' lending are presented in Section 4 and several robustness checks are conducted in Section 5. Finally, Section 6 concludes the paper.

2 Literature Review

There is a large body of literature describing the effects of liquidity shocks on the real economy. Theoretical papers by Bernanke & Blinder (1988), Bernanke & Gertler (1989) and Holmstrom & Tirole (1997) find that liquidity shocks are transmitted to the real economy only when there are financial frictions at both the bank and the firm levels. The early empirical literature by Bernanke (1983) and Bernanke & Blinder (1992) highlights that liquidity shocks affect the real economy, by calculating correlations between changes in the liquidity and changes in the aggregate loans. However, these correlations could be driven by

systemic shocks that affect both firm investment and bank lending at the same time.

Moving away from aggregate data, more recent empirical literature such as Kashyap et al. (1994), Kashyap & Stein (2000), Campello (2000), Ashcraft (2006) and Ashcraft & Campello (2007) has used micro data concentrating on the variation across banks and firms. Kashyap et al. (1994) examine micro data on US manufacturing firms' inventory behavior during different macroeconomic periods. They find that the inventory investment of firms without access to public bond markets was significantly liquidity constrained during the $1981-1982$ recession. Kashyap & Stein (2000) support the existence of a bank lending channel of monetary transmission. They report that changes in monetary policy matter more for the lending of banks with less liquid balance sheets. Campello (2000) compares the responses of small subsidiary and independent banks to monetary policy by analyzing internal capital markets in financial conglomerates. The results show that internal capital markets relax the credit constraints faced by smaller subsidiaries relative to independent banks. Ashcraft & Campello (2007) investigate the question whether borrower creditworthiness influences the response of bank lending to monetary policy. They explore the lending behavior of small subsidiary banks that are affiliated with the same holding company but operate in different geographical areas, using the fact that these banks face the same cost of funds due to internal capital markets. Their results suggest that borrowers' balance sheet status can explain a significant fraction of the response of bank lending to monetary policy.

There is also a growing body of empirical literature that uses instrumental variables or exploits a natural experiment to generate exogenous liquidity shocks, such as Ashcraft (2005), Gan (2007), Paravisini (2008), Khwaja & Mian (2008), Iyer & Peydro (2011), Chava & Purnanandam (2011) and Schnabl (2012). Ashcraft (2005) uses the exogenous failure of otherwise healthy subsidiary banks when lead banks were declared insolvent as a natural experiment to study the impact of bank failure on real economic activity. The results support that healthy bank failures have significant and permanent effects on real economic activity.

Gan (2007) examines how a shock to the financial health of banks affects the real economy by exploiting the land market collapse in Japan to separate the impact of a loan supply shock from demand shock. The results highlight that banks with greater real estate exposure have to reduce lending. Paravisini (2008) exploits a shock to the financial position of local banks by a government lending program in Argentina to test for the effects of financial constraints on the supply of credit. Banks expand lending by \$0.66 in response to an additional dollar of external financing. The results demonstrate that financial shocks to constrained banks are found to have a quick, persistent and amplified effect on the aggregate supply of credit. Khwaja & Mian (2008) analyze the impact of liquidity shocks by using cross-bank liquidity variation induced by unanticipated nuclear tests in Pakistan. They find that a percentage point decline in bank liquidity supply leads to a reduction of 0.6 percentage points in the amount lent by banks. Large firms compensate for this loss by borrowing through the credit market, whereas small firms are unable to do so and face large drops in overall borrowing. Iyer & Peydro (2011) exploit a sudden shock caused by a large bank failure on interbank exposures and analyze the real economic effects. They argue that higher interbank exposure to the failed bank leads to large deposit withdrawals and the contagion is higher for banks with weaker fundamentals. Chava & Purnanandam (2011) provide evidence that adverse capital shocks to banks affect their borrowers' performance negatively by using the 1998 Russian default as an exogenous shock on the US banking system. They find that firms that primarily relied on banks suffered larger valuation losses. Schnabl (2012) also exploits the 1998 Russian default as a negative liquidity shock to international banks and analyzes its transmission to Peru. After the shock, international banks reduced bank-to-bank lending to Peruvian banks and Peruvian banks reduced lending to Peruvian firms.

This paper also adds to the literature that tries to explain the real effects of the financial crisis, such as Ivashina & Scharfstein (2010), Almeida et al. (2010) and Puri et al. (2011). Ivashina & Scharfstein (2010) demonstrate that new loans declined substantially during the

financial crisis across all types of loans. They argue that some of this decline could be coming from the decrease in loan demand. Almeida et al. (2010) investigate the effect of financial contracting on real firm behavior. They find that firms whose long-term debt largely matured right after the third quarter of 2007 cut their investment-to-capital ratio by 2.5 percentage points more than otherwise similar firms. The effects of the US financial crisis on retail bank lending in Germany are examined in Puri et al. (2011). They find that the savings banks affected by the US financial crisis cut their credit supply more compared to non-affected saving banks.

Recent literature has studied the effects of TARP on banks' risk taking and lending behavior. Bayazitova & Shivdasani (2012) demonstrate that TARP capital infusions did not have certification effects, but the subsequent stress tests conducted for major banks had significant certification effects. Li (2013) studies the effect of participation in TARP on credit supply in the economy by testing whether the injection of capital boosted bank loan supply and mitigated the negative effects of a banking crisis on the real economy. The results show that participation in TARP increased bank loan supply by an annualized rate of 6.43% for banks with below median Tier 1 capital ratios (less capitalized banks) and there is no effect on well capitalized banks.

This paper also contributes to the literature that investigates whether the bank balance sheet affects the transmission of liquidity shocks to the real economy. Kashyap & Stein (1995), Kashyap & Stein (2000) and Kishan & Opiela (2000) study the effects of bank size, bank size and liquidity, and bank size and capital, respectively. These studies find that a bank lending channel exists and is transmitted by under-capitalized banks or the ones that have less liquid assets. These results support the hypothesis that under-capitalized banks are unable to raise capital through alternative financing sources when there are market frictions. The cost of funding is higher for under-capitalized banks since bank capital provides a signal about a bank's creditworthiness (Holmstrom & Tirole, 1997) (Jayaratne & Morgan, 2000).

Gambacorta (2005) finds that bank size is irrelevant; small banks are not more sensitive to monetary policy shocks than large banks.

3 Empirical Design

In this paper, the effect of liquidity shocks on banks' lending is examined by employing the difference-in-differences methodology. More precisely, this paper addresses the following question. Do banks reduce the amount of their lending when they face a negative liquidity shock? This question is analyzed by exploiting the $2007-2009$ financial crisis as an adverse liquidity shock on banks. The identification for the empirical test is based on the fact that banks have different fractions of their long-term debt maturing during the crisis.[2] This fraction is used to measure bank-specific exposure of similar banks to the same systemic liquidity shock.[3] The banks with at least 10% of their long-term debt maturing during the crisis are assigned to the treated banks. The remaining banks with less than 10% of their long-term debt maturing during the crisis are assigned to the non-treated banks. The long-term debt is calculated at the end of 2006. The banks were not anticipating the financial crisis before the end of 2006, so long-term debt that is issued before the end of 2006 and maturing during the crisis was an exogenous shock.

The baseline regression model for the difference-in-differences methodology to estimate the treatment effect is specified as follows:

$$\Delta y_i = \beta_0 + \beta_1 \cdot \text{Treat}_i + \epsilon_i \tag{1}$$

In the above equation, the dependent variable Δy_i is equivalent to the change in the variable

[2]The long-term debt is defined as the total debt with at least one year maturity.

[3]To use this identification, one needs to show that there is enough cross-bank variation in the fraction of long-term debt maturing during the crisis period. It is examined in the next section and the results demonstrate that there is enough cross-bank variation in this fraction.

of interest (loans, long-term debt, short-term debt, equity, deposits, assets and return on assets) for bank i. For example for loans, the change in loans is calculated as Δloans = (loans$_t$−loans$_{t-1}$) / total assets$_{t-1}$. The treatment effect is captured by β_1 where Treat$_i$ is 1 if bank i is a treated bank. Here, t corresponds to the treatment period and $t-1$ is the pre-treatment period. The post-treatment variables are calculated as an average of 2009 and 2008 and pre-treatment variables are the average of 2007 and 2006.

3.1 Sample Selection and Data

The data used in this paper is from the SNL Financial's Bank Balance Sheet and Capital Structure. This study concentrates on commercial banks since the vast majority of loans is issued by commercial banks. In the US, about 84 percent of commercial banks are part of a bank holding company structure. The internal capital markets in bank holding companies might relax the capital constraints of small subsidiaries by sharing liquidity. To control for the possible liquidity sharing across subsidiaries, US bank holding companies have been used instead of individual commercial banks. Finally, US bank holding companies and euro-area commercial banks with annual complete data for total assets, equity, deposits, loans, total debt, cash and cash equivalents, total operating income, net income and loan loss reserves from 2005 to 2009 have been included in the sample.[4]

The data on debt issuance and maturity are available on SNL Financial's Capital Structure. The debt that was issued before the end of 2006 and maturing between the end of 2007 and the end of 2009 (between 12/31/2007 and 12/31/2009) is calculated. This is the long-term debt the bank is holding at the end of 2006 that matures during the crisis period. The long-term debt is defined as the debt with maturity of at least one year. The ratio of this long-term debt over total long-term debt that is calculated at the end of 2006 is used to measure the banks' exposure to the negative liquidity shock. The ten largest banks from

[4]Annual data is used since the balance sheet data for euro-area banks is available only annually.

both samples are deleted. At the end, there are 100 euro-area commercial banks and 405 US bank holding companies.

To measure a bank's financial condition, several bank characteristic variables that proxy for the components of the CAMELS rating are used. The CAMELS rating is a supervisory rating used by federal banking regulators to provide a convenient summary of bank conditions. The acronym CAMELS refers to the six components of a bank's condition: Capital adequacy, Asset quality, Management, Earnings, Liquidity and Sensitivity to market risk. Banking regulators believe that these six components can provide a comprehensive assessment of a bank's overall condition (Lopez (1999)).

This paper uses these six components to evaluate a bank's overall condition. The (Total Equity/Total Assets) ratio is used as a proxy for a bank's capital adequacy (C). As a proxy for a bank's asset quality (A), the (Loan Loss Reserves/Total Loans) ratio is used. For management quality (M), the (Operating Income/Total Assets) is used, and return on assets (Net Income/Total Assets) is chosen to approximate the Earnings (E). For Liquidity (L), the (Cash and Cash Equivalents/Total Assets) ratio is used as a proxy and for the last acronym sensitivity to market risk (S), the (Loans/Deposits) ratio is used as a proxy. As this ratio increases, banks become more sensitive to the market risk.

Besides the above variables, (Size), which is the natural logarithm of total assets, (Loans/Total Assets), (Long-Term Debt/Total Assets) and (Short-Term Debt/Total Assets) are used. In total, ten bank characteristic variables are used to match treated and control banks. The details of the matching is explained in the next section.

The analysis starts by showing that there is enough variation in the ratio of long-term debt maturing during the crisis. Figure 1 shows the ex-ante fraction of long-term debt maturing during the crisis period over total long-term debt for all US and euro-area banks. This fraction is calculated at the end of 2006 to guarantee that financial institutions were not anticipating the financial crisis when they decided on their capital structure. This is

crucial since the exogeneity of the shock used in the experiment is an important assumption for the validity of the difference-in-differences estimation. As shown in Figure 1, 412 banks, out of total 505 banks, have no long-term debt that was issued before the end of 2006 and matured during the crisis period. On the other hand, for 9 banks, all of the outstanding long-term debt at the end of 2006 matures during the crisis period. If banks' debt maturity structure is well diversified, we would expect some concentration of the fraction around a specific value. Figure 1 shows that there is enough cross-bank variation in the fraction, so banks' debt maturity structure is not well diversified and this fraction can be used as a source of exogenous heterogeneity in the exposure of similar banks to the systemic liquidity shock during the crisis. The banks that did not have maturing long-term debt during the crisis is 81% of total banks.[5] This raises the question whether this could be a sign that banks actually anticipated the crisis even before the end of 2006. To alleviate this concern, the same fraction is calculated for another period of time without the crisis. The histogram for the fraction of long-term debt maturing during $2004 - 2005$ that was issued before 2002 is plotted in Figure 2. This calculation is done only for US banks since the balance sheet data for euro-area banks starts in 2005. As it is displayed in Figure 2, 147 out of 185 banks, 79%, have no long-term debt maturing in the period $2004 - 2005$ that was issued before 2002, which is similar to the crisis period. The results suggest that the variation in the fraction of long-term debt maturing during the crisis period is thus similar to another period of time where there is no crisis. This mitigates the concerns about the possibility whether banks anticipated the financial crisis already before the end of 2006.

3.2 Treated and Control Banks

Banks are sorted into treated and non-treated groups based on the fraction of their long-term debt maturing during the crisis. As already mentioned in the empirical design section, the

[5] It is 85% for US banks and 65% for euro-area banks, separately.

banks with at least 10% of their total long-term debt maturing during the crisis are assigned to treated banks, the remaining banks with less than 10% are assigned to non-treated banks.

The first sample consists of 405 US banks. There are 29 treated and 376 non-treated banks. Table 1 shows the comparative statistics for treated and non-treated US banks. The Wilcoxon rank-sum test is used to test for differences in the distribution of matching characteristics across two groups (Wilcoxon (1945)). There are significant differences in the distribution of four bank characteristics between the two groups: size, return on assets, loans and long-term debt. More specifically, treated banks are on average larger than non-treated banks and they are more profitable; their average return on assets is about 1.1% of total assets whereas it is 0.9% for non-treated banks. They have lower loans ratio, 64.6% to 70.9% of total assets, and hold on average relatively more long-term debt.

Six control banks are chosen for each treated bank, 174 control banks in total, using the nearest neighbor matching. All above-mentioned bank characteristics measured in 2006 are used for the matching. Table 2 reports the summary statistics of bank characteristics for both treated and control banks after matching. Size and return on assets are the only bank characteristics that are still significantly different between treated and control banks after the matching although a relatively large number of variables is used for matching. When we look at the differences, treated banks are on average larger than control banks and they are more profitable, as their return on assets is on average 1.1% whereas it is 0.9% for control banks. Differences in individual bank characteristics do not affect the application of the difference-in-differences estimation methodology. The main assumption of the method is that the average change in the response variable would have been the same for both treated and control banks in the absence of the treatment. This assumption is referred to as the "parallel trends" assumption and it requires any trends in outcomes for treated and control groups prior to treatment to be the same (Roberts & Whited (2011)). Table 3 compares the trends in bank characteristics for treated and control banks prior to treatment for the

period $2005-2007$. There is no significant trend difference in any of the bank characteristics between treated and control banks.

In the second sample, there are 26 treated banks and 74 non-treated banks out of total 100 euro-area banks.[6] Table 4 shows the comparative statistics for treated and non-treated euro-area banks. The Wilcoxon rank-sum test is used to test for differences in the distribution of matching characteristics across two groups. Treated banks have on average significantly different size, return on assets, cash and long-term debt ratio. More precisely, treated banks are on average larger than non-treated banks. Their return on assets is on average significantly higher compared to non-treated banks, so they are more profitable. They have on average a higher cash ratio, 3.8% to 1.6% of total assets, and a higher long-term debt ratio, 9.1% relative to 7.1% of total assets.

For each treated bank, two banks that have the closest bank characteristics measured in 2006 and also similar trends in the period from 2005 to 2007 are chosen as control banks using the nearest neighbor matching, where all above-mentioned bank characteristics are used. Table 5 reports the summary statistics for bank characteristics of treated and control banks after matching. Return on assets, long-term debt and size are the only bank characteristics that are still significantly different between treated and control banks. When we look at the differences, treated banks are on average more profitable compared to control banks, 0.8% to 0.7% of total assets. Their long-term debt ratio is on average higher, 9.1% to 5.6% of total assets, and treated banks are on average larger than control banks. Table 6 compares the trends in bank characteristics for treated and control banks prior to treatment, during the period $2005-2007$. There is no significant difference in the trends for any of the bank characteristics between treated and control banks. Two control banks are chosen for each treated bank since this is the largest number of banks having the closest bank characteristic levels and satisfying the "parallel trends" assumption for all bank characteristics as well.

[6]The number of banks from each country is reported in Table 7.

For US banks, size and return on assets are included as control variables in the regression to control for the possible heterogeneity that is left after matching; since size and return on assets are the only bank characteristics that are significantly different between treated and control banks. For euro-area banks, return on assets, long-term debt and size are included in the regression for the same reason. Additionally, as a robustness check, country dummies have been included to control for unobservable country-specific effects for euro-area banks in Section 5. All reported p-values are based on heteroskedasticity robust standard errors.

4 Main Results

The estimates for the effect of negative liquidity shocks on several bank characteristics are presented in this section. The results are discussed for US and euro-area banks separately.

4.1 US Banks

The first question to analyze is whether banks with at least 10% of their total long-term debt maturing during the crisis period (treated banks) reduced the quantity of their loans relative to otherwise similar control banks. The difference-in-differences estimation method is used to identify a differential effect on treated versus control banks. The main assumption is that changes in the quantity of loans would be the same among treated and control banks in the absence of the financial crisis. Table 3 shows the trends in all bank characteristics between $2005 - 2007$ before the crisis. According to the Wilcoxon rank-sum test, the difference in the trends of loans between treated and control banks is statistically indistinguishable from zero. This assures the parallel trends assumption.

The difference-in-differences estimation results for US banks are reported in the top panel of Table 8. The first column shows that the point estimate of the effect on loans is -5.37 percentage points yearly difference, which is highly significant at the 1% level. This suggests

that treated banks reduced their lending by an average 5.37% of their total assets relative to control banks. Remember that treated banks' loans ratio is on average 64.6% of their total assets, so treated banks reduced their lending by 8.31% of their total loans. This is the effect of the negative liquidity shocks on the amount of loans during the crisis.

The second interesting question is whether treated banks with larger fractions of their long-term debt maturing during the crisis finance themselves issuing new long-term debt or use alternative financing sources. The effect of the negative liquidity shocks on the amount of long-term debt is analyzed by addressing the question whether treated banks changed their long-term debt relative to similar control banks. The difference in the trends of long-term debt between treated and control banks before the crisis is statistically insignificant as presented in Table 3, which means that treated and control banks have parallel trends in their long-term debt in the absence of the financial crisis. There is no significant difference in the long-term debt during the crisis period as reported in the second column of Table 8. The point estimate of the effect is-0.26 percentage points yearly difference, which is not significant, so the change in the amount of long-term debt is the same for both treated and control banks. This indicates that when treated banks had larger fractions of their long-term debt maturing during the crisis, they issued new long-term debt with high interest rates to cover their shortfall from maturing long-term debt.

The next interesting question is whether this decline in the amount of loans could be coming from a significant change in other sources of funding. This raises three questions: The first question is whether treated banks changed the amount of their short-term debt. Treated and control banks have similar trends in their short-term debt before the crisis as reported in Table 3. There is no significant difference in the absence of the crisis. During the crisis period, Table 8 presents that there is -1.35 percentage points yearly difference in their short-term debt, which is not significant. Treated banks and control banks have similar changes in their short-term debt during the crisis period. The second question is whether

treated banks changed their equity levels relative to control banks. Table 3 shows that the difference in the trends of equity among treated and control banks is indistinguishable from zero, which suggests that treated and control banks have similar trends in the absence of treatment. As reported in the fifth column of the top panel in Table 8, the estimate shows no significant difference in their equity during the crisis. The third question is whether there is a significant change in their deposits. Table 3 shows that treated and control banks have similar trends in their deposits in the absence of treatment before the crisis. The change in their deposits during the crisis is not statistically significant as reported in Table 8. This suggests that the change in deposits is the same for both treated and control banks.

These results show that US banks with larger fractions of their long-term debt maturing during the crisis issued new long-term debt to finance their shortfall from maturing long-term debt and reduced their lending significantly relative to control banks. Overall, affected banks transmitted the negative liquidity shocks to the real economy during the financial crisis.

4.1.1 Monetary Policy Responses by the Federal Reserve

When the global financial crisis started in August 2007, the central banks responded to the crisis by cutting interest rates close to zero and adopted a large scale of unconventional monetary policy measures. The Federal Reserve's policy action has been characterized by an emphasis on non-bank financial markets, such as the commercial-paper market or the market for asset-backed securities, both of which play major roles in the extension of credit in the US (Bernanke (2009)). These alternative non-bank financial markets are populated by financial institutions that conduct maturity, credit and liquidity transformation through a wide range of secured funding techniques such as asset-backed commercial papers (ABCP), asset-backed securities (ABS), collateralized debt obligations (CDO) and repos. The strong interconnection in these financial markets accelerated the transmission of the liquidity shocks and quickly affected the prices of all instruments. For the Federal Reserve, liquid non-bank

financial markets are a key prerequisite to sustain economic activity, since 75% of corporate external financing is raised through these non-bank financial markets. Accordingly, the Federal Reserve extended the provision of liquidity to these markets through programmes such as the ABCP Money Market Fund Liquidity Facility (AMLF), the Commercial Paper Funding Facility (CPFF) and the Term Asset-Backed Securities Loan Facility (TALF) under the unconventional measures adopted since mid-September 2008 (Collignon et al. (2012)).

The Federal Reserve also undertook massive asset purchases financed by central bank money which can be qualified as "Quantitative Easing" to restore the market liquidity and support the banking system. One of them is the "Troubled Asset Relief Program" (TARP). The US congress passed the Emergency Economic Stabilization Act of 2008 to strengthen market stability and restore market liquidity after the Lehman Brothers' bankruptcy. The Treasury announced a voluntary Capital Purchase Program, under which it purchased up to USD $250 billion of senior preferred stocks and warrants to encourage financial institutions to increase the flow of financing to businesses and consumers, and to support the US economy (Li (2013)).

The important question is whether a high proportion of control banks participated in TARP, as this may be driving the results shown above. More precisely, if control banks participated in TARP, this might have led to an increase in the amount of their lending during the crisis period and this may be driving the decrease in the amount of loans for treated banks relative to control banks. To address this concern, TARP data from the SNL database is used to calculate the percentage of banks which participated in TARP among treated and control banks respectively. As shown in Table 9, 62.1% of treated banks and 52.9% of control banks participated in TARP. The proportion of banks that participated in TARP is higher in treated banks compared to control banks. This increases the robustness of the results since treated banks on average decreased their loans significantly relative to control banks although a large proportion of them participated in TARP.

The results are extended by including TARP as an additional control variable in the regression to analyze the effect of TARP on the transmission of liquidity shocks to the real economy. Instead of including participation in TARP as a dummy, the amount of TARP capital received over total assets ratio, which is labeled as "TARP", is included in the estimation. As shown in the third column of Table 10, the effect of TARP on the change in the amount of loans is not significant. The point estimate of the difference-in-differences coefficient becomes -5.32 percentage points, which is significant at the 1% significance level, so including TARP as an additional control variable in the regression does not decrease the significance of the treatment effect. As reported in the second column of Table 10, the point estimate for the coefficient of the interaction term "Treatment*TARP" is 0.72, which is not significant, so TARP did not mitigate the reduction in treatment banks' lending. The point estimate of the treatment effect for the treated banks which did not participate in TARP is -6.42 percentage points, which is significant at the 5% significance level.

The effect of TARP on the amount of long-term debt is also examined and the results are reported in Table 10. The point estimate of the treatment effect is -0.27 percentage points, which is not significant. As shown in the fifth column, treated banks that did not participate in TARP decreased the amount of their long-term debt 1.03 percentage points, which is significant at the 1% significance level, relative to control banks. The coefficient estimate for the interaction term "Treat*TARP" is 0.49 percentage points, which is significant at the 5% significance level. This means that treated banks participating in TARP decreased their long-term debt significantly less compared to the treated banks that did not participate in TARP. A one percent increase in the TARP capital ratio leads to a 0.49 percentage points increase in the change of long-term debt. This indicates that treated banks which did not participate in TARP decreased their long-term debt significantly relative to control banks. On the other hand, treated banks which participated in TARP used TARP capital to issue new long-term debt when they had larger fractions of their long-term debt maturing during

the crisis.

Treated banks that received TARP capital issued new long-term debt to finance their shortfall from maturing long-term debt but they did not use this capital to issue new loans. These results suggest that receiving TARP capital did not mitigate the reduction in their lending, which means that TARP was not successful in encouraging banks to continue lending in order to support economic activity.

4.1.2 Results by Bank Size and Capital

Some studies find that small and under-capitalized banks transmit liquidity shocks more compared to large and well-capitalized banks.[7] These results support the hypothesis that small and under-capitalized banks are unable to raise alternative funds to continue financing loans during contraction periods. This section reports the effects of bank size and bank capital on the transmission of liquidity shocks.

A bank is defined as large if bank size is above the median and small if it is below the median. Similarly, a bank is well-capitalized if equity ratio is above the median and under-capitalized if it is below the median.

The top panel of Table 11 reports the coefficient estimates for well-capitalized and under-capitalized banks separately. There is no significant change in the amount of loans for well-capitalized banks, whereas under-capitalized treated banks reduced the amount of their loans significantly relative to control banks. The point estimate of the difference-in-differences coefficient is -9.37 percentage points, which is significant at the 1% significance level. Similarly, well-capitalized treated banks do not show a significant change in their long-term debt while under-capitalized treated banks reduced their long-term debt significantly. They decreased their long-term debt 0.83 percentage points relative to control banks, which is significant at the 5% significance level. These results suggest that well-capitalized US banks did not

[7] See Kishan & Opiela (2000) and Kashyap & Stein (2000).

transmit the negative liquidity shocks, in contrast to under-capitalized banks, which reduced their lending significantly.

The estimates for large and small banks are reported in the top panel of Table 12. Large treated banks reduced the amount of their loans but the reduction is not significant, which indicates that large US banks did not transmit the liquidity shocks to the real economy. Small treated banks decreased the amount of their loans 8.62 percentage points, which is significant at the 5% significance level, relative to control banks, so small banks reduced their lending when faced with a negative liquidity shock during the crisis. This result is supported by the difference in the equity ratios. Small banks have on average lower equity ratios compared to large banks, 9.3 to 10.7 of their total assets. Small banks are more fragile to a liquidity shock compared to large banks.

4.2 Euro-Area Banks

This section reports the results for euro-area banks. Firstly, the effect of a negative liquidity shock on the amount of loans is analyzed. Table 6 shows the difference in the trends of loans between treated and control banks in the absence of treatment during $2005 - 2007$. The difference in trends in the amount of loans between two groups is indistinguishable from zero. This supports the parallel trends assumption for the amount of loans. The bottom panel of Table 8 reports the difference-in-differences coefficient estimates for several bank characteristics during the crisis period. The first column presents the estimate for the treatment effect on the amount of loans. The difference between the average treated and control bank of -1.78 percentage points is not significant, which means that negative liquidity shocks during the financial crisis do not have a significant effect on the amount of loans. This indicates that treated euro-area banks did not have a significant reduction in their loans although they had larger fractions of their long-term debt maturing during the crisis.

This result raises the question how these treated banks financed their gap from maturing long-term debt to continue lending. The first question is whether there is any significant change in their long-term debt. The trend in the long-term debt before the crisis is not statistically different between treated and control banks. When we look at the change in their long-term debt during the crisis period, the second column in the bottom panel of Table 8 shows that the point estimate of the effect is an average of -4.84 percentage points, which is highly significant at the 1% significance level. Treated banks reduced their long-term debt significantly when they face larger fractions of their long-term debt maturing during the crisis period. This result indicates that treated banks did not issue new long-term debt to cover their shortfall from maturing long-term debt.

The next question is whether treated banks could cover this shortfall from the reduction in their long-term debt through alternative financing sources. This raised the question of whether treated banks issue more short-term debt relative to control banks during the crisis period. The difference in the trends of short-term debt is indistinguishable from zero in the absence of treatment as reported in Table 6. The third column at the bottom panel of the Table 8 shows that there is an average 3.09 percentage points yearly increase in short-term debt during the crisis period, which is significant with a p-value of 0.06. This suggests that treated banks issue short-term debt to fill their gap from maturing long-term debt.

There are two other alternative sources: equity and deposits. The trends in the equity and deposits is not statistically different between treated and control banks as shown in Table 6. During the crisis, the estimate of the treatment effect on the change in equity is an average -0.07 percentage points, which is not statistically significant as reported in the fifth column of the bottom panel in Table 8. The point estimate of the effect on deposits is an average -0.81 percentage points yearly difference, which is not statistically significant. There was no significant change in either equity or deposits.

Treated euro-area banks could issue short-term debt when they had larger fractions of

their long-term debt maturing during the crisis. Their ability to find short-term debt financing helped them to avoid the transmission of liquidity shocks to the real economy.

4.2.1 Monetary Policy Responses by the ECB

Bank lending is a particularly important source of financing in the euro area. Accordingly, the smooth functioning of loan supply from the banking system to creditworthy borrowers is a key prerequisite for a sustained economic activity in the euro area (ECB (2009)). The ECB's main policy approach can be qualified as "Credit Easing" (Gros et al. (2012)), which is a series of unconventional measures focusing on expanding provision of credit to banks in the framework of the so-called "Enhanced Credit Support Program" in order to assure the well functioning of the credit mechanism in the euro area. After the Lehman collapse in October 2008, the ECB decided to conduct all its refinancing operations with fixed rate tenders and full allotment instead of variable rate tender. This made the provision of liquidity to the banks unlimited so that the availability of collateral became the only constraint. The ECB then extended the list of assets accepted as collateral for refinancing operations and set up additional longer-term refinancing operations (LTRO) for financial institutions with a maturity up to six months (Collignon et al. (2012)). The ECB's LTRO program aimed at providing funding to banks from some parts of the euro area, distressed countries on its periphery that have been cut off from the inter-bank market. The LTRO program has provided EUR one trillion to euro-area banks which could not obtain funding from other financing sources.

The results of this paper indicate that euro-area banks that had larger fractions of their long-term debt maturing during the crisis financed the shortfall from maturing debt by issuing short-term debt. This raises the question of how euro-area banks were able to issue short-term debt during the financial crisis whereas the US counterparts seemed unable to do so. As inter-bank markets also dried up in the euro area at the onset of the financial

crisis similar to the US, this may be explained by a central bank support that focused on the provision of short-term liquidity such as LTRO.

Further analysis to differentiate the effect of the LTRO program on banks' loan supply is hindered by the limited availability of data. The information about the recipients of LTRO financing has not been disclosed by the ECB. It is known that the ECB extended the list of assets accepted as collateral and switched from variable rate tender to fixed rate tender right after the Lehman bankruptcy in October 2008. This increased the provision of liquidity to the banks significantly. If the ability to issue short-term debt comes from the ECB policy responses during the crisis, it is expected to see a higher effect in 2009 compared to 2008. When the change in short-term debt is calculated separately for the years 2008 and 2009, treated banks on average increased the amount of their short-term debt 1.75 percentage points, which is not significant, in 2008 and 4.22 percentage points, which is highly significant at the 1% significance level, in 2009 relative to control banks. This result supports that the euro-area banks' ability of issuing short-term debt is explained by the monetary policy measures of the ECB during the financial crisis.

4.2.2 Results by Bank Size and Capital

For euro-area banks, negative liquidity shocks do not have any significant effect on the amount of loans for both well-capitalized and under-capitalized banks as reported in the bottom panel of Table 11. Although the effect of the negative liquidity shocks on the amount of loans is not significant for both group of banks, there is a significant difference between them. For well-capitalized banks, treated banks increase their loans 1.92 percentage points relative to control banks, which is not significant. On the other hand, for under-capitalized banks, treated banks decreased their loans 3.84 percentage points relative to control banks, which is not significant with a p-value of 0.22. Well-capitalized treated banks decreased their long-term debt 3.53 percentage points and increased their short-term debt 2.01 per-

centage points (both of which are not significant) relative to control banks. Under-capitalized treated banks also decreased their long-term debt 1.37 percentage points. The change in their short-term debt is -1.12 percentage points relative to control banks. The main difference between well-capitalized and under-capitalized banks is that well-capitalized banks could issue short-term debt whereas under-capitalized banks could not. This supports the hypothesis that under-capitalized banks are unable to raise alternative funds to continue financing loans during contraction periods. Bank capital can affect banks' external ratings, providing investors with a signal about their creditworthiness. The cost of funding is higher for under-capitalized banks as they are perceived as riskier by the market.[8] This can explain the difference between well-capitalized and under-capitalized treated banks in issuing short-term debt during the crisis period.

The coefficient estimates for large and small banks are reported separately in the bottom panel of Table 12. Small treated banks decreased their long-term debt 7.07 percentage points relative to control banks with a p-value of 0.08 and increased their short-term debt 5.87 percentage points, which is significant at the 5% significance level. This suggests that small treated banks could finance their shortfall from maturing long-term debt through issuing new short-term debt. There is no significant effect on the amount of loans, so small treated banks did not change their loans significantly. On the other hand, large treated banks reduced the amount of their loans significantly relative to control banks. The point estimate of the effect is an average of -10.70 percentage points, which is significant at the 1% significance level. Large treated banks decreased their long-term debt 3.01 percentage points, which is not significant, and they could not increase their short-term debt. The relative change in their short-term debt is -0.76 percentage points, which is not significant. The results suggest that large euro-area banks transmitted the negative liquidity shocks to the real economy by cutting their lending. These banks could not issue short-term debt to

[8]See Holmstrom & Tirole (1997), Jayaratne & Morgan (2000).

cover their shortfall from maturing long-term debt. When we compare the bank capital of large and small banks, the equity ratio for large banks is on average 5.15% of total assets, while it is 7.40% for small banks, i.e. large banks are on average less capitalized compared to small banks. This difference in the equity ratios can explain why large banks were not able to raise short-term debt to cover the shortfall from the reduction in their long-term debt.

5 Robustness Checks

In this section, several robustness checks are conducted to show that the results are not driven by other factors.

5.1 Different Cutoff Values for the Fraction of Long-Term Debt Maturing during the Crisis

So far treated banks are defined as those with at least 10% of their long-term debt maturing during the $2007 - 2009$ financial crisis. As a first robustness check, the same experiment is repeated for different cutoff values of 5% and 20%. Treated banks are the banks with at least 5% and 20% of their long-term debt maturing during the crisis, respectively. This addresses the question whether the effect of the liquidity shocks is higher when the importance of the maturing long-term debt is higher. The difference-in-differences estimation results for the change in loans, long-term debt and short-term debt are presented in Table 13.[9] The bank characteristics that remain significantly different between treated and control banks after matching are included as additional control variables to control for possible heterogeneity between treated and control banks.

The top panel of Table 13 reports the results for US banks. For the cutoff value of

[9]The estimates are presented only for three bank characteristics since there are significant differences only in these.

5%, there are 38 treated banks and five control banks are chosen for each treated bank. There is no significant difference between treated and control banks in any of the bank characteristics. Treated banks reduced their loans by an average −3.64 percentage points, which is not significant. This indicates that the treatment effect is not significant anymore when the cutoff value is low. For the cutoff value of 20%, there are 21 treated banks and six control banks are chosen for each treated bank. As shown in Table 13, there is a highly significant treatment effect on the amount of loans. Treated banks reduced the amount of their lending significantly relative to control banks. The point estimate of the effect is an average of −7.84 percentage points, which is highly significant at the 1% significance level. The effect for the cutoff value of 20% is higher compared to the 10% cutoff, −7.84 percentage points to −5.37 percentage points. When the importance of debt is higher, treated banks reduced the amount of their loans more, which means that the effect of the liquidity shocks is higher.

The bottom panel of Table 13 reports the results for euro-area banks. For the cutoff value of 5%, there are 30 treated banks and two control banks are chosen for each treated bank and for the cutoff value of 20%, there are 17 treated banks and three control banks are chosen for each treated banks. There is no significant effect of the liquidity shocks on the amount of loans for any cutoff value. Treated banks decrease their long-term debt significantly for all three cutoff values. The decline in the long-term debt is higher as the cutoff value is higher. The point estimate of the effect is an average of −4.15 percentage points for the cutoff value of 5%, while it is −4.84 percentage points for the cutoff value of 10%. For the cutoff value of 20%, the effect is the highest and the point estimate of the effect is an average of −7.12 percentage points, which is highly significant at the 1% significance level. Similarly, the effect of the liquidity shocks on short-term debt is higher as the importance of debt is higher. There is no significant effect on the short-term debt for the 5% cutoff value. The point estimate of the effect is 3.09 percentage points for the cutoff value of 10%, while it is

4.34 percentage points for 20%, which is highly significant at the 1% level. When treated banks are chosen as the ones with at least 20% of their long-term debt maturing during the crisis, they decrease their long-term debt more and increase their short-term debt more compared to 10%. At the end, there is no significant effect on the amount of loans.

The results in this section support that the effect of the negative liquidity shocks is higher when the importance of the maturing long-term debt is higher.

5.2 Country Fixed Effects

To control for unobservable country-specific effects in the euro area, country dummies have been included in the estimation as additional control variables. Table 14 shows the estimation results that are comparable to those in Table 8 for euro-area banks. Including country dummies does not have any significant effect on the coefficient estimates and the significance levels.

The experiment for different cutoff values are also repeated with the country fixed effects. Table 15 shows the estimation results for the cutoff values of 5% and 20% that are comparable with Table 13 for euro-area banks. There is no significant change in the results when the country dummies are included in the estimation. These results indicate that the effect of the negative liquidity shocks on euro-area banks is robust to control for country fixed effects.

5.3 Falsification Test

The assumption of the difference-in-differences methodology is that banks with larger fractions of their long-term debt maturing during the crisis are affected more by the liquidity shocks since it is difficult for them to refinance their obligations through alternative financing sources. This assumption does not hold in periods with easier credit opportunities. This implies that the effect of the maturing long-term debt must be insignificant if the same

experiment is repeated for a period before the crisis.

The same experiment is replicated for the period $2004 - 2005$ where there was no crisis and it was easier to find alternative financing sources to refinance the maturing long-term debt. This experiment can be applied only for US banks since the balance sheet data for euro-area banks starts in 2005. The banks with at least 10% of their long-term debt, which is calculated at the end of 2002, maturing during $2004 - 2005$ are assigned to treated banks.

As reported in Table 16, the results show that the treatment effect is indistinguishable from zero. The effect is the same for both treated and control banks, which means that there is no significant effect on the amount of loans. The changes in the long-term and short-term debt are also not affected by the treatment, and there is no significant difference between treated and control banks.

The experiment is also repeated for different cutoff values, similarly to the previous section. Table 17 reports the changes in the amount of loans, long-term and short-term debt for cutoff values of 5% and 20% as well. The effect of the treatment is not significant for any of the cutoff values.

This replication ensures that the observed change in the amount of loans is more likely due to the treatment.

5.4 Different Long-Term Debt Ratios

In this section, the difference-in-differences estimation method is applied separately for banks with higher and lower long-term debt ratios. This exercise addresses the question whether the treated banks with larger fractions of their long-term debt maturing during the crisis are affected more when they have higher long-term debt ratios. The banks with long-term debt ratios above median are assigned to the higher long-term debt ratio group and the banks with long-term debt ratios below median are assigned to the lower long-term debt ratio group. Table 18 reports the results for different long-term debt ratio groups.

The top panel of Table 18 reports the results for US banks. Treated banks with long-term debt ratios above median reduced the amount of their lending 7.42 percentage points, which is highly significant at the 5% significance level, relative to control banks, whereas the treated banks with long-term debt ratios below median reduced their lending 5.29 percentage points, which is significant at the 10% significance level. This indicates that treated banks with higher long-term debt ratios are affected more.

The bottom panel of Table 18 reports the estimates for euro-area banks. There is no significant effect on the amount of loans for both high and low long-term debt ratios. Treated banks with higher long-term debt ratios decreased their long-term debt 7.80 percentage points and increased their short-term debt 4.66 percentage points relative to control banks, which are both significant. Treated banks with lower long-term debt ratios did not show any significant change in their long-term and short-term debt.

The results show that the effect of the liquidity shocks is higher when the importance of long-term debt is higher.

6 Conclusion

This paper analyzes the transmission of liquidity shocks to the real economy, highlighting the differences between US and euro-area banks. The $2007 - 2009$ financial crisis is used as an adverse liquidity shock on banks to explore the effect of a negative liquidity shock on banks' loan supply.

In this paper, the ex-ante heterogeneity in the fraction of long-term debt maturing during the crisis is used to measure bank-specific exposure to liquidity shocks. Banks are sorted into treated and control groups based on the fraction of their long-term debt maturing during the crisis. More precisely, the ones with at least 10% of their long-term debt maturing during the crisis are assigned to treated banks and the ones with less than 10% are assigned to

control banks. Loan supply and maturity structure of long-term debt are jointly determined by other bank characteristics such as equity and cash ratio. It is important to focus on exogenous liquidity shocks to banks when exploring the impact of negative liquidity shocks on banks' loan supply. Accordingly, long-term debt is calculated at the end of 2006 to ensure that banks did not anticipate the crisis when they decided on the maturity structure of their long-term debt. This ensures the exogeneity of the fractions of long-term debt maturing during the crisis. Using the difference-in-differences estimation methodology, the differential effect on treated versus control banks is identified.

The results show that affected US banks transmitted negative liquidity shocks to the real economy by cutting their lending, whereas there was no transmission in the euro area. Affected US banks reduced their lending by an average 5.37% of their total assets, which is highly significant. The main difference between US and euro-area banks is the ability of accessing alternative financing sources to cover their shortfall from maturing long-term debt. Affected US banks issued new long-term debt with high interest rates to finance this shortfall, whereas affected euro-area banks issued short-term debt. They reduced the amount of their long-term debt by an average 4.84% and increased their short-term debt by an average 3.09% of their total assets, both of which are highly significant. The ability of finding short-term debt financing helped euro-area banks to avoid the transmission of liquidity shocks to the real economy.

This raises the question of how affected euro-area banks were able to issue short-term debt during the financial crisis, whereas the US counterparts seemed unable to do so. As inter-bank markets also dried up in the euro area at the onset of the financial crisis similar to the US, this may be explained by a central bank support that focused on the provision of short-term liquidity. The possible explanation lies in the differences between monetary policy responses to the crisis.

Different financial structures led to different monetary policy responses in the US and

the euro area. In the US, only 25% of corporate external financing is raised through banks and 75% through non-bank financial markets, such as the commercial paper market or the market for asset-backed securities. In the euro area, the opposite is the case: the main source of credit is the banking sector (de la Dehesa (2012)). Accordingly, for the Federal Reserve, the monetary policy response has been characterized by an emphasis on non-bank financial markets and the ECB has focused on the banking sector supporting the loan supply from the banking system to households and firms. Further analysis to differentiate the effects of different policy measures is hindered by the limited availability of data, as the ECB has not disclosed information about the recipients of its refinancing operations.

Although the differential effects of different monetary policy responses can not be analyzed, the results of this paper support the view that the ECB's extension of liquidity to the banking sector helped affected euro-area banks to issue short-term debt in order to cover their shortfall from maturing long-term debt and continue lending. On the other hand, affected US banks could not find alternative financing sources and cut their lending significantly. This implies that banks transmit liquidity shocks to the real economy when financing frictions prevent them from accessing alternative financing sources. These results suggest that differences in the monetary policy responses of the Federal Reserve in the US and the ECB in the euro area led to differences in the transmission of negative liquidity shocks to the real economy during the financial crisis.

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7 Appendix-Variable Definitions and Tables

Size = Natural Logarithm of Total Assets

Change in Assets = (Total Assets$_t$-Total Assets$_{t-1}$) / (Total Assets$_{t-1}$)

Change in Loans = (Loans$_t$-Loans$_{t-1}$) / (Total Assets$_{t-1}$) (changes in other bank variables are calculated in the same way)

Long-Term Debt = The Total Debt with at least one year maturity

Short-Term Debt = The Total Debt with maturity less than one year

Return on Assets = Net Income / Total Assets

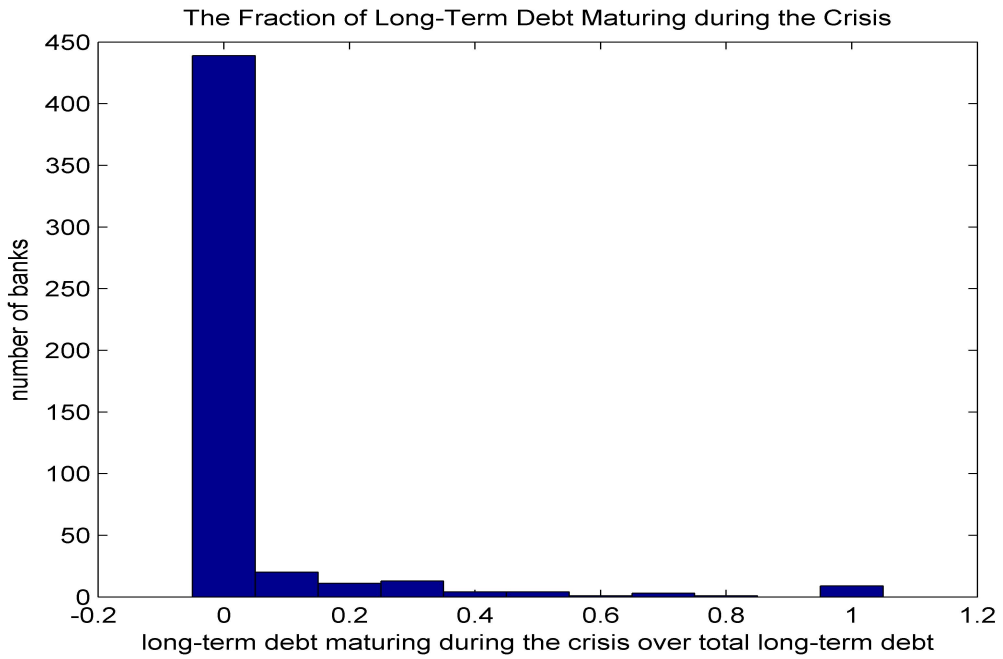

Figure 1: The fraction of long-term debt maturing during the crisis ($2008 - 2009$) that was issued before the end of 2006 for all banks.

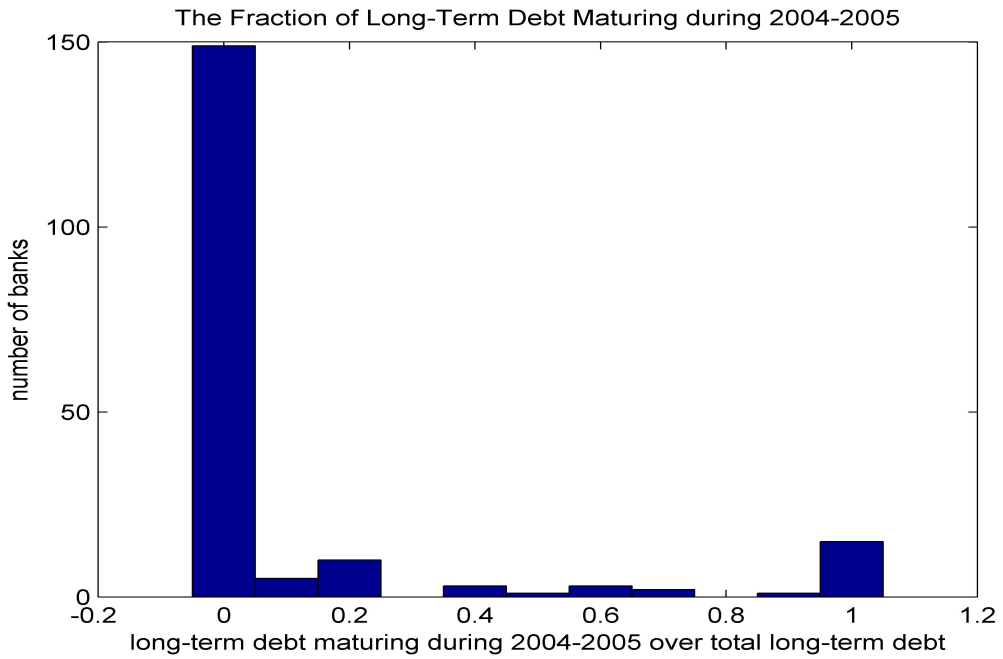

Figure 2: The fraction of long-term debt maturing during $2004-2005$ that was issued before the end of 2002 for US banks.

Table 1: **Summary Statistics for Treated vs Non-Treated US Banks** This table compares the distributional properties for the various matching characteristics of treated and non-treated US banks based on 2006 data. Treated banks are the banks with at least 10% of their long-term debt maturing during the crisis ($2008 - 2009$). The test for differences in the distribution of matching characteristics across two groups is conducted by the Wilcoxon rank-sum test. The p-values of the Wilcoxon rank-sum test are presented in the rightmost column.

		Min	Median	Mean	Max	Wilcoxon-test
Size	Treated	5.387	8.430	8.596	12.112	0.000
	Non-Treated	4.713	6.730	7.001	11.706	
Equity/Assets (%)	Treated	6.166	8.624	10.036	24.627	0.139
	Non-Treated	4.252	8.335	8.718	23.854	
Loan Loss Reserves/Loans (%)	Treated	0.140	1.196	1.251	3.999	0.561
	Non-Treated	0.084	1.118	1.128	2.440	
Operating Income/Assets (%)	Treated	2.274	4.407	4.485	8.095	0.768
	Non-Treated	1.432	4.175	4.255	9.698	
Return on Assets (%)	Treated	-0.930	1.096	1.089	2.758	0.024
	Non-Treated	-1.888	0.895	0.896	2.013	
Cash/Assets (%)	Treated	0.504	3.893	5.892	35.826	0.766
	Non-Treated	0.654	3.808	4.670	22.890	
Loans/Deposits	Treated	0.514	0.887	0.918	1.543	0.231
	Non-Treated	0.136	0.934	0.940	1.786	
Loans/Assets (%)	Treated	36.517	68.873	64.641	82.507	0.005
	Non-Treated	8.331	72.451	70.971	94.765	
Long-Term Debt/Assets (%)	Treated	0.297	2.391	3.206	10.299	0.021
	Non-Treated	0.027	1.972	2.052	6.298	
Short-Term Debt/Assets (%)	Treated	0.541	11.671	11.262	39.920	0.956
	Non-Treated	0.006	10.182	11.506	62.856	

Table 2: **Summary Statistics for Treated vs Control US Banks** This table compares the distributional properties of the various matching characteristics for treated and control US banks based on 2006 data. Treated banks are the banks with at least 10% of their long-term debt maturing during the crisis (2008−2009). Control banks are a subset of non-treated banks selected as the closest match to the treated banks based on a set of bank characteristics: equity scaled by total assets (Equity/Assets), loan loss reserves scaled by total loans (Loan Loss Reserves/Loans), total operating income scaled by total assets (Operating Income/Assets), net income scaled by total assets (Net Income/Assets), cash and equivalents scaled by total assets (Cash/Assets), total loans scaled by deposits(Loans/Deposits), total loans scaled by total assets (Loans/Assets), long-term debt scaled by total assets (Long-Term Debt/Assets), short-term debt scaled by total assets (Short-Term Debt/Assets) and the natural logarithm of total assets (Size). The test for differences in the distribution of a matching characteristic across the two groups is conducted by the Wilcoxon rank-sum test. The p-values of the Wilcoxon rank-sum test is presented in the rightmost column.

		Min	Median	Mean	Max	Wilcoxon-test
Size	Treated	5.387	8.430	8.596	12.112	0.000
	Control	4.713	6.735	7.101	11.706	
Equity/Assets (%)	Treated	6.166	8.624	10.036	24.627	0.124
	Control	4.652	8.335	8.603	22.786	
Loan Loss Reserves/Loans (%)	Treated	0.140	1.196	1.251	3.999	0.780
	Control	0.302	1.150	1.153	2.327	
Operating Income/Assets (%)	Treated	2.274	4.407	4.485	8.095	0.933
	Control	1.861	4.227	4.294	7.977	
Return on Assets (%)	Treated	-0.930	1.096	1.089	2.758	0.022
	Control	-0.221	0.888	0.897	2.013	
Cash/Assets (%)	Treated	0.504	3.893	5.892	35.826	0.865
	Control	0.654	3.853	4.636	14.332	
Loans/Deposits	Treated	0.514	0.887	0.918	1.543	0.957
	Control	0.542	0.899	0.896	1.784	
Loans/Assets (%)	Treated	36.517	68.873	64.641	82.507	0.234
	Control	30.860	69.913	68.272	83.505	
Long-Term Debt/Assets (%)	Treated	0.297	2.391	3.206	10.299	0.184
	Control	0.065	2.116	2.298	5.853	
Short-Term Debt/Assets (%)	Treated	0.541	11.671	11.262	39.920	0.987
	Control	0.040	10.595	11.129	47.128	

Table 3: **Trend Comparison for US Banks** This table compares changes in matching characteristics for treated and control US banks over the period $2005 - 2007$ prior to the crisis. Treated banks are the banks with at least 10% of their long-term debt maturing during the crisis ($2008 - 2009$). Control banks are a subset of non-treated banks selected as the closest match to the treated banks based on a set of bank characteristics: equity scaled by total assets (Equity/Assets), loan loss reserves scaled by total loans (Loan Loss Reserves/Loans), total operating income scaled by total assets (Operating Income/Assets), net income scaled by total assets (Net Income/Assets), cash and equivalents scaled by total assets (Cash/Assets), total loans scaled by deposits(Loans/Deposits), total loans scaled by total assets (Loans/Assets), long-term debt scaled by total assets (Long-Term Debt/Assets), short-term debt scaled by total assets (Short-Term Debt/Assets) and the natural logarithm of total assets (Size). The p-values of the Wilcoxon rank-sum test are presented in the rightmost column. The changes are reported in percentage points.

	Difference in Mean Treated-Control	Wilcoxon-test
Asset	1.834	0.648
Equity	0.994	0.690
Loan Loss Reserves	-1.829	0.257
Operating Income	0.328	0.812
Return on Assets	0.083	0.680
Cash	2.511	0.117
Deposit	0.261	0.540
Loans	-1.959	0.290
Long-Term Debt	0.055	0.930
Short-Term Debt	0.315	0.783

Table 4: **Summary Statistics for Treated vs Non-Treated Euro-Area Banks** This table compares the distributional properties for the various matching characteristics of treated and non-treated euro area banks based on 2006 data. Treated banks are the banks with at least 10% of their long-term debt maturing during the crisis ($2008 - 2009$). The test for differences in the distribution of matching characteristics across the two groups is conducted by the Wilcoxon rank-sum test. The p-values of the Wilcoxon rank-sum test are presented in the rightmost column.

		Min	Median	Mean	Max	Wilcoxon-test
Size	Treated	9.959	11.354	11.482	14.048	0.099
	Non-Treated	8.007	10.853	10.919	14.079	
Equity/Assets (%)	Treated	2.504	6.197	6.277	14.776	0.335
	Non-Treated	1.245	5.283	5.676	11.560	
Loan Loss Reserves/Loans (%)	Treated	0.053	1.737	1.691	6.255	0.351
	Non-Treated	0.018	1.642	1.916	9.170	
Operating Income/Assets (%)	Treated	1.387	2.599	2.648	3.920	0.612
	Non-Treated	0.221	2.420	2.637	8.880	
Return on Assets (%)	Treated	-0.984	0.910	0.840	1.405	0.003
	Non-Treated	-1.959	0.580	0.644	2.173	
Cash/Assets (%)	Treated	0.396	1.379	3.842	43.514	0.008
	Non-Treated	0.007	0.861	1.667	15.247	
Loans/Deposits	Treated	0.819	1.281	1.458	3.949	0.230
	Non-Treated	0.606	1.455	2.198	26.867	
Loans/Assets (%)	Treated	30.687	67.450	62.486	83.706	0.355
	Non-Treated	5.224	61.377	58.999	89.764	
Long-Term Debt/Assets (%)	Treated	1.073	8.802	9.128	23.855	0.037
	Non-Treated	0.040	3.993	7.050	53.725	
Short-Term Debt/Assets (%)	Treated	5.643	13.355	16.089	41.026	0.201
	Non-Treated	0.063	18.225	20.372	79.326	

Table 5: **Summary Statistics for Treated vs Control Euro-Area Banks** This table compares the distributional properties for the various matching characteristics of treated and control group for euro area banks based on 2006 data. Treated banks are the banks with at least 10% of their long-term debt maturing during the crisis (2008 − 2009). Control banks are a subset of non-treated banks selected as the closest match to the treated banks based on a set of bank characteristics: equity scaled by total assets (Equity/Assets), loan loss reserves scaled by total loans (Loan Loss Reserves/Loans), total operating income scaled by total assets (Operating Income/Assets), net income scaled by total assets (Net Income/Assets), cash and equivalents scaled by total assets (Cash/Assets), total loans scaled by deposits(Loans/Deposits), total loans scaled by total assets (Loans/Assets), long-term debt scaled by total assets (Long-Term Debt/Assets), short-term debt scaled by total assets (Short-Term Debt/Assets) and the natural logarithm of total assets (Size). The test for differences in the distribution of matching characteristics across the two groups is conducted by the Wilcoxon rank-sum test. The p-values of the Wilcoxon rank-sum test are presented in the rightmost column.

		Min	Median	Mean	Max	Wilcoxon-test
Size	Treated	9.959	11.354	11.482	14.048	0.015
	Control	8.007	10.662	10.614	13.363	
Equity/Assets (%)	Treated	2.504	6.197	6.277	14.776	0.995
	Control	2.368	6.320	6.188	11.560	
Loan Loss Reserves/Loans (%)	Treated	0.053	1.737	1.691	6.255	0.190
	Control	0.105	1.894	2.047	9.170	
Operating Income/Assets (%)	Treated	1.387	2.599	2.648	3.920	0.364
	Control	0.621	2.791	2.949	8.880	
Return on Assets (%)	Treated	-0.984	0.910	0.840	1.405	0.040
	Control	-1.959	0.708	0.707	2.173	
Cash/Assets (%)	Treated	0.396	1.379	3.842	43.514	0.113
	Control	0.051	1.110	1.862	15.247	
Loans/Deposits	Treated	0.819	1.281	1.458	3.949	0.435
	Control	0.812	1.428	1.659	6.951	
Loans/Assets (%)	Treated	30.687	67.450	62.486	83.706	0.652
	Control	24.700	66.611	64.999	89.764	
Long-Term Debt/Assets (%)	Treated	1.073	8.802	9.128	23.855	0.016
	Control	0.042	3.818	5.609	25.749	
Short-Term Debt/Assets (%)	Treated	5.643	13.355	16.089	41.026	0.220
	Control	0.063	18.225	19.570	59.242	

Table 6: **Trend Comparison for Euro-Area Banks** This table compares changes in matching characteristics for treated and control euro area banks over the period $2005-2007$ prior to the crisis. The treated banks are the banks with at least 10% of their long-term debt maturing during the crisis ($2008-2009$). Control banks are a subset of non-treated banks selected as the closest match to the treated banks based on a set of bank characteristics: equity scaled by total assets (Equity/Assets), loan loss reserves scaled by total loans (Loan Loss Reserves/Loans), total operating income scaled by total assets (Operating Income/Assets), net income scaled by total assets (Net Income/Assets), cash and equivalents scaled by total assets (Cash/Assets), total loans scaled by deposits(Loans/Deposits), total loans scaled by total assets (Loans/Assets), long-term debt scaled by total assets (Long-Term Debt/Assets), short-term debt scaled by total assets (Short-Term Debt/Assets) and the natural logarithm of total assets (Size). The p-values of the Wilcoxon rank-sum test are presented in the rightmost column. The changes are reported in percentage points.

	Difference in Mean Treated-Control	Wilcoxon-test
Asset	3.911	0.197
Equity	0.309	0.480
Loan Loss Reserves	-4.704	0.811
Operating Income	-0.208	0.353
Return on Assets	-0.111	0.945
Cash	1.824	0.163
Deposit	2.775	0.311
Loans	2.760	0.311
Long-Term Debt	0.676	0.585
Short-Term Debt	2.638	0.263

Table 7: **Euro-Area Banks** The number of banks from each country in the euro area.

	Number of Banks
Austria	8
Belgium	3
Finland	4
France	13
Germany	11
Greece	5
Ireland	6
Italy	16
Luxembourg	3
Netherlands	8
Portugal	5
Spain	18
Total	100

Table 8: **The Difference-in-Differences of Bank Characteristics over the Treatment Period** This table presents the difference-in-differences estimation results for the effect of negative liquidity shocks on changes in loans, long-term debt, short-term debt, deposit, equity, total assets and return on assets (ROA). Treated banks are the banks with at least 10% of their long-term debt maturing during the crisis ($2008-2009$). The treat coefficient is equivalent to the treatment effect, where pre-treatment observations are mean sample values over the period $2006-2007$ and post-treatment observations are mean sample values over the period $2008-2009$. The bank characteristics that are still significantly different between treated and control banks after the matching are included in the regressions to control for the possible heterogeneity between treated and control banks. The p-values are reported in parentheses. All reported p-values are based on heteroskedasticity robust standard errors. The changes are reported in percentage points. Significant levels of 1%, 5% and 10% are denoted by $***$, $**$ and $*$, respectively.

US Banks							
	ΔLoan	ΔLtDebt	ΔStDebt	ΔDeposit	ΔEquity	ΔAsset	ΔROA
Treat	-5.375***	-0.269	-1.359	-0.409	-0.396	-3.157	0.120
	(0.010)	(0.314)	(0.120)	(0.907)	(0.489)	(0.454)	(0.658)
Euro-Area Banks							
	ΔLoan	ΔLtDebt	ΔStDebt	ΔDeposit	ΔEquity	ΔAsset	ΔROA
Treat	-1.789	-4.840**	3.098*	-0.810	-0.072	-5.718	-0.337
	(0.484)	(0.017)	(0.069)	(0.716)	(0.826)	(0.166)	(0.293)

Table 9: **The Number of US banks participating in TARP** This table presents the number of banks participating in TARP among treated and control banks. The p-value is reported in parenthesis.

	Participating	Not Participating	Total	Fraction
treated banks	18	11	29	0.621
control banks	92	82	174	0.529
difference				0.092
				(0.352)

Table 10: **The Effect of TARP** This table presents the difference-in-differences estimation results for the effect of negative liquidity shocks on changes in loans, long-term debt and short-term debt for US banks when the amount of TARP received by the bank scaled by total assets in 2006, which is labeled as "TARP", is included as an additional control variable. The treat coefficient is equivalent to the treatment effect, where pre-treatment observations are mean sample values over the period $2006 - 2007$ and post-treatment observations are mean sample values over the period $2008 - 2009$. The effect of TARP capital on the transmission of liquidity shocks is examined by including the interaction term "Treat*TARP" in the estimation. The bank characteristics that are still significantly different between treated and control banks after the matching are included in the regressions to control for the possible heterogeneity between treated and control banks. The p-values are reported in parentheses. All reported p-values are based on heteroskedasticity robust standard errors. The changes are reported in percentage points. Significant levels of 1%, 5% and 10% are denoted by $***$, $**$ and $*$, respectively.

	ΔLoan	ΔLoan	ΔLoan	ΔLtDebt	ΔLtDebt	ΔLtDebt
Treat	-5.375***	-6.429**	-5.322***	-0.269	-1.037***	-0.276
	(0.010)	(0.038)	(0.010)	(0.337)	(0.007)	(0.304)
Treat*TARP		0.723			0.497**	
		(0.609)			(0.015)	
TARP		0.019	0.020		-0.003**	-0.002
		(0.834)	(0.823)		(0.049)	(0.142)

Table 11: **The Difference-in-Differences of Bank Characteristics over the Treatment Period for Different Equity Ratios** This table presents the difference-in-differences estimation results for the effect of negative liquidity shocks on changes in loans, long-term debt and short-term debt for well-capitalized (equity $\geq$ median) and under-capitalized (equity $<$ median) banks separately. The treat coefficient is equivalent to the treatment effect, where pre-treatment observations are mean sample values over the period $2006 - 2007$ and post-treatment observations are mean sample values over the period $2008 - 2009$. The bank characteristics that are still significantly different between treated and control banks after the matching are included in the regressions to control for the possible heterogeneity between treated and control banks. The p-values are reported in parentheses. All reported p-values are based on heteroskedasticity robust standard errors. The changes are reported in percentage points. Significant levels of 1%, 5% and 10% are denoted by $***$, $**$ and $*$, respectively.

US Banks			
	ΔLoan	ΔLtDebt	ΔStDebt
Treat	0.218	0.295	-1.650
(Equity $\geq$ Median)	(0.953)	(0.508)	(0.217)
Treat	-9.373***	-0.839**	-1.395
(Equity $<$ Median)	(0.005)	(0.012)	(0.280)
Euro-Area Banks			
	ΔLoan	ΔLtDebt	ΔStDebt
Treat	1.925	-3.535	2.007
(Equity $\geq$ Median)	(0.483)	(0.216)	(0.468)
Treat	-3.844	-1.370	-1.120
(Equity $<$ Median)	(0.228)	(0.506)	(0.407)

Table 12: **The Difference-in-Differences of Bank Characteristics over the Treatment Period for Different Sizes** This table presents the difference-in-differences estimation results for the effect of negative liquidity shocks on changes in loans, long-term debt and short-term debt for larger (total assets $\geq$ median) and smaller (total assets $<$ median) banks separately. The treat coefficient is equivalent to the treatment effect, where pre-treatment observations are mean sample values over the period $2006 - 2007$ and post-treatment observations are mean sample values over the period $2008 - 2009$. The bank characteristics that are still significantly different between treated and control banks after the matching are included in the regressions to control for the possible heterogeneity between treated and control banks. The p-values are reported in parentheses. All reported p-values are based on heteroskedasticity robust standard errors. The changes are reported in percentage points. Significant levels of 1%, 5% and 10% are denoted by $***$, $**$ and $*$, respectively.

US Banks			
	ΔLoan	ΔLtDebt	ΔStDebt
Treat	-4.725	0.0458	-2.038
(Total Assets $\geq$ Median)	(0.173)	(0.923)	(0.122)
Treat	-8.626**	-0.618**	0.235
(Total Assets $<$ Median)	(0.047)	(0.023)	(0.885)
Euro-Area Banks			
	ΔLoan	ΔLtDebt	ΔStDebt
Treat	-10.701***	-3.009	-0.762
(Total Assets $\geq$ Median)	(0.006)	(0.132)	(0.753)
Treat	2.920	-7.071*	5.872*
(Total Assets $<$ Median)	(0.384)	(0.089)	(0.057)

Table 13: **Robustness Check: The Difference-in-Differences of Bank Characteristics over the Treatment Period for Different Cutoff Values** This table presents the difference-in-differences estimation results for the effect of negative liquidity shocks on changes in loans, long-term debt and short-term debt for different cutoff values. The estimates for the experiment, where treated banks are the banks with at least 5%, 10% and 20% of their long-term debt maturing during the crisis ($2008 - 2009$), are shown separately. The treat coefficient is equivalent to the treatment effect, where pre-treatment observations are mean sample values over the period $2006 - 2007$ and post-treatment observations are mean sample values over the period $2008 - 2009$. The bank characteristics that are still significantly different between treated and control banks after the matching are included in the regressions to control for the possible heterogeneity between treated and control banks. The p-values are reported in parentheses. All reported p-values are based on heteroskedasticity robust standard errors. The changes are reported in percentage points. Significant levels of 1%, 5% and 10% are denoted by $***$, $**$ and $*$, respectively.

US Banks			
	ΔLoan	ΔLtDebt	ΔStDebt
Treat	-3.644	-0.237	-1.165
(cutoff = 5%)	(0.128)	(0.280)	(0.200)
Treat	-5.375***	-0.269	-1.359
(cutoff = 10%)	(0.010)	(0.314)	(0.120)
Treat	-7.841***	-0.330	-1.469
(cutoff = 20%)	(0.001)	(0.336)	(0.160)
Euro-Area Banks			
	ΔLoan	ΔLtDebt	ΔStDebt
Treat	-2.987	-4.153**	1.933
(cutoff = 5%)	(0.193)	(0.012)	(0.265)
Treat	-1.789	-4.840**	3.098*
(cutoff = 10%)	(0.484)	(0.017)	(0.069)
Treat	-2.406	-7.121***	4.341**
(cutoff = 20%)	(0.309)	(0.002)	(0.011)

Table 14: **Robustness Check: The Difference-in-Differences of Bank Characteristics over the Treatment Period with Country Dummies (Euro-Area Banks)** This table presents the difference-in-differences estimation results for the effect of negative liquidity shocks on changes in loans, long-term debt, short-term debt, deposit, equity, total assets and return on assets (ROA). Treated banks are the banks with at least 10% of their long-term debt maturing during the crisis ($2008 - 2009$). The treat coefficient is equivalent to the treatment effect, where pre-treatment observations are mean sample values over the period $2006 - 2007$ and post-treatment observations are mean sample values over the period $2008 - 2009$. The bank characteristics that are still significantly different between treated and control banks after the matching are included in the regressions to control for the possible heterogeneity between treated and control banks. To control for unobservable country-specific effects, country dummies have been included in the estimation as additional control variables. This table presents estimation results that are comparable to those in Table 8 for euro-area banks. The p-values are reported in parentheses. All reported p-values are based on heteroskedasticity robust standard errors. The changes are reported in percentage points. Significant levels of 1%, 5% and 10% are denoted by $***$, $**$ and $*$, respectively.

Euro-Area Banks							
	ΔLoan	ΔLtDebt	ΔStDebt	ΔDeposit	ΔEquity	ΔAsset	ΔROA
Treat	-0.848	-5.776**	3.212*	1.583	-0.056	-3.733	-0.164
	(0.718)	(0.049)	(0.075)	(0.486)	(0.876)	(0.399)	(0.588)

Table 15: **Robustness Check: The Difference-in-Differences of Bank Characteristics over the Treatment Period for Different Cutoff Values with Country Dummies (Euro-Area Banks)** This table presents the difference-in-differences estimation results for the effect of negative liquidity shocks on changes in loans, long-term debt and short-term debt for different cutoff values. The estimates for the experiment, where treated banks are the banks with at least 5%, 10% and 20% of their long-term debt maturing during the crisis ($2008 - 2009$), are shown separately. The treat coefficient is equivalent to the treatment effect, where pre-treatment observations are mean sample values over the period $2006 - 2007$ and post-treatment observations are mean sample values over the period $2008 - 2009$. The bank characteristics that are still significantly different between treated and control banks after the matching are included in the regressions to control for the possible heterogeneity between treated and control banks. To control for unobservable country-specific effects, country dummies have been included in the estimation as additional control variables. This table presents estimation results that are comparable to those in Table 13 for euro-area banks. The p-values are reported in parentheses. All reported p-values are based on heteroskedasticity robust standard errors. The changes are reported in percentage points. Significant levels of 1%, 5% and 10% are denoted by $***$, $**$ and $*$, respectively.

Euro-Area Banks			
	ΔLoan	ΔLtDebt	ΔStDebt
Treat	-3.271	-4.683**	1.941
(cutoff = 5%)	(0.129)	(0.025)	(0.292)
Treat	-0.848	-5.776**	3.212*
(cutoff = 10%)	(0.718)	(0.049)	(0.075)
Treat	-2.779	-6.644**	4.275**
(cutoff = 20%)	(0.209)	(0.020)	(0.039)

Table 16: **Robustness Check: The Difference-in-Differences of Bank Characteristics over the Period 2004-2005 (US Banks)** This table presents the difference-in-differences estimation results for the effect of negative liquidity shocks on changes in loans, long-term debt, short-term debt, deposit, equity, total assets and return on assets (ROA). Treated banks are the banks with at least 10% of their long-term debt maturing during the period $(2004 - 2005)$. The treat coefficient is equivalent to the treatment effect, where pre-treatment observations are mean sample values over the period $2002 - 2003$ and post-treatment observations are mean sample values over the period $2004 - 2005$. The bank characteristics that are still significantly different between treated and control banks after the matching are included in the regressions to control for the possible heterogeneity between treated and control banks. The p-values are reported in parentheses. All reported p-values are based on heteroskedasticity robust standard errors. The changes are reported in percentage points. Significant levels of 1%, 5% and 10% are denoted by $***$, $**$ and $*$, respectively.

US Banks							
	ΔLoan	ΔLtDebt	ΔStDebt	ΔDeposit	ΔEquity	ΔAsset	ΔROA
Treat	1.769	0.423	0.902	3.054	0.182	4.371	-0.157
	(0.601)	(0.152)	(0.633)	(0.359)	(0.804)	(0.366)	(0.227)

Table 17: **Robustness Check: The Difference-in-Differences of Bank Characteristics over 2004-2005 for Different Cutoff Values (US Banks)** This table presents the difference-in-differences estimation results for the effect of negative liquidity shocks on changes in loans, long-term debt and short-term debt for different cutoff values. The estimates for the experiment, where treated banks are the banks with at least 5%, 10% and 20% of their long-term debt maturing during the crisis ($2004 - 2005$), are demonstrated separately. The treat coefficient is equivalent to the treatment effect, where pre-treatment observations are mean sample values over the period $2002 - 2003$ and post-treatment observations are mean sample values over the period $2004 - 2005$. The bank characteristics that are still significantly different between treated and control banks after the matching are included in the regressions to control for the possible heterogeneity between treated and control banks. The p-values are reported in parentheses. All reported p-values are based on heteroskedasticity robust standard errors. The changes are reported in percentage points. Significant levels of 1%, 5% and 10% are denoted by $***$, $**$ and $*$, respectively.

US Banks			
	ΔLoan	ΔLtDebt	ΔStDebt
Treat	2.504	0.356	-0.242
(Cutoff = 5%)	(0.429)	(0.124)	(0.861)
Treat	1.769	0.423	0.902
(Cutoff = 10%)	(0.601)	(0.152)	(0.633)
Treat	3.570	0.397	2.108
(Cutoff = 20%)	(0.313)	(0.170)	(0.319)

Table 18: **Robustness Check: The Difference-in-Differences of Bank Characteristics over the Treatment Period for Different Long-Term Debt Ratios** This table presents the difference-in-differences estimation results for the effect of negative liquidity shocks on changes in loans, long-term debt and short-term debt for banks with higher (long-term debt $\geq$ median) and lower (long-term debt $<$ median) long-term debt ratios separately. The treat coefficient is equivalent to the treatment effect, where pre-treatment observations are mean sample values over the period $2006 - 2007$ and post-treatment observations are mean sample values over the period $2008 - 2009$. The bank characteristics that are still significantly different between treated and control banks after the matching are included in the regressions to control for the possible heterogeneity between treated and control banks. The p-values are reported in parentheses. All reported p-values are based on heteroskedasticity robust standard errors. The changes are reported in percentage points. Significant levels of 1%, 5% and 10% are denoted by $***$, $**$ and $*$, respectively.

US Banks			
	ΔLoan	ΔLtDebt	ΔStDebt
Treat	-7.429**	-0.468	-0.385
(Long-Term Debt $\geq$ Median)	(0.046)	(0.401)	(0.834)
Treat	-5.294*	-0.155	-1.802
(Long-Term Debt $<$ Median)	(0.088)	(0.562)	(0.111)
Euro-Area Banks			
	ΔLoan	ΔLtDebt	ΔStDebt
Treat	1.345	-7.806**	4.668*
(Long-Term Debt $\geq$ Median)	(0.696)	(0.041)	(0.100)
Treat	-5.062	-1.218	0.376
(Long-Term Debt $<$ Median)	(0.151)	(0.434)	(0.831)