Bank Liquidity Creation, Monetary Policy, and Financial Crises

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The efficacy of monetary policy depends largely on how it affects bank behavior. Recent events have cast doubt on how well monetary policy works in this respect, particularly during financial crises. In addition, issues have been raised about the role of banks in creating asset bubbles that burst and lead to crises. In this paper, we address these issues by focusing on bank liquidity creation, which is a comprehensive measure of bank output that accounts for all on- and off-balance sheet activities. Specifically we formulate and test hypotheses that address the following questions: (1) How does monetary policy affect total bank liquidity creation and its two main components, on- and off-balance sheet liquidity creation, during normal times? (2) Does monetary policy affect bank liquidity creation differently during financial crises versus normal times? (3) Is high aggregate bank liquidity creation an indicator of an impending financial crisis?

We identify five financial crises and use data on virtually all U.S. banks between 1984:Q1 to 2008:Q4. Our main findings are as follows.

First, during normal times, monetary policy tightening is associated with a reduction in liquidity creation by small banks, with much of the impact driven by a reduction in on-balance sheet liquidity creation. Monetary policy does not significantly affect liquidity creation by large and medium banks, which create roughly 90% of aggregate bank liquidity.

Second, during financial crises, the effect of monetary policy on liquidity creation is weaker than during normal times for banks of all sizes. This result is driven by a weaker response of both on- and off-balance sheet liquidity creation to monetary policy during crises.

Third, liquidity creation tends to be high (relative to a trend line) prior to financial crises. Its level has incremental explanatory power in predicting crises even after controlling for various other macroeconomic factors.

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According to financial intermediation theory, the creation of liquidity is a key reason why banks exist.[1] Banks create liquidity on the balance sheet by financing relatively illiquid assets such as business loans with relatively liquid liabilities such as transactions deposits (e.g., Bryant 1980, Diamond and Dybvig 1983), and off the balance sheet through loan commitments and similar claims to liquid funds (e.g., Boot, Greenbaum, and Thakor 1993, Holmstrom and Tirole 1998, Kashyap, Rajan, and Stein 2002).[2] The importance of bank liquidity creation is typically heightened during financial crises (e.g., Acharya, Shin, and Yorulmazer 2009). For example, in the current subprime lending crisis, liquidity seemed to dry up for an extended time period, with severe consequences for the real sector.

To ameliorate liquidity concerns and to stimulate the economy via increased bank liquidity creation, monetary policy is typically loosened during financial crises. However, as Stiglitz and Weiss (1981) point out in the narrower context of bank lending, such monetary policy initiatives will only work if banks indeed start to extend more loans or – more generally – start to create more liquidity, something Stiglitz and Weiss (1981) show banks may not do in some circumstances. This means understanding the response of banks to monetary policy initiatives during crises is crucial. One impediment to developing such an understanding is that there is virtually no empirical evidence on the effectiveness of monetary policy in affecting bank liquidity creation during either normal times or crises. This is perhaps because empirical measures of bank liquidity creation have been lacking until recently.

A further intriguing possibility is raised by the fact that bank liquidity creation and the probability of the occurrence of a crisis may not be unrelated. On the one hand, Diamond and Rajan (2000, 2001) suggest that fragility is needed to create liquidity. On the other hand, banks that create a lot of liquidity may also pursue lending policies that generate asset price bubbles and increase the fragility of the banking sector (see Acharya and Naqvi 2009). In either case, the theory of liquidity creation points to a possible correlation between bank liquidity creation and crises that is worth testing empirically.

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[1] According to the theory, another central role of banks in the economy is to transform credit risk (e.g., Diamond 1984, Ramakrishnan and Thakor 1984, Boyd and Prescott 1986). Recently, Coval and Thakor (2005) theorize that banks may also arise in response to the behavior of irrational agents in financial markets. See Bhattacharya and Thakor (1993) and Freixas and Rochet (2008) for a summary of financial intermediary existence theories.

[2] James (1981) and Boot, Thakor, and Udell (1991) endogenize the loan commitment contract due to informational frictions. Boot, Greenbaum and Thakor (1993) rationalize the existence of the material adverse change clause in commitment contracts. The loan commitment contract is subsequently used in Holmstrom and Tirole (1998) and Kashyap, Rajan, and Stein (2002) to show how banks can provide liquidity to borrowers.

To understand these issues more deeply, we address the following three questions that are motivated by the above discussion. First, how does monetary policy affect total bank liquidity creation and its two main components, on-balance sheet and off-balance sheet liquidity creation, during normal times? Our focus on bank liquidity creation, which takes into account all on- and off-balance sheet activities, is a departure from the existing literature which has typically focused on two components, lending and deposits. According to the bank lending channel literature, monetary policy may affect bank lending and deposits (for survey papers on this, see Bernanke and Gertler 1995, Kashyap and Stein 1997), but this literature has paid less attention to the fact that monetary policy may also affect off-balance sheet activities like loan commitments (e.g., Woodford 1996, Morgan 1998), given that these are present commitments to lend in the future.

Second, does monetary policy affect bank liquidity creation differently during financial crises versus normal times? It is intuitive that monetary policy would generate an effect that is different than during other times because of numerous factors, such as depleted bank capital during a crisis, greater reluctance to lend by banks that may perceive higher default risk during a crisis, and so on. Also, the demand for and supply of loan commitments and other off-balance-sheet guarantees may be affected during financial crises (e.g., Thakor 2005).

Third, does the level of aggregate bank liquidity creation provide an indication of an impending crisis? This question is motivated by the theoretical result that the creation of liquidity makes banks fragile and susceptible to runs (e.g., Diamond and Dybvig 1983, Chari and Jagannathan 1988), and that such runs can lead to financial crises via contagion effects. It is also related to our earlier discussion of the causal theoretical linkages between liquidity creation and fragility.

We formulate and test hypotheses related to these questions using data on virtually all banks in the U.S. from 1984:Q1-2008:Q4. The sample period includes five financial crises: the 1987 stock market crash, the credit crunch of the early 1990s, the Russian debt crisis plus the Long-Term Capital Management meltdown in 1998, the bursting of the dot.com bubble plus the September 11 terrorist attack of the early 2000s, and the subprime lending crisis of 2007 – ?.

To examine the effect of monetary policy on liquidity creation, we focus on changes in monetary policy based on two measures – the change in the federal funds rate and Romer and Romer (2004) monetary policy shocks. The change in the federal funds rate measures the change in monetary policy because the Federal Reserve explicitly targeted the federal funds rate over our entire sample period. A drawback of this measure, however, is that it may contain anticipatory movements. That is, movements in the federal funds rate may respond to information about future developments in the economy, making it harder to isolate the effect of monetary policy on bank output. The monetary policy shock measure developed in Romer and Romer (2004) takes into account such endogeneity.

The amount of liquidity created by the banking sector is calculated using Berger and Bouwman's (2009) preferred liquidity creation measure.[3] Since the effects of monetary policy on liquidity creation are expected to differ by size class, in most analyses, bank liquidity creation is split into liquidity created by small banks (gross total assets or GTA[4] up to $1 billion), medium banks (GTA exceeding $1 billion and up to $3 billion), and large banks (GTA exceeding $3 billion). In some analyses, liquidity creation is in addition split into liquidity created on versus off the balance sheet in order to test the hypotheses.

Our main findings, which generally support our hypotheses, are as follows. First, during normal times, monetary policy tightening (MPT) is associated with a reduction in liquidity creation by small banks, driven largely by the impact on on-balance sheet liquidity creation. Monetary policy does not have a significant effect on liquidity creation by medium and large banks, which create roughly 90% of aggregate bank liquidity. It does not have a significant effect on off-balance sheet liquidity creation of banks of any size class.

Second, for banks of all sizes, the effect of monetary policy relative to its intent is weaker during financial crises than during normal times. This result is driven by a weaker response of both on- and off-balance sheet liquidity creation to monetary policy. While this effect is not significant for small banks, it is at times significant for medium and large banks.

Third, liquidity creation tends to be high (relative to a trend line) prior to financial crises. Its level has incremental explanatory power in predicting crises even after controlling for various other macroeconomic factors.

[3] Section 3.3 describes how bank liquidity creation is measured.

[4] GTA equals total assets plus the allowance for loan and lease losses and the allocated transfer risk reserve (a reserve for certain foreign loans). Total assets on Call Reports deduct these two reserves, which are held to cover potential credit losses. We add these reserves back to measure the full value of the loans financed and the liquidity created by the bank on the asset side.

The remainder of this paper is organized as follows. Section 2 develops the hypotheses. Section 3 describes the five financial crises, explains the monetary policy and liquidity creation measures, discusses our sample, and presents summary statistics. Section 4 analyzes the relationship between monetary policy and bank liquidity creation during normal times and financial crises. Section 5 examines whether high liquidity creation is an indicator of an impending crisis. Section 6 concludes.

2. Development of the Hypotheses

This section formulates three hypotheses related to the questions raised in the Introduction.

2.1. Hypothesis related to the first question

Hypothesis 1: During normal times, monetary policy tightening (MPT) will: (a) reduce total liquidity creation by small and (possibly) medium banks, but the effect on large banks will be ambiguous; (b) reduce on-balance sheet liquidity creation for all banks and this effect will be strongest for smaller banks; and (c) have an ambiguous effect on off-balance sheet liquidity creation for banks of all sizes.

Motivation: Monetary policy will affect on-balance sheet and off-balance sheet liquidity creation differently during normal times. For ease of exposition we focus on MPT (tightening), but want to emphasize that, in line with the literature, we assume symmetry – the opposite effects are expected to occur for MPL (loosening).

On-balance sheet liquidity creation: MPT is expected to decrease on-balance sheet liquidity creation through the bank lending channel by reducing both deposits and loans (see survey papers by Bernanke and Gertler 1995 and Kashyap and Stein 1997). To elaborate, MPT may cause a decline in bank deposits through a decline in bank reserves. This may lessen the amount of loanable funds available because the decline in deposits may not be offset by increases in other sources of funds such as federal funds or large CDs, or deposits may have to be replaced by funds with higher marginal costs (e.g., Bernanke and Blinder 1992, Stein 1998). Banks may respond by cutting back on lending, including rationing some loan applicants (e.g., Stiglitz and Weiss (1981).[5] The effect is expected to be greater for smaller banks because smaller banks have less access to non-deposit sources of funds (Kashyap and Stein 2000).

Off-balance sheet liquidity creation: The effect of MPT on off-balance sheet liquidity creation is ambiguous for banks of all size classes. On the one hand, customers who are getting rationed in the spot credit market may increase their demand for loan commitments and other off-balance sheet guarantees to offset the reduction in spot loans (Thakor 2005). On the other hand, banks may reduce the supply of these guarantees in reaction to MPT because of a lack of loanable funds or an increase in the cost of these funds.[6] It is unclear ex ante which effect dominates.

Total liquidity creation: The effect of MPT on total liquidity creation by small and possibly medium banks will be negative since for these banks, the negative effect of MPT on on-balance sheet liquidity creation is expected to dominate the ambiguous effect on off-balance sheet liquidity creation. The reason is that these banks create most of their liquidity on the balance sheet (see Berger and Bouwman 2009). In contrast, large banks create a large fraction of their liquidity off the balance sheet. Therefore, the ambiguous effect on off-balance sheet liquidity creation is likely to dominate the negative effect on on-balance sheet liquidity creation, causing the effect of MPT on total liquidity creation by large banks to be ambiguous.

2.2. Hypothesis related to the second question

Hypothesis 2: The effect of monetary policy on liquidity creation is weaker during crises than during normal times for banks of all size classes. This will hold for: (a) total liquidity creation; (b) on-balance sheet liquidity creation; and (c) off-balance sheet liquidity creation.

Motivation: Monetary policy will affect on-balance sheet and off-balance sheet liquidity creation differently during crises. Since monetary policy is typically loosened during crises (see Section 3.2), we

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[5] Additionally, an increase in market interest rates caused by MPT reduces the present value of fixed-rate loans in a bank's portfolio, which causes a decline in the bank's net worth, thereby also resulting in a reduction in bank credit supply.

[6] In addition, since there are complementarities between offering deposits and selling loan commitments, a reduction in deposits can also induce the bank to provide less liquidity to its customers via loan commitments (see Kashyap, Rajan, and Stein 2002).

focus our discussion on MPL (loosening), but note that the opposite effects are expected to occur for MPT (tightening).

On-balance sheet liquidity creation: During a crisis, monetary policy is generally loosened to stimulate bank lending and hence on-balance sheet liquidity creation. However, the response of on-balance sheet liquidity creation to monetary policy loosening may be muted relative to what it would be during normal times because of numerous factors, such as depleted bank capital during crises, greater reluctance to lend by banks that may perceive higher default risk during a crisis, and so on. These factors could cause banks to not be willing to deploy the additional liquidity made available by MPL to increase lending much.

Off-balance sheet liquidity creation: The effect of monetary policy on off-balance sheet liquidity creation is also weaker during crises. During normal times, MPL facilitates an increase in the supply of spot loans, and as a result, the demand for loan commitments and other off-balance sheet guarantees goes down. That is, MPL will reduce off-balance-sheet liquidity creation. During crises, the reduction in demand for these off-balance sheet guarantees is smaller because there is more rationing in the spot market, so some borrowers who would have gone to the spot market shift to loan commitments. Similarly, banks will reduce the supply of these guarantees less during crises because they are less responsive to changes in loanable funds and cost of funding during crises. Consequently, MPL will have a smaller effect in reducing off-balance-sheet liquidity creation.

Total liquidity creation: The effect of MPT on total liquidity creation is the sum of these two effects. Since both effects are weaker during crises than during normal times, the overall effect is also weaker.

2.3. Hypothesis related to the third question

Hypothesis 3: The level of liquidity creation is an indicator of an impending crisis: high (relative to the trend line) liquidity creation is accompanied by a high likelihood of occurrence of a crisis.

Motivation: Diamond and Rajan (2000, 2001) argue that financial fragility is needed to create liquidity. However, it is intuitive that the causality may be reversed as well and that an excessive build-up of liquidity may lead to a crisis. A theoretical argument that formalizes this intuition has recently been provided by

Acharya and Naqvi (2009). They show that attempts by the central bank to deal with an adverse economic shock by injecting liquidity can have unintended consequences due to the liquidity-creation response of banks to such attempts. Specifically, banks respond to the higher liquidity supply by lowering lending standards and lending more. This increases on-balance sheet bank liquidity creation that results in an asset bubble, and sows the seeds of a crisis. Thakor (2005) shows that banks shy away from exercising the material adverse change clause in loan commitment contracts during economic booms and hence take on more credit risk with commitment lending than they might during economic downturns. This results in greater bank liquidity creation during booms, and suggests that an increase in off-balance sheet liquidity creation in a given period may also contribute to an increase in the probability of a financial crisis in a subsequent period. Some empirical evidence that the abundant availability of liquidity prior to the current crisis may have contributed to the crisis by inducing banks to lower their credit standards has recently been provided by Dell'Ariccia, Igan, and Laeven (2008), and Keys, Mukherjee, Seru, and Vig (forthcoming).

3. Financial crises, monetary policy measures, bank liquidity creation, and the sample

This section first discusses the five financial crises included in this study. It then describes the two measures of the change in monetary policy, Romer and Romer's monetary policy shocks and the change in the federal funds rate, and provides summary statistics on both. Next, it explains Berger and Bouwman's (2009) preferred liquidity creation measure and an alternative measure. Finally, it describes the sample and provides sample summary statistics.

3.1. Five financial crises

Our analyses focus on five financial crises that occurred between 1984:Q1 and 2008:Q4. The crises include: (1) the 1987 stock market crash; (2) the credit crunch of the early 1990s; (3) the Russian debt crisis plus Long-Term Capital Management (LTCM) bailout of 1998; (4) the bursting of the dot.com bubble and the September 11 terrorist attacks of the early 2000s; and (5) the current subprime lending crisis. The Appendix describes these crises in detail.

Our main analysis aggregates the data across these five crises. As a robustness check, we also split the data into banking crises versus market crises based on whether a crisis originated within the banking sector or outside it.[7] Using this method, crises (2) and (5) are classified as banking crises, and crises (1), (3), and (4) are identified as market crises.

3.2. Two monetary policy measures

To examine how monetary policy affects liquidity creation, we focus on the change in monetary policy based on two measures. These are the monetary policy shocks developed by Romer and Romer (2004), and the change in the federal funds rate.

Since the Federal Reserve explicitly targeted the federal funds rate over our entire sample period, the change in the federal funds rate measures the change in monetary policy.[8] A drawback of this measure, however, is that it may contain anticipatory movements. That is, movements in the federal funds rate may respond to information about future developments in the economy, making it harder to isolate the effect of monetary policy on bank output. The Romer and Romer (2004) measure takes into account such endogeneity.

Romer and Romer (2004) construct their monetary policy shock measure using the following procedure. First, the intended federal funds rate changes around meetings of the Federal Open Market Committee (FOMC), the institution responsible for setting monetary policy in the U.S., are obtained by examining narrative accounts of each FOMC meeting. Next, anticipatory movements are removed by regressing the intended federal funds rate on the Federal Reserve's internal forecasts of inflation and real activity. The residuals from this regression are the monetary policy shocks, i.e., the changes in the intended federal funds rate that are not made in response to forecasts of future economic conditions. While Romer and Romer's (2004) monetary policy shock data end in 1996:Q4, Barakchian and Crowe (2009) extend the data through 2008:Q2, and Crowe provides a further extension to 2008:Q4.[9]

Figure 1 shows the Romer and Romer monetary policy shocks (*Panel A*) and the change in the federal funds rate (*Panel B*) over time. The five financial crises are indicated with dotted lines. The Figure shows that while MPL is prevalent during crises, monetary policy is not always loosened. Specifically, loosening took place in 83% of the 31 crisis quarters in our sample based on the change in the federal funds

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[7] See Section 4.4.

[8] We use the actual federal funds rate (as in Romer and Romer 2004) rather than the target federal funds rate since bank behavior will be affected most by the actual rate.

[9] We are grateful to Christopher Crowe for making these data available to us.

rate, and in 58% of these quarters based on the Romer and Romer (2004) policy shocks. The reason why the fractions are very different based on the two measures is the following. When the federal funds rate is reduced, it will always be recorded as MPL based on the change in the federal funds rate. However, it will only be recorded as MPL based on the Romer and Romer policy shocks if the reduction in the federal funds rate was more than it normally would based on the Federal Reserve's internal forecasts of inflation and growth.

3.3. Bank liquidity creation: preferred and alternative measure

To construct a measure of liquidity creation, we follow Berger and Bouwman's (2009) three-step procedure (see *Table 1*). Below, we briefly discuss these three steps.

In Step 1, we classify all bank activities (assets, liabilities, equity, and off-balance sheet activities) as liquid, semi-liquid, or illiquid. For assets, this is based on the ease, cost, and time for banks to dispose of their obligations in order to meet these liquidity demands. For liabilities and equity, this is based on the ease, cost, and time for customers to obtain liquid funds from the bank. We follow a similar approach for off-balance sheet activities, classifying them based on functionally similar on-balance sheet activities. For all activities other than loans, this classification process uses information on both product category and maturity. Due to data restrictions, we classify loans entirely by category.

In Step 2, we assign weights to all the bank activities classified in Step 1. The weights are consistent with liquidity creation theory, which argues that banks create liquidity on the balance sheet when they transform illiquid assets into liquid liabilities. We therefore apply positive weights to illiquid assets and liquid liabilities. Following similar logic, we apply negative weights to liquid assets and illiquid liabilities and equity, since banks destroy liquidity when they use illiquid liabilities to finance liquid assets. We use weights of ½ and -½, because only half of the total amount of liquidity created is attributable to the source or use of funds alone. For example, when $1 of liquid liabilities is used to finance $1 in illiquid assets, liquidity creation equals ½ * $1 + ½ * $1 = $1. In this case, maximum liquidity is created. However, when $1 of liquid liabilities is used to finance $1 in liquid assets, liquidity creation equals ½ * $1 + -½ * $1 = $0. In this case, no liquidity is created as the bank holds items of approximately the same liquidity as those it gives to the nonbank public. Maximum liquidity is destroyed when $1 of illiquid liabilities or equity is used to finance $1 of liquid assets. In this case, liquidity creation equals -½ * $1 + -½ * $1 = -$1. An intermediate weight of 0 is applied to semi-liquid assets and liabilities. Weights for off-balance sheet activities are assigned using the same principles.

In Step 3, we combine the activities as classified in Step 1 and as weighted in Step 2 to construct Berger and Bouwman's (2009) preferred liquidity creation measure. This measure classifies loans by category, while all activities other than loans are classified using information on product category and maturity, and includes off-balance sheet activities.[10] To obtain the dollar amount of liquidity creation at a particular bank, we multiply the weights of ½, -½, or 0, respectively, times the dollar amounts of the corresponding bank activities and add the weighted dollar amounts.

Since the ability to securitize assets has changed greatly over time, we also construct an alternative liquidity creation measure as in Berger and Bouwman (2009). This measure is identical to the preferred measure, except for the way we classify loans. For each loan category, we use U.S. Flow of Funds data on the total amount of loans outstanding and the total amount of loans securitized to calculate the fraction of loans that has been securitized in the market at each point in time. Following Loutskina (2006), we then assume that each bank can securitize that fraction of its own loans. To give an example, in 1993:Q4, $3.1 trillion in residential real estate loans were outstanding in the market, and 48.4% of these loans were securitized. If a bank has $10 million in residential real estate loans in that quarter, we assume that 48.4% of it can be securitized. Hence, we classify $4.84 million of these loans as semi-liquid and the remainder as illiquid. Note that this alternative measure faces a significant drawback. While the theories suggest that it is the ability to securitize that matters for liquidity creation, this measure uses the actual amount of securitization. Thus, while the vast majority of these residential real estate loans may be securitizable, this alternative measure treats only about half of them as such.

We provide descriptive statistics on the preferred and the alternative liquidity creation measures in Section 3.5. Since we obtain qualitatively similar regression results based on the alternative measure, all reported regression results are based on the preferred measure for brevity.

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[10] Berger and Bouwman (2009) construct four liquidity creation measures by alternatively classifying loans by category or maturity, and by alternatively including or excluding off-balance sheet activities. However, they argue that the measure we use here is the preferred measure since for liquidity creation, banks' ability to securitize or sell loans is more important than loan maturity, and banks do create liquidity both on and off the balance sheet.

3.4. Sample description

We include virtually all commercial and credit card banks in the U.S. in our study.[11] For each bank, we obtain quarterly Call Report data from 1984:Q1 to 2008:Q4. We keep a bank in the sample if it: 1) has commercial real estate or commercial and industrial loans outstanding; 2) has deposits; 3) has gross total assets or GTA exceeding $25 million; 4) has an equity capital to GTA ratio of at least 1%.

For each bank, we calculate the dollar amount of liquidity creation in each quarter (933,209 bank-quarter observations from 18,294 distinct banks) using the process described in Section 3.3. We aggregate these amounts to obtain the dollar amount of liquidity creation by the banking sector, and put these (and all other financial values) into real 2008:Q4 dollars using the implicit GDP price deflator. We thus end up with a final sample that contains 100 inflation-adjusted, quarterly liquidity creation amounts.

Since the hypothesized effects of monetary policy on liquidity creation differ by bank size, we also split the sample into small, medium, and large banks, and perform our analyses separately for three sets of banks. Small banks have GTA up to $1 billion, medium banks have GTA exceeding $1 billion and up to $3 billion, and large banks have gross total assets (GTA) exceeding $3 billion.

3.5. Bank liquidity creation summary statistics

Figure 2 Panel A shows the dollar amount of liquidity created by the banking sector, calculated using the preferred liquidity creation measure over our sample period. It also shows the breakout into on- and off-balance sheet liquidity creation. Dotted lines indicate when the five financial crises occurred. As shown, liquidity creation increased substantially over time: it almost quadrupled from $1.398 trillion in 1984:Q1 to $5.304 trillion in 2008:Q4 (in real 2008:Q4 dollars). Using the alternative liquidity creation measure (see Section 3.3), liquidity creation grew from $1.715 trillion to $5.797 trillion over this period (not shown for brevity). Since the mid-1990s, off-balance sheet liquidity creation has exceeded and grown faster than on-balance sheet liquidity creation.

Figure 2 Panel B shows that most of the liquidity in the banking sector is created by large banks and that their share of liquidity creation has increased from 76% in 1984:Q1 to 86% in 2008:Q4. Using the

[11] Berger and Bouwman (2009) include only commercial banks. We also include credit card banks to avoid an artificial $0.19 trillion drop in bank liquidity creation in the fourth quarter of 2006 when Citibank N.A. moved its credit-card lines to Citibank South Dakota N.A., a credit card bank.

alternative measure, it increased from 70% to 87% (not shown for brevity). Over this same time frame, the shares of medium and small banks dropped from 8% to 5% and from 16% to 9%, respectively. Using the alternative measure, their shares dropped from 9% to 4% and from 21% to 8%, respectively (not shown for brevity).

4. The effect of monetary policy on bank liquidity creation during normal times and financial crises

This section focuses on testing Hypotheses 1 and 2. We first discuss our methodology and explain why we use regression analysis in the spirit of Romer and Romer (2004) rather than a vector autoregression (VAR) setup (Section 4.1). We then present regression results for total liquidity creation (Section 4.2), and on- versus off-balance sheet liquidity creation (Section 4.3). Finally, we briefly discuss a robustness check in which we split the crises into banking versus market crises and rerun all of the regressions (Section 4.4).

We acknowledge that our results, while suggestive of causation, may merely reflect association. Thus, we are not asserting causality.

4.1. Monetary policy and bank liquidity creation – methodology

To study the effects of monetary policy, the macroeconomic literature typically uses a VAR setup (e.g., Christiano, Eichenbaum, and Evans 1999). A VAR is an n-equation, n-variable linear model in which each variable is explained by its own lagged values and past (and possibly current) values of the remaining n-1 variables (e.g., Stock and Watson 2001).[12] The objective in these studies generally is to examine what the immediate, medium-term, and long-term effects are of monetary policy on output and inflation. For that purpose, several years of lags of all the variables are included in the VAR.

Our goal is different. Rather than examining whether monetary policy has a permanent effect on liquidity creation, we are interested in the short-run effect. Furthermore, we want to know whether the effect of monetary policy on liquidity creation is different across normal times and crises. A VAR

[12] The most widely used are recursive VARs, in which the variables are generally ordered so that monetary policy is allowed to respond to, but not affect, the other variables contemporaneously. To see that, consider a three-variable VAR ordered as (1) output, (2) inflation, and (3) monetary policy. This VAR consists of three equations, all of which will include lagged values of all three variables. In addition, the inflation equation will include current values of output, and the monetary policy equation will include current values of output and inflation. In this setup, monetary policy can respond to, but not contemporaneously affect, output and inflation. For a discussion, see Stock and Watson (2001).

approach seems inappropriate for such a purpose. So, we use a single-equation approach in the spirit of Romer and Romer (2004), which includes one year of lagged values of all the variables.

To analyze how monetary policy affects liquidity creation during normal times and whether the effect varies across normal times and financial crises, we use the following regression setup:

$$\%\Delta LC_{X,t} = \beta_0 + \sum_{i=1}^{4} \beta_i \, \Delta MONPOL_{t-i} + \sum_{j=1}^{4} \beta_j \, \%\Delta LC_{X,t-j} + \sum_{k=1}^{4} \beta_k \, D\ CRIS_{t-k} + \sum_{l=1}^{4} \beta_l \, \Delta MONPOL_{t-l} * D\ CRIS_{t-l} + \sum_{m=1}^{3} \beta_m \, D\ SEASON_m \quad (1)$$

where $\%\Delta LC_{X,t}$ is the percentage change in liquidity creation by banks of size class X in year t, with $X \in \{Small,\ Medium,\ Large\}$. $\%\Delta LC_{X,t}$ is alternatively defined as total liquidity creation ($\%\Delta LC\ TOTAL_{X,t}$) or one of its components, on-balance sheet or off-balance sheet liquidity creation ($\%\Delta LC\ ON\ BS_{X,t}$ and $\%\Delta LC\ OFF\ BS_{X,t}$, respectively). $\Delta MONPOL_{t-i}$ is the (lagged) change in monetary policy, alternatively defined as Romer and Romer's monetary policy shocks ($RR\ POLICYSHOCKS_{t-i}$) and the change in the federal funds rate ($\Delta FEDFUNDS_{t-i}$). In both cases, a positive number indicates monetary policy tightening and a negative number reflects monetary policy loosening. $D\ CRIS_{t-k}$ is a crisis dummy that equals one if there was a crisis in quarter t-k and is zero otherwise. $\Delta MONPOL_{t-l} * D\ CRIS_{t-l}$ is an interaction term of a (lagged) change in monetary policy with a (lagged) crisis dummy. $D\ SEASON_m$ is a quarterly dummy to control for seasonal effects. Inference is based on robust standard errors.

In these regressions, the coefficients on the change in monetary policy pick up the effect of monetary policy during normal times, while the coefficients on the interaction terms show whether monetary policy has a different effect during financial crises versus normal times. For example, if monetary policy is less effective during financial crises than during normal times as hypothesized, the coefficients on the interaction term will be positive and significant. The overall crisis effect can be found by adding the coefficient on the change in monetary policy and the coefficient on the interaction term.[13]

4.2. Monetary policy and total liquidity creation (Hypotheses 1 Part (a) and 2 Part (a))

Table 2 shows the regression results based on the Romer and Romer monetary policy shocks (*Panel A*) and the change in the federal funds rate (*Panel B*). Each panel contains the results for the three size classes

[13] Also, if liquidity creation is negatively affected during financial crises as one might expect, the coefficients on the crisis dummies will be negative. We generally find this to be the case. Since this is not part of our hypotheses, we show these coefficients in *Tables 2* and *3* but do not elaborate on them.

(small, medium, and large banks). The regression results indicate whether individual lags of the regression variables affect liquidity creation. For example, the first (second/third/fourth) lag of the Romer and Romer monetary policy shock variable indicates whether a shock one (two/three/four) quarter(s) ago affects liquidity creation. As is customary in the macroeconomic literature, we also show the cumulative impact after one/two/three/four quarters (see *Figure 3*) and, discuss our results based on the latter.[14]

Figure 3 shows the implied response of bank liquidity creation to a one percentage point Romer and Romer monetary policy shock (*Panel A*) and a one percentage point change in the federal funds rate (*Panel B*), together with 90% confidence intervals (±1.6 standard errors). We test for the effects of changes in monetary policy on total liquidity creation by examining whether zero lies outside the 90% confidence interval.

To test Hypothesis 1 Part (a), we focus on the top row in *Figure 3 Panels A* and *B*, which shows the implied responses for each size class during normal times (based on the coefficients of the lagged change in the monetary policy variable). During normal times, the estimated cumulative impact of a Romer and Romer monetary policy shock or a change in the federal funds rate is negative and significant for small banks in (virtually) every quarter. In contrast, the estimated cumulative effect is generally negative but not significant for medium and large banks. This suggests that during normal times, monetary policy is effective in impacting liquidity creation by small banks, but not liquidity creation by medium and large banks. That is, after MPT (a positive Romer and Romer shock or an increase in the federal funds rate) during normal times, only small banks create significantly less liquidity. This evidence is consistent with Hypothesis 1 Part (a), which argues that during normal times, MPT will reduce total liquidity creation by small and (possibly) medium banks, but will have an ambiguous effect on large banks.

To test Hypothesis 2 Part (a), we examine the middle row of *Figure 3 Panels A* and *B*, which shows the differential effect of monetary policy during financial crises (based on the coefficients of the lagged changes in the monetary policy variable interacted with the lagged crisis dummies). The hypothesis is that the effect of monetary policy is weaker during crises. That is, MPT is predicted to be followed by a smaller reduction in liquidity creation and MPL is predicted to be followed by a smaller increase in

[14] At times, individual coefficients presented in *Table 2* may be significant while the impact shown in *Figure 3* is not significant, and vice versa. This is because *Table 2* shows the individual effects in each quarter while *Figure 3* shows the cumulative impacts.

liquidity creation during crises than during normal times. This implies positive cumulative effects of the interaction terms (i.e., the lines in the pictures in the middle row of *Figure 3 Panels A* and *B* should be above zero). These cumulative effects are indeed generally positive for banks of all size classes. They are not significant based on the Romer and Romer measure, but they are significant in two cases based on the change in the federal funds rate: the cumulative effect is positive and significant after three (two) quarters for medium (large) banks. This suggests that monetary policy is generally less effective during financial crises. This evidence is consistent with Hypothesis 2 Part (a).[15]

To gauge the economic significance of the results, we focus on the change in the federal funds rate because they are easier to interpret, but note that the results based on the Romer and Romer policy shocks are similar. We discuss the small-bank results first. The cumulative coefficients on the change in the federal funds rate of -0.021, -0.014, -0.018, and -0.018 after one to four quarters (top left picture in *Figure 3 Panel B*) suggests that if the federal funds rate increases by one percentage point, the cumulative drop in liquidity creation by small banks is 2.1%, 1.4%, 1.8%, and 1.8% after one, two, three, and four quarters, respectively. Evaluated at the average dollar amount of liquidity created by small banks of $333 billion, this translates into a cumulative decline in liquidity creation of $6.99 billion, $4.66 billion, $5.99 billion, and $5.99 billion after one, two, three, and four quarters, respectively. So while the effect of monetary policy on liquidity creation by small banks is statistically significant during normal times, the magnitudes seem relatively small from an economic viewpoint. The cumulative coefficients on the change in the federal funds rate interacted with the crisis dummies (i.e. the differential crisis effects) are not significant for small banks.

We next discuss the economic significance of the medium- and large-bank results. For these banks, the effects of monetary policy are not significant during normal times. However, the differential crisis effect (i.e., the cumulative coefficients on the change in the federal funds rate interacted with the crisis dummies) is positive and significant in two cases: after three quarters for medium banks and after two quarters for large banks. As discussed above, a positive coefficient implies a weaker effect of monetary

[15] For completeness, the bottom row of *Figure 3 Panels A* and *B*, obtained by adding the top and middle rows, shows the overall effect of monetary policy during crises. For small banks, whereas monetary policy was effective in virtually every quarter during normal times, it is not significant in any quarter during crises. Thus, monetary policy loses its effectiveness during crises for these banks. For medium and large banks, while monetary policy continues to be ineffective in most quarters, it now has a (significantly) perverse effect in one quarter in that MPL (MPT) is followed by a decrease (an increase) in liquidity creation by these banks.

policy during a crisis. We now quantify this weaker effect. The respective coefficients of 0.0577 and 0.0203 suggest that if the federal funds rate increases by one percentage point during crises, the cumulative increase in liquidity creation by these banks relative to normal times is 5.77% and 2.03%, respectively. Evaluated at the average amount of liquidity created by medium and large banks of $175 billion and $2,609 billion, respectively, this translates into a cumulative increase in liquidity creation relative to normal times of $10.10 billion and $52.96 billion after two and three quarters, respectively. Thus, while we do not find overwhelming statistical significance for medium and large banks, the economic significance of the effects appear to be sizeable, especially for large banks.

4.3. Monetary policy and on- versus off-balance sheet liquidity creation (Hypotheses 1 and 2 Parts (b) and (c))

Table 3 and *Figure 4* show how monetary policy affects on-balance sheet liquidity creation (*Panel I*) and off-balance sheet liquidity creation (*Panel II*). *Table 3* contains the actual regression results. *Figure 4* shows the implied responses of on- and off-balance sheet liquidity creation to a one percentage point Romer and Romer monetary policy shock (*Subpanel A*) and a one percentage point change in the federal funds rate (*Subpanel B*). As before, we discuss the results based on the implied responses (*Figure 4*).

To examine how monetary policy affects on- and off-balance sheet liquidity creation during normal times (Hypothesis 1 Parts (b) and (c)), we focus on the top rows in *Figure 4 Panels I-A, I-B, II-A* and *II-B*. We first consider small banks. As discussed above, monetary policy is effective for these banks during normal times. The results in *Figure 4* provide strong evidence that this is driven by the effect of monetary policy on on-balance sheet liquidity creation. Specifically, MPT reduces on-balance sheet liquidity creation of small banks,[16] but does not have a significant effect on off-balance sheet liquidity creation of these banks.[17] Next, we consider medium and large banks. We discussed above that monetary policy is not effective for these banks during normal times. Despite this, the results in *Figure 4* provide some evidence that MPT reduces the on-balance sheet liquidity created by medium and large banks.[18] MPT does not have

[16] Significance for several lags based on both monetary policy measures – see the top left pictures in *Figure 4 Panels I-A* and *I-B*.
[17] The effect is generally negative but never significant – see the top left pictures in *Figure 4 Panels II-A* and *II-B*.
[18] Significance after two and one quarter(s) based on the Romer and Romer monetary policy shock measure, respectively – see the top middle and right pictures in *Figure 4 Panel I-A*.

a significant effect on off-balance sheet liquidity creation by these banks during normal times.[19] These results are consistent with Hypothesis 1 Parts (b) and (c), which states that MPT will reduce on-balance sheet liquidity creation and this effect will be stronger for smaller banks, and will have an ambiguous effect on off-balance sheet liquidity creation for banks of all sizes.

We now investigate whether our earlier result that monetary policy is generally less effective during financial crises is driven by a weaker effect on both on- and off-balance sheet liquidity creation during crises (Hypothesis 2 Parts (b) and (c)). Again, the hypothesis that the effect of monetary policy is weaker during crises predicts positive cumulative effects of the interaction terms (i.e., as before, the lines in the pictures in the middle row of *Figure 4 Panels I-A, I-B, II-A* and *II-B* should be above zero). The results show that they indeed tend to be positive based on both on-balance sheet liquidity creation[20] and off-balance sheet liquidity creation[21] for both monetary policy measures for banks of all size classes. The results support Hypothesis 2 Parts (b) and (c) – the weaker effect of monetary policy during crises is driven by the effect of monetary policy on *both* on- and off-balance sheet liquidity creation.[22]

4.4. Robustness check: banking versus market crises

It might be argued that aggregating banking and market crises is akin to mixing apples and oranges, and that the aggregation might obscure valuable information. So as a robustness check, we now split the five crises into banking crises (the credit crunch of the early 1990s and the current subprime lending crisis) versus market crises (the 1987 stock market crash, the Russian debt crisis plus LTCM bailout of 1998, and the bursting of the dot.com bubble plus the September 11 terrorist attacks of the early 2000s) and check whether our main results are driven by one or both of these sets of crises.

We use the following regression equation:

[19] See the top middle and right pictures in *Figure 4 Panels II-A* and *II-B*.

[20] Significance after one quarter based on the Romer and Romer monetary policy shock measure for large banks only – see the middle right picture in *Figure 4 Panel I-A*.

[21] Significance after three and one quarters based on the Romer and Romer monetary policy shocks and the change in the federal funds rate, respectively, for small banks; and significance after two quarters based on the Romer and Romer monetary policy shock measure for large banks – see the middle row of *Figure 4 Panels II-A* and *II-B*.

[22] The magnitude of the effect tends to be greater for off-balance sheet liquidity creation as is clear from comparing *Figure 4 Panels I-A* and *II-A*, and *I-B* and *II-B*). Despite the greater magnitude, it merely causes the overall crisis effect to be insignificantly (rather than significantly) positive. (The overall effect is shown for completeness in the bottom rows in *Figure 4 Panels II-A* and *II-B*, and is obtained by adding the top and middle rows.) The effect in terms of statistical significance is stronger based on on-balance sheet liquidity creation as is apparent from comparing the top and bottom rows in *Figure 4 Panels I-A* and *I-B*.

$$\%\Delta LC_{X,t} = \beta_0 + \sum_{i=1}^{4} \beta_i \, \Delta MONPOL_{t-i} + \sum_{j=1}^{4} \beta_j \, \%\Delta LC_{X,t-j}$$
$$+ \sum_{n=1}^{4} \beta_n \, D\ CRIS\ BANK_{t-n} + \sum_{p=1}^{4} \beta_p \, D\ CRIS\ MKT_{t-p}$$
$$+ \sum_{q=1}^{4} \beta_q \, \Delta MONPOL_{t-q} * D\ CRIS\ BANK_{t-q} + \sum_{r=1}^{4} \beta_r \, \Delta MONPOL_{t-r} * D\ CRIS\ MKT_{t-r}$$
$$+ \sum_{m=1}^{3} \beta_m \, D\ SEASON_m \qquad (2)$$

This equation is identical to equation (1) except that we split $D\ CRIS$ into $D\ CRIS\ BANK$ and $D\ CRIS\ MKT$. Thus, we now have eight crisis dummies (rather than four), and eight interaction terms (instead of four). In the interest of brevity, we merely describe the results rather than showing tables with the regression coefficients and figures with pictures of the implied impulse responses. Since the normal times results are similar to those presented in Sections 4.2 and 4.3, we focus here on the differential effects during banking and market crises.

Our main results suggested that during financial crises, monetary policy has a weaker effect on total liquidity creation and its two main components, on- and off-balance sheet liquidity creation. We now find that these results seem to be driven by the weaker effects of monetary policy during *both* banking and market crises. While the effects are more significant during banking crises, there is significance nonetheless during both banking and market crises. This indicates that aggregating across banking and market crises in our main analysis did not qualitatively affect our conclusions and validates our combining both sets of crises.

5. Is high liquidity creation an indicator of an impending crisis?

This section analyzes whether high liquidity creation is an indicator of an impending crisis (Hypothesis 3). It first provides graphical evidence which suggests that liquidity creation (in particular its off-balance sheet component) tends to be abnormally high relative to a trend line before crises. It then proceeds to formally examine whether the level of liquidity creation predicts the probability of occurrence of a crisis. We explain why we use logit regressions rather than a hazard model for that purpose.

The analysis presented in this section is based on deseasonalized and detrended data. The next subsection explains why.

5.1. Detrended bank liquidity creation

As shown in Section 3.5, liquidity creation has grown dramatically over time. It is also likely that it contains seasonal components. This poses a problem because any analysis that tries to examine whether high levels of liquidity creation precede financial crises would be strongly affected by the long-run trend (and possibly the seasonal components). What we are interested in are *deviations* from the trend. To link liquidity creation to the advent of a crisis, we therefore use an approach widely used in the macroeconomics literature (e.g., Barro 1997): we first deseasonalize and then detrend the data.

To deseasonalize the data, we use the prominent X11 procedure developed by the U.S. Census Bureau. This procedure identifies and adjusts for outliers. For detrending, we use the Hodrick-Prescott (1997) (HP) filter.[23] Henceforth, we call deseasonalized and detrended data "detrended data" for brevity.

A naïve approach would be to simply take data over our entire sample period and detrend it. However, such an approach is subject to criticism since the detrended amounts are based on (varying degrees of) forward-looking data. While the detrended amount in the last quarter is fully based on historic data, the detrended amount in the first quarter is entirely based on future data. This may not be problematic if our only goal is to show that detrended liquidity creation is high before crises. However, we also want to see if we can predict future crises. For such an analysis, it is paramount that the detrended data are not based on forward-looking data.

To ensure that the quarterly detrended amounts used in this paper are based purely on historical data, we use the following approach. Since the HP filter requires that at least twelve quarterly observations are used, we first detrend the initial twelve quarters in the sample period (1984:Q1-1986:Q4). We drop the first eleven quarterly detrended amounts since they are in part based on forward-looking data. Thus, the first detrended amount in our sample is from the twelfth quarter, 1986:Q4. To obtain the detrended amount in next quarter, we use data from 1984:Q1-1987:Q1 in our detrending process and only keep the result for 1987:Q1. We follow a similar procedure for every subsequent quarter and end up with a detrended liquidity creation series from 1986:Q4 – 2008:Q4 that is based on historical data in every quarter. We repeat the procedure to obtain detrended on- and off-balance sheet liquidity creation series over the same

[23] Assuming the original series has a trend component and a cyclical component, the HP filter identifies the cyclical component by trading off smoothness and goodness of fit. The trade-off parameter is set to 1,600, which is customary for quarterly data. The HP filter is known to be sensitive to the endpoints, but since no obvious remedies exist, we present the results as they are.

time period.

5.2. Is liquidity creation high (relative to a trend line) before crises?

Figure 5 Panel A shows detrended liquidity creation over the sample period. Detrended bank liquidity was high around the beginning of the credit crunch, and also from late 1994 through late 1999, a period which includes the Russian debt crisis and the prelude to the bursting of the dot.com bubble. It was also high prior to the current subprime lending crisis.

Figure 5 Panels B and C split detrended liquidity creation into its on- and off-balance sheet components, respectively. Panel B shows a far less pronounced pattern for detrended on-balance sheet liquidity creation, with somewhat elevated levels in the mid-1990s and more pronounced peaks in the late 1990s, including around the start of the Russian debt crisis and the bursting of the dot.com bubble. Panel C shows that the pattern for detrended off-balance sheet liquidity creation is very similar to that shown for total liquidity creation in Panel A.

These graphs provide some initial support for the hypothesis that high (detrended) liquidity creation precedes crises. This seems to be driven by off-balance sheet liquidity creation.

5.3. Is a high level of liquidity creation (relative to a trend line) an indicator of an impending crisis? (Hypothesis 3)

We now formally examine whether abnormally high detrended liquidity creation presages a financial crisis as predicted by Hypothesis 3. To investigate this, we perform out-of-sample predictions in which we link the level of detrended liquidity creation with the probability of occurrence of a crisis. To predict the onset of a crisis, we keep the normal time period quarters and the first quarter of each crisis (e.g., Demirguc-Kunt and Detragiache 2001). We drop the remaining crisis quarters because a crisis cannot start if one is already underway. As a result, the sample used here is smaller than the one used above. A dummy is created that equals 1 during the first quarter of each crisis and 0 otherwise.

One possible way to examine this issue would be to use a hazard model. The finance literature has used hazard models to predict a variety of "failures," such as companies going bankrupt (e.g., Shumway 2001). However, in our context, using a hazard model to predict crises is inappropriate. The reason is that hazard models adjust for an age effect. That is, they assume that the time that has elapsed since the last failure matters in determining the probability of occurrence of the next failure. This assumption is not economically justifiable in our context since a financial crisis can happen at any time, and the time since the last crisis occurred is not an economically sensible variable on which one can condition the probability of occurrence of the next crisis. We therefore predict crises using logit models instead.

Ideally, we would like to use data from a sample period that contains a large number of crises, obtain the regression coefficients, and use them to predict the advent of several subsequent crises. Unfortunately, our sample period includes only five crises. The models we use to obtain the regression coefficients therefore always include the first four crises and our focus is on predicting the start of the next crisis.

To predict the start of the fifth crisis, it is important to only use historical data. For this purpose, we run 19 logit regressions each of which adds one additional quarter of data. The first logit regression uses data through 2002:Q4, one quarter after the end of the fourth crisis (the bursting of the dot.com bubble). It regresses the log odds ratio of a crisis striking on (lagged) detrended total liquidity creation and various (lagged) macroeconomic variables discussed below which may help predict the start of a crisis. The coefficients from this regression are used to predict the probability of a crisis occurring one quarter hence (i.e., in 2003:Q1). Each of the next 18 regressions adds one quarter of data. The last one uses data through 2007:Q2, the quarter before the fifth crisis (the current subprime lending crisis) actually hit. The coefficients from these 18 regressions are used to predict the probability of a crisis striking one quarter ahead in 2003:Q2 through 2007:Q3, respectively. We also tried including four lags of every regression variable, but there were not enough observations to support this specification (half of the regression variables dropped out).

Specifically, we estimate the following regression equations:

$$\log\left(\frac{Prob(CRISIS_t)}{1-\mathrm{Prob(CRISIS_t)}}\right) = \beta_0 + \beta_1 DETRENDED\ LC_{t-1} + \beta_2 DETRENDED\ GDP_{t-1} + \beta_3 MONPOL_{t-1} + \beta_4 MKTRETURN_{t-1} \quad (3)$$

where *DETRENDED LC* is detrended liquidity creation, *DETRENDED GDP* is detrended GDP, *MONPOL* is monetary policy measured as the level of the federal funds rate, and *MKTRETURN* is the performance of the stock market as proxied by the average quarterly return on the value-weighted CRSP index.[24]

Note that Hypothesis 3 is phrased in terms of the level of liquidity creation rather than the change. When liquidity creation is high for a number of periods, a crisis may be likely to strike even if the change in liquidity creation is small. For consistency, the other variables are expressed in levels as well.[25] This is why we use the level of the federal funds rate in this analysis and not the Romer and Romer policy shocks, which measure changes in monetary policy.

Table 4 Panel A shows the results of the logit regressions. Instead of presenting the regression coefficients, we report odds ratios which are obtained by exponentiating the original coefficients. When *DETRENDED LC* has an odds ratio that exceeds (is less than) 1, a higher level of detrended liquidity creation is associated with higher (lower) odds of a crisis striking. *Panel A* shows that the odds ratios of detrended liquidity creation exceed 1 in all cases and are significant at the 5% - 10% level in 18 out of 19 cases. These results suggest that a higher level of detrended liquidity creation is associated with a higher risk of a crisis striking one quarter hence. The percentage change in the odds of a crisis striking can be calculated as 100 * (odds ratio – 1). Thus, the exponentiated coefficients of slightly over 1.03 in most models suggest that a $1 billion increase in detrended liquidity creation increases the odds of a crisis occurring one quarter hence by over 3.0% in each quarter. The odds ratios for detrended GDP are smaller than 1 in all cases and always significant, suggesting that a higher level of detrended GDP reduces the probability of a crisis striking. The odds ratios for monetary policy is positive and in many cases marginally significant, suggesting that higher federal funds rate is associated with a higher probability of a crisis occurring.[26] The odds ratios for the return on the stock market are never significant. These results suggest that detrended liquidity creation has explanatory power even after including detrended GDP, the federal funds rate, and the return on the market.

Table 4 Panel B interprets our findings using the predicted probabilities of a crisis occurring one quarter hence starting in 2002:Q4 (the first quarter after the fourth crisis) and ending in 2007:Q2 (one quarter before the fifth crisis). The results clearly show that the probability of a crisis striking was close to zero soon after the fourth crisis was over, but started to increase in 2005:Q4. As of the end of 2006:Q3, the

[24] Regressions based on the equal-weighted CRSP index or the S&P 500 yield similar results.
[25] As an exception, we include market returns rather than the level of the stock market.
[26] Note that we are not asserting causation here – it may be the case that the federal funds rate was generally at a high level before crises because the authorities tried to slow down the economy.

probability of a crisis occurring in the next quarter was close to 25%. Two quarters before the crisis started, the probability of a crisis striking had increased to over 90%, although this dropped to 33% the quarter before the crisis.[27]

These results clearly suggest that excessively high total liquidity creation presages a crisis. This supports Hypothesis 3. We have also run two additional sets of 19 logit regressions based on detrended on- and off-balance sheet liquidity creation to examine whether our findings are in support of this hypothesis are driven by on-balance sheet liquidity creation, off-balance sheet liquidity creation, or both. Our analyses suggest that the results are driven primarily by off-balance sheet liquidity creation (not shown for brevity).

6. Conclusions

This paper formulates hypotheses related to the following three questions. First, how does monetary policy affect aggregate bank liquidity creation and its two main components – on- balance-sheet and off-balance sheet liquidity creation, during normal times? Second, does monetary policy affect bank liquidity creation differently during financial crises versus normal times? Third, is high aggregate bank liquidity creation an indicator of an impending crisis?

To test our hypotheses, we use data on virtually all banks in the U.S. from 1984:Q1 to 2008:Q4. Five financial crises are identified over this time period. Two monetary policy measures, Romer and Romer monetary policy shocks and the change in the federal funds rate, are used in the analyses. Our main findings, which generally support our hypotheses, are as follows.

First, monetary policy seems to significantly affect liquidity creation by small banks in that a tightening (loosening) of monetary policy is associated with a reduction (an increase) in liquidity creation by these banks. This result seems to be driven by the response of on-balance sheet liquidity creation to monetary policy. However, even though monetary policy affects on-balance sheet liquidity creation by medium and large banks, it does not seem to have a significant effect on total liquidity creation by these banks, which create roughly 90% of aggregate bank liquidity. Moreover, monetary policy does not have a significant effect on the off-balance sheet liquidity creation by banks of any size class.

[27] This drop in the last quarter is driven primarily by an increase in detrended GDP.

Second, for banks of all sizes, the effect of monetary policy is weaker during financial crises than during normal times. This result is driven by the response of both on- and off-balance sheet liquidity creation to monetary policy.

Third, detrended liquidity creation tends to be high prior to financial crises. Results from logit regressions suggest that detrended liquidity creation has incremental explanatory power in predicting crises even after controlling for various other macroeconomic factors.

Our results raise interesting questions for future research. For example, is there a "socially optimal" level of aggregate liquidity creation? If so, is it possible to engage in calibration exercises that can help regulators to determine when the social optimum has been exceeded and the banking sector needs to be reined in?

Appendix

This Appendix describes the five financial crises that occurred in the U.S. between 1984:Q1 and 2008:Q4.

Financial crisis #1: Stock market crash (1987:Q4)

On Monday, October 19, 1987, the stock market crashed, with the S&P500 index falling about 20%. During the years before the crash, the level of the stock market had increased dramatically, causing some concern that the market had become overvalued.[28] A few days before the crash, two events occurred that may have helped precipitate the crash: 1) legislation was enacted to eliminate certain tax benefits associated with financing mergers; and 2) information was released that the trade deficit was above expectations. Both events seemed to have added to the selling pressure and a record trading volume on Oct. 19, in part caused by program trading, overwhelmed many systems.

Financial crisis #2: Credit crunch (1990:Q1 – 1992:Q4)

During the first three years of the 1990s, bank commercial and industrial lending declined in real terms, particularly for small banks and for small loans (see Berger, Kashyap, and Scalise 1995, Table 8, for details). The ascribed causes of the credit crunch include a fall in bank capital from the loan loss experiences of the late 1980s (e.g., Peek and Rosengren 1995), the increases in bank leverage requirements and implementation of Basel I risk-based capital standards during this time period (e.g., Berger and Udell 1994, Hancock, Laing, and Wilcox 1995, Thakor 1996), an increase in supervisory toughness evidenced in worse examination ratings for a given bank condition (e.g., Berger, Kyle, and Scalise 2001), and reduced loan demand because of macroeconomic and regional recessions (e.g., Bernanke and Lown 1991). The existing research provides some support for each of these hypotheses.

Financial crisis #3: Russian debt crisis / LTCM bailout (1998:Q3 – 1998:Q4)

Since its inception in March 1994, hedge fund Long-Term Capital Management ("LTCM") followed an arbitrage strategy that was avowedly "market neutral," designed to make money regardless of whether prices were rising or falling. When Russia defaulted on its sovereign debt on August 17, 1998, investors

[28] E.g., "Raging bull, stock market's surge is puzzling investors: When will it end?" on page 1 of the Wall Street Journal, Jan. 19, 1987.

fled from other government paper to the safe haven of U.S. treasuries. This flight to liquidity caused an unexpected widening of spreads on supposedly low-risk portfolios. By the end of August 1998, LTCM's capital had dropped to $2.3 billion, less than 50% of its December 1997 value, with assets standing at $126 billion. In the first three weeks of September, LTCM's capital dropped further to $600 million without shrinking the portfolio. Banks began to doubt its ability to meet margin calls. To prevent a potential systemic meltdown triggered by the collapse of the world's largest hedge fund, the Federal Reserve Bank of New York organized a $3.5 billion bail-out by LTCM's major creditors on September 23, 1998. In 1998:Q4, several large banks had to take substantial write-offs as a result of losses on their investments.

Financial crisis #4: Bursting of the dot.com bubble and Sept. 11 terrorist attack (2000:Q2 – 2002:Q3)

The dot.com bubble was a speculative stock price bubble that was built up during the mid- to late-1990s. During this period, many internet-based companies, commonly referred to as "dot.coms," were founded. Rapidly increasing stock prices and widely available venture capital created an environment in which many of these companies seemed to focus largely on increasing market share. At the height of the boom, many dot.com's were able to go public and raise substantial amounts of money even if they had never earned any profits, and in some cases had not even earned any revenues. On March 10, 2000, the Nasdaq composite index peaked at more than double its value just a year before. After the bursting of the bubble, many dot.com's ran out of capital and were acquired or filed for bankruptcy (examples of the latter include WorldCom and Pets.com). The U.S. economy started to slow down and business investments began falling. The September 11, 2001 terrorist attacks may have exacerbated the stock market downturn by adversely affecting investor sentiment. By 2002:Q3, the Nasdaq index had fallen by 78%, wiping out $5 trillion in market value of mostly technology firms.

Financial crisis #5: Subprime lending crisis (2007:Q3 – ?)

The subprime lending crisis has been characterized by turmoil in financial markets as banks have experienced difficulty in selling loans in the syndicated loan market and in securitizing loans. According to press reports, banks also seem to be reluctant to provide credit: they appear to have cut back their lending to firms and individuals, and have also been reticent to lend to each other. Some banks have experienced substantial losses in capital. Massive losses at Countrywide resulted in a takeover by Bank of America. Bear Stearns suffered a fatal loss in confidence and was sold at a fire-sale price to J.P. Morgan Chase with the Federal Reserve guaranteeing $29 billion in potential losses. Washington Mutual, the sixth-largest bank, became the biggest bank failure in the U.S. financial history. J.P. Morgan Chase purchased the banking business while the rest of the organization filed for bankruptcy. IndyMac Bank was seized by the FDIC after it suffered substantive losses and depositors had started to run on the bank. The FDIC sold all deposits and most of the assets to OneWest Bank, FSB. The Federal Reserve also intervened in some unprecedented ways in the market. It extended its safety-net privileges to investment banks and one insurance company (AIG) and began holding mortgage-backed securities and lending directly to investment banks. The Treasury set aside $250 billion out of its $700-billion bailout package (TARP program) to enhance capital ratios of selected banks.

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Table 1: Liquidity classification of bank activities and construction of the liquidity creation measure

This table explains the Berger and Bouwman (forthcoming) methodology to construct their preferred liquidity creation measure that classifies loans by category and includes off-balance sheet activities in three steps.

Step 1: Classify all bank activities as liquid, semi-liquid, or illiquid. For activities other than loans, information on product category and maturity are combined. Due to data limitations, loans are classified entirely by product category.

Step 2: Assign weights to the activities classified in Step 1.

ASSETS:

Illiquid assets (weight = ½)	**Semi-liquid assets (weight = 0)**	**Liquid assets (weight = - ½)**
Commercial real estate loans (CRE)	Residential real estate loans (RRE)	Cash and due from other institutions
Loans to finance agricultural production	Consumer loans	All securities (regardless of maturity)
Commercial and industrial loans (C&I)	Loans to depository institutions	Trading assets
Other loans and lease financing receivables	Loans to state and local governments	Fed funds sold
Other real estate owned (OREO)	Loans to foreign governments	
Investment in unconsolidated subsidiaries		
Intangible assets		
Premises		
Other assets		

LIABILITIES PLUS EQUITY:

Liquid liabilities (weight = ½)	**Semi-liquid liabilities (weight = 0)**	**Illiquid liabilities plus equity (weight = - ½)**
Transactions deposits	Time deposits	Subordinated debt
Savings deposits	Other borrowed money	Other liabilities
Overnight federal funds purchased		Equity
Trading liabilities		

OFF-BALANCE SHEET GUARANTEES (notional values):

Illiquid guarantees (weight = ½)	**Semi-liquid guarantees (weight = 0)**	**Liquid guarantees (weight = - ½)**
Unused commitments	Net credit derivatives	Net participations acquired
Net standby letters of credit	Net securities lent	
Commercial and similar letters of credit		
All other off-balance sheet liabilities		

OFF-BALANCE SHEET DERIVATIVES (gross fair values):

		Liquid derivatives (weight = -½)
		Interest rate derivatives
		Foreign exchange derivatives
		Equity and commodity derivatives

Step 3: Combine bank activities as classified in Step 1 and as weighted in Step 2 to construct the liquidity creation (LC) measure.

LC =	+ ½ * illiquid assets	+ 0 * semi-liquid assets	– ½ * liquid assets
	+ ½ * liquid liabilities	+ 0 * semi-liquid liabilities	– ½ * illiquid liabilities
			– ½ * equity
	+ ½ * illiquid guarantees	+ 0 * semi-liquid guarantees	– ½ * liquid guarantees
			– ½ * liquid derivatives

Table 2: The effect of monetary policy on bank liquidity creation during normal times and financial crises

This table examines the relationship between monetary policy and bank liquidity creation. The dependent variables are $\%\Delta LC\ TOTAL_S$, $\%\Delta LC\ TOTAL_M$, and $\%\Delta LC\ TOTAL_L$, the percentage change of liquidity created by small banks (GTA up to $1 billion), medium banks (GTA $1 billion–$3 billion), and large banks (GTA exceeding $3 billion), respectively. GTA equals total assets plus the allowance for loan and lease losses and the allocated transfer risk reserve (a reserve for certain foreign loans). In Panels A and B, the (lagged) change in monetary policy, *ΔMONPOL*, is alternatively defined as Romer and Romer's monetary policy shocks (*RR POLICYSHOCKS*) and the change in the federal funds rate (*ΔFEDFUNDS*). $\%\Delta LC\ TOTAL_{X,t\text{-}i}$ is the lagged version of the corresponding left-hand side variable, where X refers to small, medium, or large banks, in quarter t-i, $i \in (1,4)$. $D\ CRIS_{t\text{-}k}$ is a crisis dummy that equals one if there was a crisis in quarter t-k, $k \in (1,4)$, and is zero otherwise. $\Delta MONPOL * D\ CRIS$ is an interaction term which interacts the (lagged) change in monetary policy with the (lagged) crisis dummies. All regressions include seasonal dummies (not shown for brevity). The sample period is 1984:Q1–2008:Q4. t-statistics based on robust standard errors are in parentheses. ∗, ∗∗, and ∗∗∗ denote significance at the 10%, 5%, and 1% levels, respectively.

	PANEL A: ΔMONPOL = RR POLICYSHOCKS			PANEL B: ΔMONPOL = ΔFEDFUNDS		
	$\%\Delta LC\ TOTAL_S$	$\%\Delta LC\ TOTAL_M$	$\%\Delta LC\ TOTAL_L$	$\%\Delta LC\ TOTAL_S$	$\%\Delta LC\ TOTAL_M$	$\%\Delta LC\ TOTAL_L$
$\Delta MONPOL_{t-1}$	-0.022	-0.020	-0.036	-0.022	-0.011	-0.005
	(-0.58)	*(-0.23)*	*(-1.04)*	*(-2.40)***	*(-0.73)*	*(-0.52)*
$\Delta MONPOL_{t-2}$	-0.100	-0.046	-0.023	0.003	-0.003	-0.003
	*(-2.69)****	*(-0.60)*	*(-0.70)*	*(0.44)*	*(-0.17)*	*(-0.46)*
$\Delta MONPOL_{t-3}$	-0.005	0.020	0.025	-0.005	0.002	-0.001
	(-0.16)	*(0.28)*	*(0.88)*	*(-0.70)*	*(0.20)*	*(-0.16)*
$\Delta MONPOL_{t-4}$	-0.027	-0.032	0.034	0.001	0.000	0.011
	(-0.65)	*(-0.54)*	*(1.41)*	*(0.21)*	*(0.02)*	*(2.51)***
$\%\Delta LC\ TOTAL_{X,t-1}$	0.114	-0.057	0.047	0.149	-0.074	0.031
	(0.90)	*(-0.55)*	*(0.37)*	*(1.28)*	*(-0.70)*	*(0.25)*
$\%\Delta LC\ TOTAL_{X,t-2}$	-0.145	-0.203	0.186	-0.039	-0.169	0.250
	(-1.13)	*(-1.80)**	*(1.62)*	*(-0.34)*	*(-1.46)*	*(2.32)***
$\%\Delta LC\ TOTAL_{X,t-3}$	-0.039	-0.047	0.117	-0.048	-0.030	0.065
	(-0.38)	*(-0.44)*	*(1.01)*	*(-0.41)*	*(-0.28)*	*(0.62)*
$\%\Delta LC\ TOTAL_{X,t-4}$	-0.036	-0.070	0.179	0.004	-0.015	0.181
	(-0.32)	*(-0.47)*	*(1.86)**	*(0.03)*	*(-0.12)*	*(2.31)***
$D\ CRIS_{t-1}$	-0.022	-0.030	-0.015	-0.020	-0.019	-0.015
	*(-3.28)****	*(-2.40)***	*(-2.32)***	*(-3.18)****	*(-1.56)*	*(-2.69)****
$D\ CRIS_{t-2}$	-0.001	0.015	-0.008	-0.004	0.010	-0.006
	(-0.09)	*(1.01)*	*(-0.90)*	*(-0.41)*	*(0.69)*	*(-0.97)*
$D\ CRIS_{t-3}$	0.005	-0.015	0.001	0.011	-0.003	0.000
	(0.44)	*(-0.57)*	*(0.13)*	*(1.08)*	*(-0.13)*	*(0.06)*
$D\ CRIS_{t-4}$	0.010	0.001	0.007	0.004	-0.003	0.003
	(1.08)	*(0.05)*	*(1.10)*	*(0.54)*	*(-0.14)*	*(0.51)*
$\Delta MONPOL_{t-1} * D\ CRIS_{t-1}$	-0.024	-0.097	0.020	0.013	0.016	-0.002
	(-0.51)	*(-0.82)*	*(0.34)*	*(1.03)*	*(0.62)*	*(-0.13)*
$\Delta MONPOL_{t-2} * D\ CRIS_{t-2}$	0.117	0.129	0.035	0.002	0.001	0.022
	*(1.98)**	*(0.99)*	*(0.73)*	*(0.14)*	*(0.02)*	*(1.98)**
$\Delta MONPOL_{t-3} * D\ CRIS_{t-3}$	0.025	-0.076	0.047	0.003	0.041	-0.008
	(0.53)	*(-0.53)*	*(0.60)*	*(0.21)*	*(1.82)**	*(-0.71)*
$\Delta MONPOL_{t-4} * D\ CRIS_{t-4}$	0.004	0.166	-0.054	-0.005	-0.030	-0.018
	(0.08)	*(1.26)*	*(-1.14)*	*(-0.46)*	*(-1.52)*	*(-1.95)**
Constant	0.015	0.024	0.012	0.010	0.019	0.012
	*(2.55)***	*(2.82)****	*(2.26)***	*(2.36)***	*(2.32)***	*(2.37)***
Observations	95	95	95	95	95	95
Adjusted R-squared	0.29	-0.06	0.31	0.26	-0.04	0.36

Table 3: The effect of monetary policy on *on- and off-balance sheet* bank liquidity creation during normal times and financial crises

This table examines the relationship between monetary policy and on- versus off-balance sheet bank liquidity creation (Panels I and II, respectively). The dependent variables in Panel I (II) are *%ΔLC ON BS$_S$*, *%ΔLC ON BS$_M$*, and *%ΔLC ON BS$_L$* (*%ΔLC OFF BS$_S$*, *%ΔLC OFF BS$_M$*, and *%ΔLC OFF BS$_L$*), the percentage change of on- (off-) balance sheet liquidity created by small banks (GTA up to $1 billion), medium banks (GTA $1 billion–$3 billion), and large banks (GTA exceeding $3 billion), respectively. GTA equals total assets plus the allowance for loan and lease losses and the allocated transfer risk reserve (a reserve for certain foreign loans). In Panel I (II), %ΔLC ON BS$_{X,t-i}$ (%ΔLC OFF BS$_{X,t-i}$) is the lagged version of the corresponding left-hand side variable, where X refers to small, medium, or large banks, in quarter t-i, $i \in (1,4)$. In Subpanels A and B, the (lagged) change in monetary policy, *ΔMONPOL*, is alternatively defined as Romer and Romer's monetary policy shocks (*RR POLICYSHOCKS*) and the change in the federal funds rate (*ΔFEDFUNDS*). *D CRIS$_{t-k}$* is a crisis dummy that equals one if there was a crisis in quarter t-k, $k \in (1,4)$, and is zero otherwise. $\Delta MONPOL * D\ CRIS$ is an interaction term which interacts the (lagged) change in monetary policy with the (lagged) crisis dummies. All regressions include seasonal dummies (not shown for brevity). The sample period is 1984:Q1–2008:Q4. t-statistics based on robust standard errors are in parentheses. ∗, ∗∗, and ∗∗∗ denote significance at the 10%, 5%, and 1% levels, respectively.

	PANEL I-A: ΔMONPOL = RR POLICYSHOCKS			**PANEL I-B: ΔMONPOL = ΔFEDFUNDS**		
	%ΔLC ON BS$_S$	%ΔLC ON BS$_M$	%ΔLC ON BS$_L$	%ΔLC ON BS$_S$	%ΔLC ON BS$_M$	%ΔLC ON BS$_L$
ΔMONPOL$_{t-1}$	-0.032	-0.032	-0.122	-0.021	-0.015	-0.014
	(-0.84)	*(-0.39)*	*(-2.38)***	*(-2.00)***	*(-1.11)*	*(-1.28)*
ΔMONPOL$_{t-2}$	-0.075	-0.121	0.067	0.007	0.002	0.010
	*(-1.98)**	*(-1.83)**	*(1.57)*	*(1.00)*	*(0.12)*	*(1.19)*
ΔMONPOL$_{t-3}$	0.011	0.038	-0.005	-0.004	0.003	-0.015
	(0.36)	*(0.61)*	*(-0.11)*	*(-0.54)*	*(0.34)*	*(-2.23)***
ΔMONPOL$_{t-4}$	-0.050	-0.026	-0.012	0.000	-0.010	0.014
	(-1.21)	*(-0.50)*	*(-0.31)*	*(0.03)*	*(-0.97)*	*(2.16)***
%ΔLC ON BS$_{X,t-1}$	0.245	0.022	-0.185	0.276	0.026	-0.311
	*(2.15)***	*(0.23)*	*(-1.05)*	*(2.46)***	*(0.25)*	*(-1.49)*
%ΔLC ON BS$_{X,t-2}$	-0.071	-0.050	0.030	0.068	-0.053	0.138
	(-0.72)	*(-0.48)*	*(0.19)*	*(0.77)*	*(-0.49)*	*(0.78)*
%ΔLC ON BS$_{X,t-3}$	0.115	0.021	0.319	0.091	0.029	0.309
	(1.27)	*(0.24)*	*(2.04)***	*(0.78)*	*(0.28)*	*(2.23)***
%ΔLC ON BS$_{X,t-4}$	-0.123	-0.125	0.306	-0.062	-0.045	0.269
	(-1.11)	*(-1.03)*	*(2.23)***	*(-0.52)*	*(-0.36)*	*(2.42)***
D CRIS$_{t-1}$	-0.016	-0.033	-0.006	-0.015	-0.020	-0.010
	*(-2.42)***	*(-2.53)***	*(-0.82)*	*(-2.33)***	*(-1.56)*	*(-1.33)*
D CRIS$_{t-2}$	0.008	0.009	-0.013	0.006	0.004	-0.005
	(0.91)	*(0.61)*	*(-1.18)*	*(0.70)*	*(0.26)*	*(-0.46)*
D CRIS$_{t-3}$	0.001	-0.027	0.004	0.009	-0.012	-0.002
	(0.11)	*(-1.31)*	*(0.41)*	*(0.85)*	*(-0.59)*	*(-0.21)*
D CRIS$_{t-4}$	0.006	0.026	-0.005	0.000	0.021	-0.005
	(0.57)	*(1.54)*	*(-0.63)*	*(0.05)*	*(1.15)*	*(-0.53)*
ΔMONPOL$_{t-1}$ * D CRIS $_{t-1}$	-0.049	-0.054	0.158	0.004	0.022	0.005
	(-1.09)	*(-0.51)*	*(2.23)***	*(0.27)*	*(1.00)*	*(0.33)*
ΔMONPOL$_{t-2}$ * D CRIS $_{t-2}$	0.101	0.048	-0.087	0.002	-0.016	0.012
	*(1.85)**	*(0.45)*	*(-1.35)*	*(0.13)*	*(-0.63)*	*(0.81)*
ΔMONPOL$_{t-3}$ * D CRIS $_{t-3}$	-0.021	-0.118	0.012	0.002	0.025	0.003
	(-0.44)	*(-1.13)*	*(0.12)*	*(0.13)*	*(1.11)*	*(0.19)*
ΔMONPOL$_{t-4}$ * D CRIS $_{t-4}$	0.043	0.189	0.028	-0.002	-0.001	-0.021
	(0.81)	*(1.64)*	*(0.39)*	*(-0.22)*	*(-0.05)*	*(-1.66)**
Constant	0.009	0.020	0.010	0.004	0.014	0.009
	*(2.03)***	*(2.54)***	*(1.14)*	*(1.08)*	*(1.76)**	*(1.07)*
Observations	95	95	95	95	95	95
Adjusted R-squared	0.43	0.05	0.23	0.37	0.04	0.23

	PANEL II-A: ΔMONPOL = RR POLICYSHOCKS			PANEL II-B: ΔMONPOL = ΔFEDFUNDS		
	$\%\Delta$LC OFF BS_S	$\%\Delta$LC OFF BS_M	$\%\Delta$LC OFF BS_L	$\%\Delta$LC OFF BS_S	$\%\Delta$LC OFF BS_M	$\%\Delta$LC OFF BS_L
$\Delta MONPOL_{t-1}$	0.031	0.052	0.040	-0.026	-0.011	0.004
	(0.47)	*(0.38)*	*(1.19)*	*(-1.48)*	*(-0.32)*	*(0.39)*
$\Delta MONPOL_{t-2}$	-0.194	0.060	-0.098	-0.011	-0.009	-0.016
	*(-2.29)***	*(0.43)*	*(-2.47)***	*(-0.55)*	*(-0.24)*	*(-2.18)***
$\Delta MONPOL_{t-3}$	-0.055	-0.028	0.051	-0.008	-0.001	0.011
	(-0.73)	*(-0.23)*	*(1.77)**	*(-0.70)*	*(-0.04)*	*(1.99)**
$\Delta MONPOL_{t-4}$	0.035	-0.048	0.056	0.008	0.024	0.008
	(0.37)	*(-0.38)*	*(1.71)**	*(0.33)*	*(0.67)*	*(1.24)*
$\%\Delta$LC OFF $BS_{X,t-1}$	-0.224	-0.160	0.225	-0.160	-0.214	0.286
	(-0.87)	*(-0.75)*	*(1.67)**	*(-0.68)*	*(-1.02)*	*(2.36)***
$\%\Delta$LC OFF $BS_{X,t-2}$	-0.403	-0.556	0.273	-0.374	-0.448	0.297
	(-1.33)	*(-2.79)****	*(2.02)***	*(-1.31)*	*(-2.18)***	*(2.24)***
$\%\Delta$LC OFF $BS_{X,t-3}$	-0.517	-0.166	-0.057	-0.459	-0.125	-0.134
	(-1.52)	*(-0.69)*	*(-0.41)*	*(-1.71)**	*(-0.57)*	*(-0.95)*
$\%\Delta$LC OFF $BS_{X,t-4}$	0.299	0.220	0.090	0.282	0.226	0.120
	(0.71)	*(0.38)*	*(0.82)*	*(0.61)*	*(0.43)*	*(1.27)*
D $CRIS_{t-1}$	-0.036	-0.028	-0.020	-0.028	-0.014	-0.015
	*(-2.53)***	*(-1.07)*	*(-2.04)***	*(-1.99)***	*(-0.56)*	*(-2.47)***
D $CRIS_{t-2}$	-0.033	0.032	-0.005	-0.039	0.023	-0.009
	(-1.42)	*(1.02)*	*(-0.44)*	*(-1.82)**	*(0.81)*	*(-1.20)*
D $CRIS_{t-3}$	0.012	0.007	-0.003	0.018	0.018	0.001
	(0.54)	*(0.13)*	*(-0.32)*	*(0.79)*	*(0.39)*	*(0.15)*
D $CRIS_{t-4}$	0.025	-0.052	0.015	0.021	-0.051	0.008
	*(1.67)**	*(-1.09)*	*(2.14)***	*(1.51)*	*(-1.17)*	*(1.14)*
$\Delta MONPOL_{t-1}$ * D $CRIS_{t-1}$	0.024	-0.236	-0.079	0.044	0.014	-0.007
	(0.23)	*(-0.90)*	*(-1.13)*	*(1.69)**	*(0.22)*	*(-0.43)*
$\Delta MONPOL_{t-2}$ * D $CRIS_{t-2}$	0.189	0.329	0.129	0.001	0.031	0.031
	(1.47)	*(1.25)*	*(2.22)***	*(0.04)*	*(0.50)*	*(2.15)***
$\Delta MONPOL_{t-3}$ * D $CRIS_{t-3}$	0.174	0.049	0.050	0.009	0.076	-0.018
	(1.66)	*(0.16)*	*(0.64)*	*(0.34)*	*(1.52)*	*(-1.22)*
$\Delta MONPOL_{t-4}$ * D $CRIS_{t-4}$	-0.092	0.122	-0.095	-0.011	-0.086	-0.013
	(-0.79)	*(0.42)*	*(-1.87)**	*(-0.47)*	*(-1.94)**	*(-1.12)*
Constant	0.037	0.033	0.014	0.032	0.030	0.014
	*(2.78)****	*(2.41)***	*(2.37)***	*(3.27)****	*(2.30)***	*(2.31)***
Observations	95	95	95	95	95	95
Adjusted R-squared	0.24	0.01	0.31	0.23	0.02	0.28

Table 4: Detrended liquidity creation as an indicator of an impending crisis

This table examines whether abnormally high detrended liquidity creation presages a financial crisis. The data is first deseasonalized using the X11 procedure developed by the U.S. Census Bureau, and then detrended using the Hodrick-Prescott (1997) filter. The sample includes the normal time period quarters and the first quarter of every crisis. We drop the remaining crisis quarters because a crisis cannot start if one is already ongoing. A dummy is created that equals 1 during the first quarter of each crisis and 0 otherwise. Panel A reports the results of 19 logit regressions in which the probability of a crisis occurring is regressed on DETRENDED LC TOTAL, the dollar amount of detrended liquidity creation, and various macroeconomic factors that may affect the likelihood of a crisis: detrended GDP; monetary policy as measured by MONPOL, the federal funds rate; and MKTRETURN, the quarterly return on the stock market measured as the average monthly return during the quarter. The regressors are lagged one quarter. The first regression uses data through 2002:Q4, one quarter after the end of the fourth crisis. Each of the next 18 regressions includes one additional quarter of data. The last regression uses data through 2007:Q2, the last quarter before the start of the current subprime lending crisis, the last crisis in the sample. Odds ratios, i.e., exponentiated regression coefficients, are reported. t-statistics are in parentheses. Bold font denotes significance at least at the 10% level. Panel B contains the predicted probability of a crisis striking one quarter hence.

Panel A: Logit regression results

	Probability of a crisis:																		
Model estimated using data through:	2002: Q4	2003: Q1	2003: Q2	2003: Q3	2003: Q4	2004: Q1	2004: Q2	2004: Q3	2004: Q4	2005: Q1	2005: Q2	2005: Q3	2005: Q4	2006: Q1	2006: Q2	2006: Q3	2006: Q4	2007: Q1	2007: Q2
DETRENDED LC TOTAL$_{t-1}$	**1.030**	**1.031**	**1.031**	**1.033**	**1.033**	**1.033**	**1.033**	**1.033**	**1.033**	**1.033**	**1.033**	**1.033**	**1.033**	**1.033**	**1.033**	**1.033**	**1.031**	**1.033**	1.024
	(1.94)	*(2.01)*	*(2.05)*	*(2.07)*	*(2.07)*	*(2.07)*	*(2.07)*	*(2.07)*	*(2.08)*	*(2.08)*	*(2.08)*	*(2.08)*	*(2.08)*	*(2.07)*	*(2.08)*	*(2.06)*	*(1.99)*	*(1.99)*	*(1.61)*
DETRENDED GDP$_{t-1}$	**0.950**	**0.951**	**0.952**	**0.952**	**0.952**	**0.952**	**0.952**	**0.952**	**0.952**	**0.952**	**0.951**	**0.951**	**0.951**	**0.951**	**0.950**	**0.949**	**0.950**	**0.950**	**0.971**
	(1.92)	*(1.90)*	*(1.88)*	*(1.87)*	*(1.87)*	*(1.88)*	*(1.88)*	*(1.88)*	*(1.88)*	*(1.88)*	*(1.88)*	*(1.88)*	*(1.89)*	*(1.88)*	*(1.90)*	*(1.93)*	*(1.88)*	*(1.88)*	*(1.90)*
MONPOL$_{t-1}$	2.030	2.190	2.250	**2.273**	**2.273**	**2.273**	**2.273**	**2.273**	**2.275**	**2.275**	**2.275**	**2.275**	**2.280**	**2.335**	**2.342**	**2.382**	**2.421**	**2.467**	2.312
	(1.31)	*(1.56)*	*(1.64)*	*(1.68)*	*(1.68)*	*(1.68)*	*(1.68)*	*(1.69)*	*(1.69)*	*(1.69)*	*(1.69)*	*(1.69)*	*(1.70)*	*(1.74)*	*(1.74)*	*(1.77)*	*(1.75)*	*(1.77)*	*(1.62)*
MKTRETURN$_{t-1}$	0.796	0.775	0.774	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.766	0.766	0.768	0.764	0.756	0.810
	(0.73)	*(0.83)*	*(0.81)*	*(0.84)*	*(0.84)*	*(0.84)*	*(0.84)*	*(0.84)*	*(0.84)*	*(0.84)*	*(0.84)*	*(0.84)*	*(0.84)*	*(0.84)*	*(0.84)*	*(0.83)*	*(0.82)*	*(0.85)*	*(0.67)*
Constant	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
	(1.77)	*(2.05)*	*(2.15)*	*(2.19)*	*(2.19)*	*(2.19)*	*(2.19)*	*(2.20)*	*(2.20)*	*(2.20)*	*(2.20)*	*(2.20)*	*(2.21)*	*(2.25)*	*(2.26)*	*(2.29)*	*(2.26)*	*(2.27)*	*(2.04)*
Observations	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62

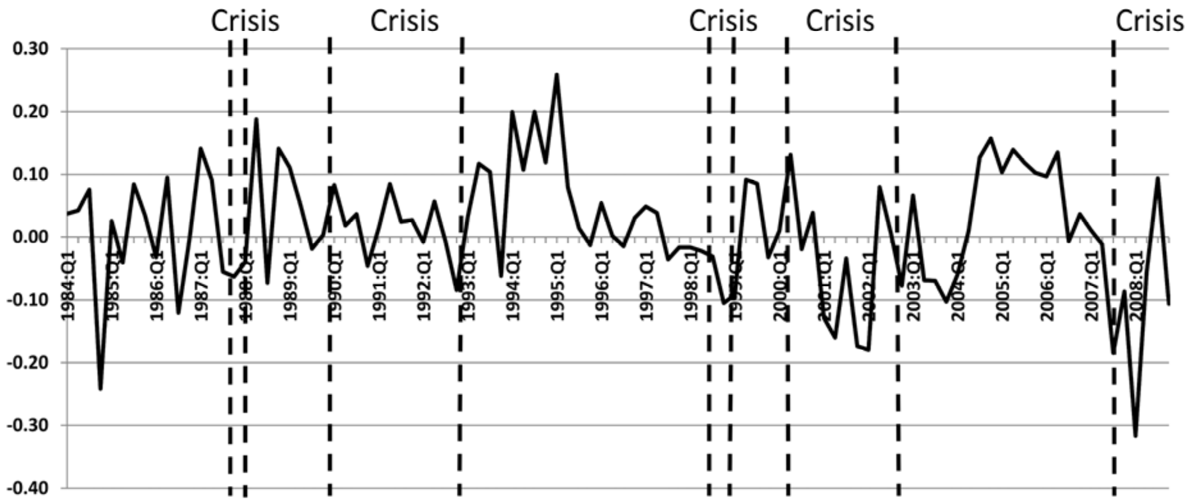
Panel I-B: Predicted probability of the occurrence of a crisis one quarter hence

	2002: Q4	2003: Q1	2003: Q2	2003: Q3	2003: Q4	2004: Q1	2004: Q2	2004: Q3	2004: Q4	2005: Q1	2005: Q2	2005: Q3	2005: Q4	2006: Q1	2006: Q2	2006: Q3	2006: Q4	2007: Q1	2007: Q2
PREDICTED PROBABILITY OF A CRISIS ONE QUARTER HENCE	10.0%	3.2%	0.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	5.3%	0.4%	5.5%	24.2%	5.6%	90.4%	33.2%

Figure 1: Changes in monetary policy

This figure shows the change in monetary policy over the sample period using two measures: the Romer and Romer monetary policy shocks (Panel A) and the change in the federal funds rate (Panel B). Each panel also shows the five financial crises studied in this paper (marked with dotted lines) – the 1987 stock market crash, the credit crunch of the early 1990s, the Russian debt crisis plus LTCM bailout in 1998, the bursting of the dot.com bubble plus Sept. 11, and the current subprime lending crisis.

Panel A: Romer and Romer monetary policy shocks (%)



Panel B: Change in the federal funds rate (%)

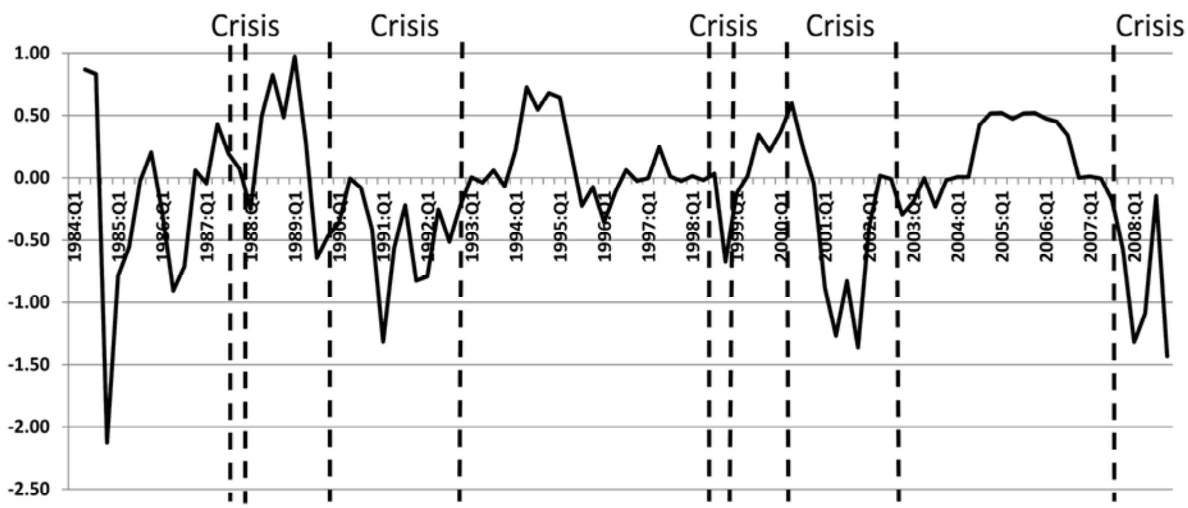
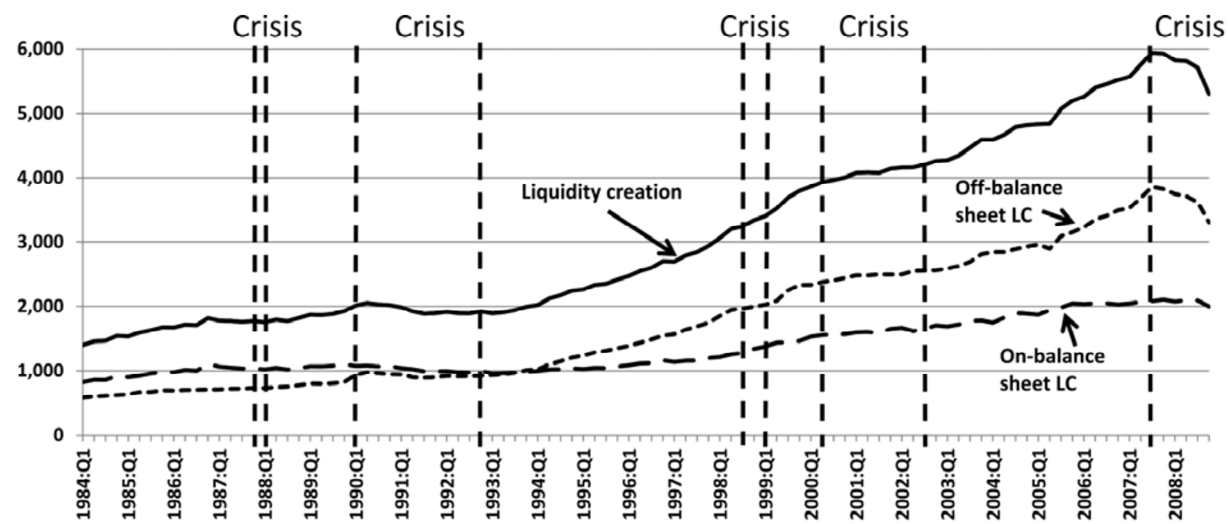


Figure 2: Liquidity creation over time

The sample includes virtually all commercial and credit card banks in the U.S. from 1984:Q1 – 2008:Q4. Panel A shows the dollar amount of liquidity created by the banking sector, calculated using Berger and Bouwman's (forthcoming) preferred liquidity creation measure, and on- versus off-balance sheet liquidity creation (LC). Panel A also shows the five financial crises studied in this paper (marked with dotted lines) – the 1987 stock market crash, the credit crunch of the early 1990s, the Russian debt crisis plus LTCM bailout in 1998, the bursting of the dot.com bubble plus Sept. 11, and the current subprime lending crisis. Panel B contains the fraction of liquidity creation by small banks (GTA up to $1 billion), medium banks (GTA $1 billion–$3 billion), and large banks (GTA exceeding $3 billion). GTA equals total assets plus the allowance for loan and lease losses and the allocated transfer risk reserve (a reserve for certain foreign loans). All dollar values are expressed in 2008:Q4 dollars.

Panel A: Liquidity creation over the sample period (in $ billion)



Panel B: Fraction of liquidity created by large, medium and small banks over time

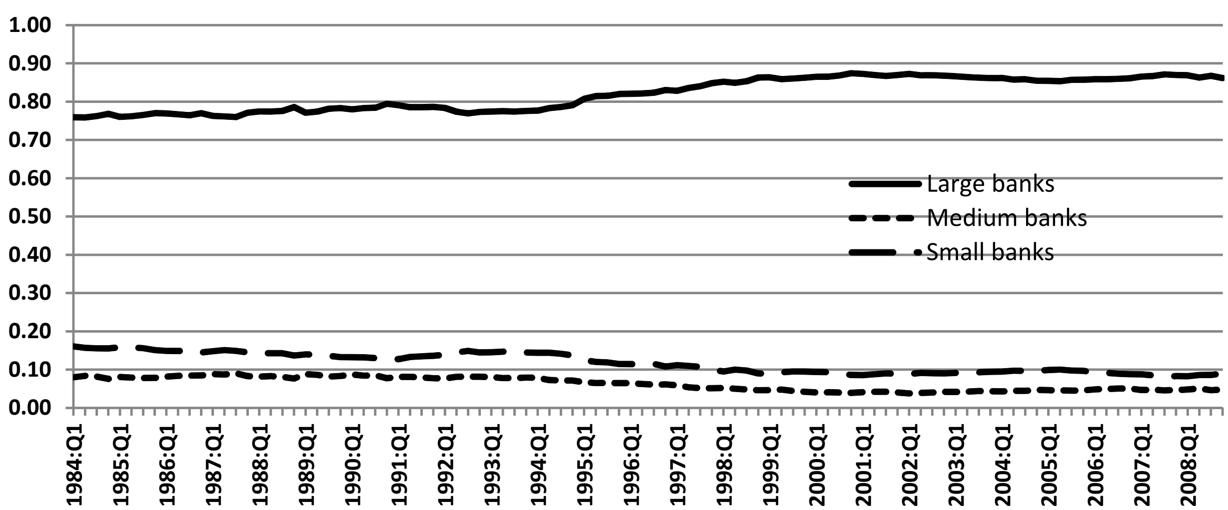
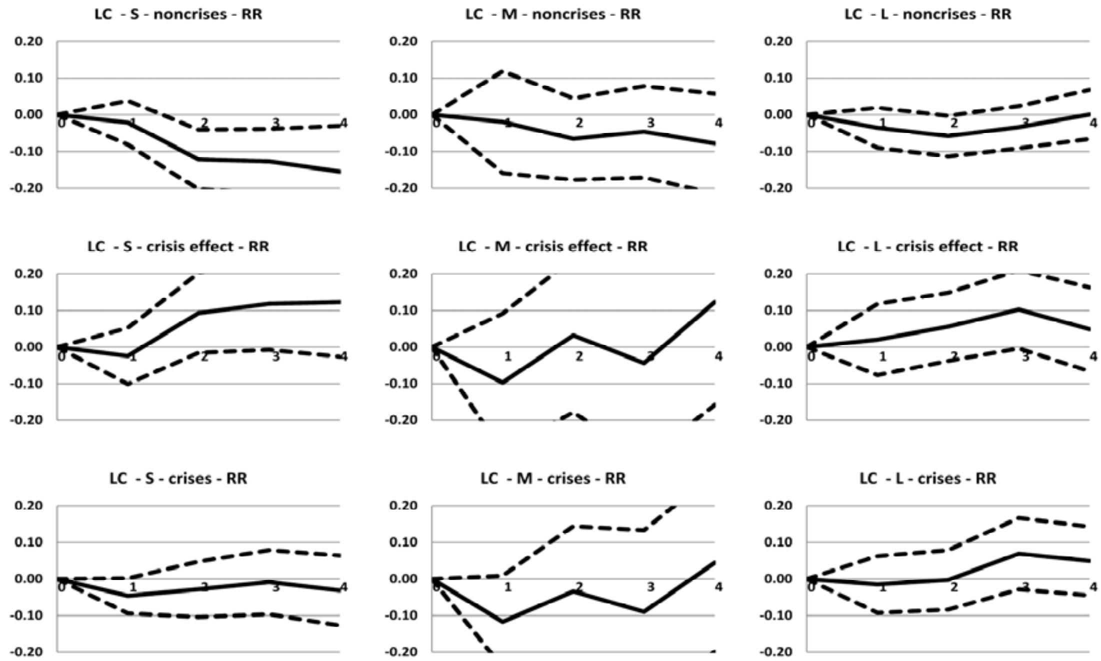


Figure 3: The effect of monetary policy on liquidity creation

This figure shows the implied response of bank liquidity creation (LC) to a one percentage point Romer and Romer monetary policy shock (RR - Panel A) and a one percentage point change in the federal funds rate (FF - Panel B), together with a 90% confidence band (±1.6 standard errors). In each panel, the top row shows the implied responses for small banks (S), medium banks (M), and large banks (L) during non-crises, i.e., normal times (based on the coefficients of the lagged monetary policy variables). This is used to test Hypothesis 1. The middle row shows the differential effect of monetary policy on liquidity creation during financial crises (based on the coefficients of the lagged monetary policy variables interacted with the lagged crisis dummies). This is used to test Hypothesis 2. For completeness, the bottom row shows the implied responses during crises (obtained by adding the top and middle rows).

Panel A: The effect of Romer and Romer monetary policy shocks (RR) on liquidity creation



Panel B: The effect of a change in the federal funds rate (FF) on liquidity creation

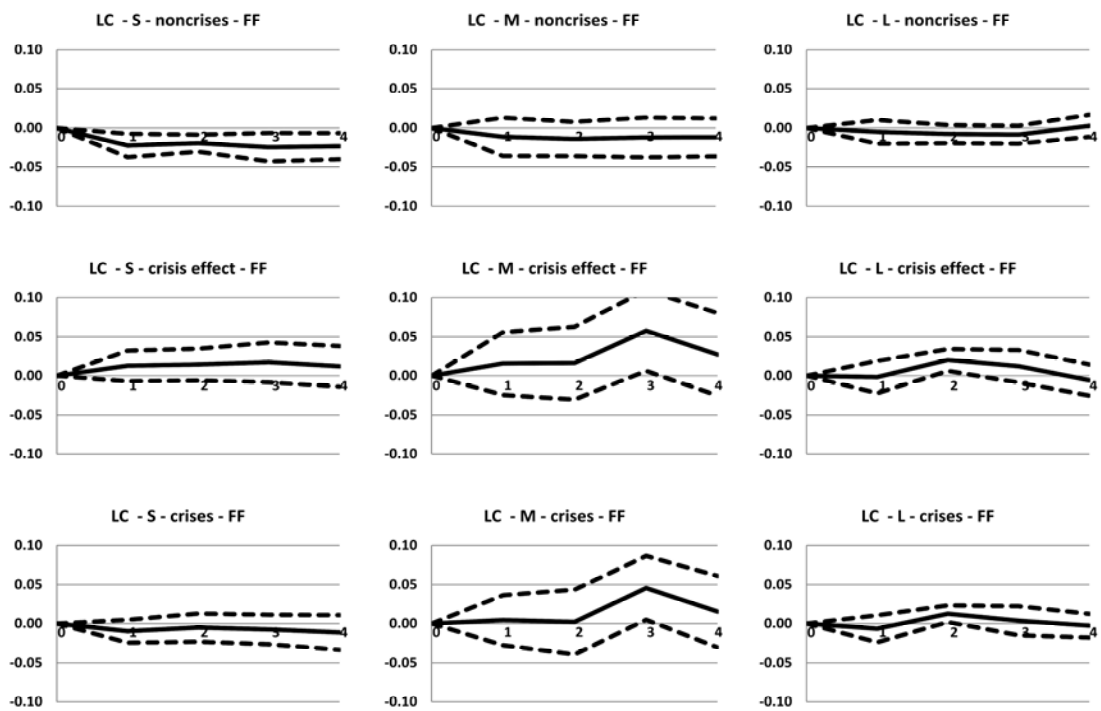
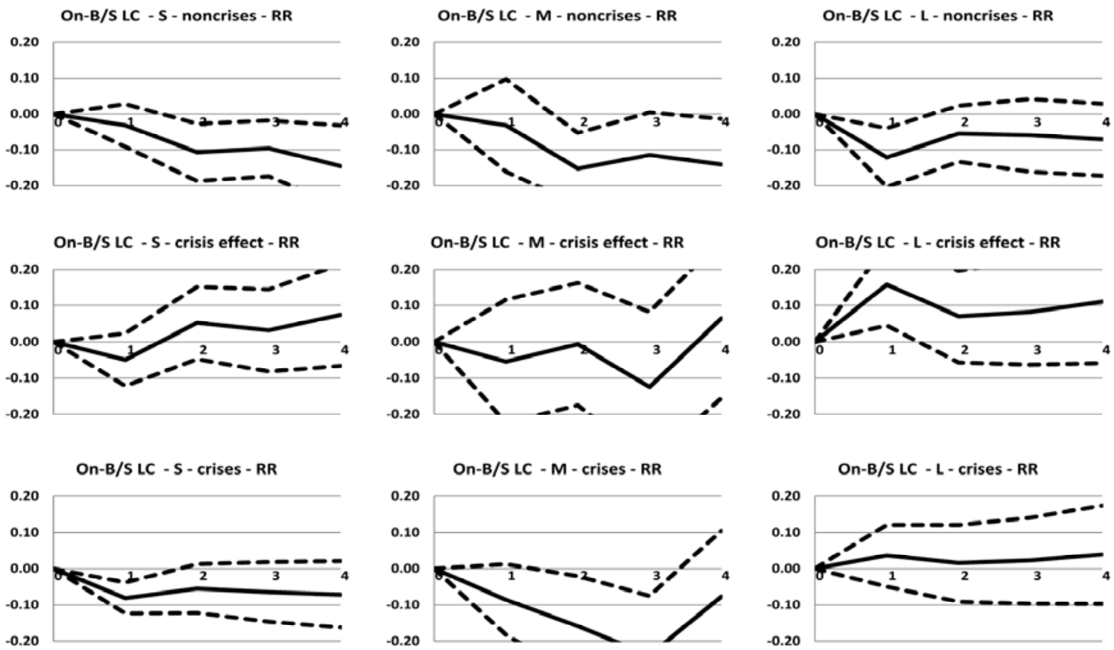


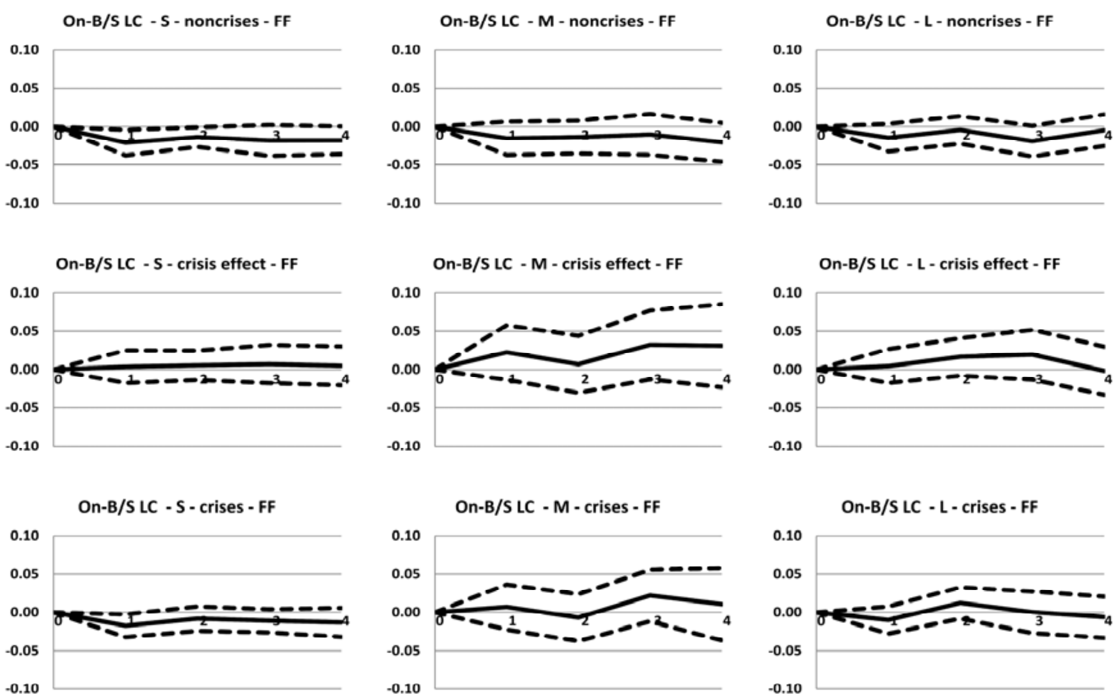
Figure 4: The effect of monetary policy on *on- and off-balance sheet liquidity* creation

This figure shows the implied response of on- and off-balance sheet liquidity creation (On-BS LC in Panel I and Off-BS LC in Panel II, respectively) to a one percentage point monetary policy shock (RR - Subpanel A) and a one percentage point change in the federal funds rate (FF - Subpanel B), together with a 90% confidence band (±1.6 standard errors). In each subpanel, the top row shows the implied responses for small banks (S), medium banks (M), and large banks (L) during non-crises, i.e., normal times (based on the coefficients of the lagged monetary policy variables). This is used to test Hypothesis 1. The middle row shows the differential effect of monetary policy on on- and off-balance sheet liquidity creation during financial crises (based on the coefficients of the lagged monetary policy variables interacted with the lagged crisis dummies). This is used to test Hypothesis 2. For completeness, the bottom row shows the implied responses during crises (obtained by adding the top and middle rows).

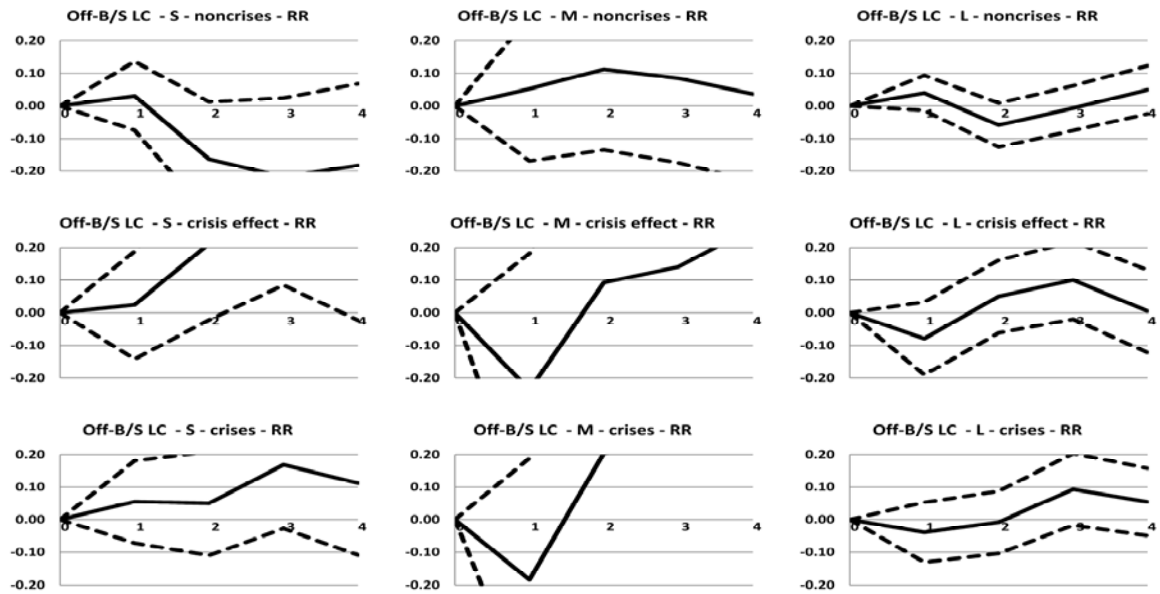
Panel I-A: The effect of Romer and Romer monetary policy shocks (RR) on *on-balance sheet liquidity* creation



Panel I-B: The effect of changes in the federal funds rate (FF) on *on-balance sheet liquidity* creation



Panel II-A: The effect of Romer and Romer monetary policy shocks (RR) on *off-balance sheet liquidity* creation



Panel II-B: The effect of changes in the federal funds rate (FF) on *off-balance sheet liquidity* creation

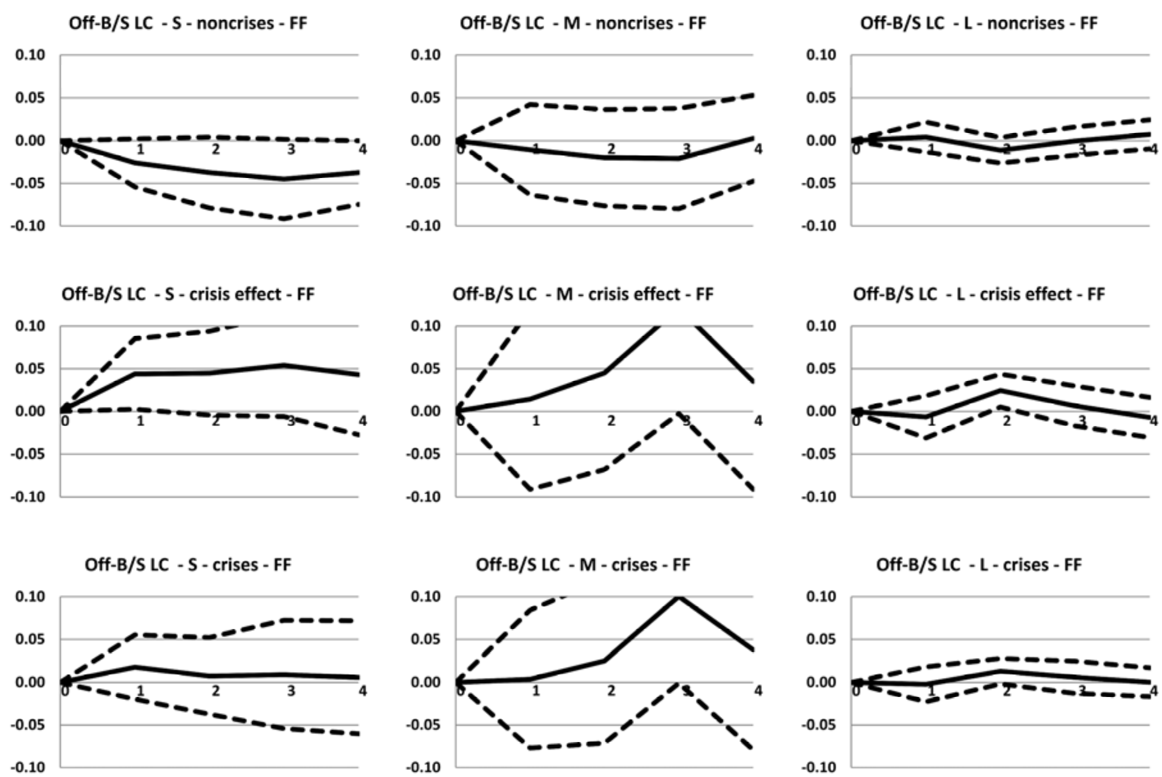
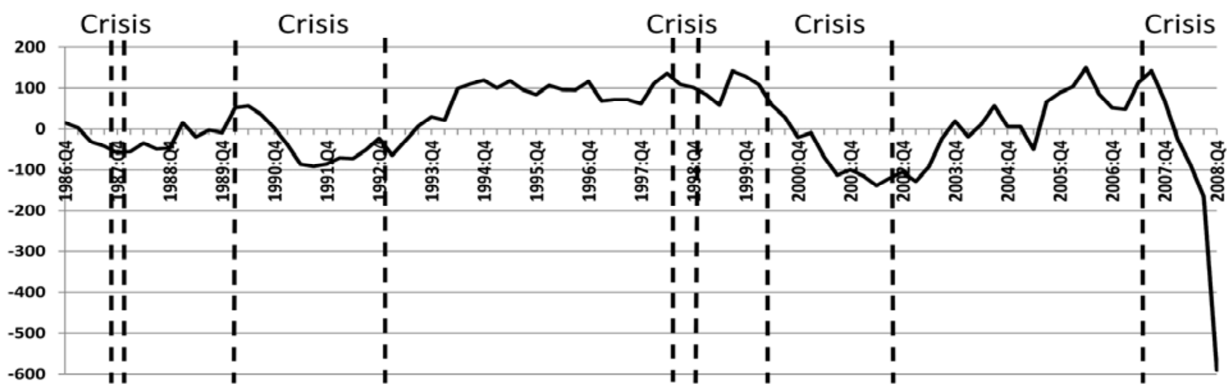


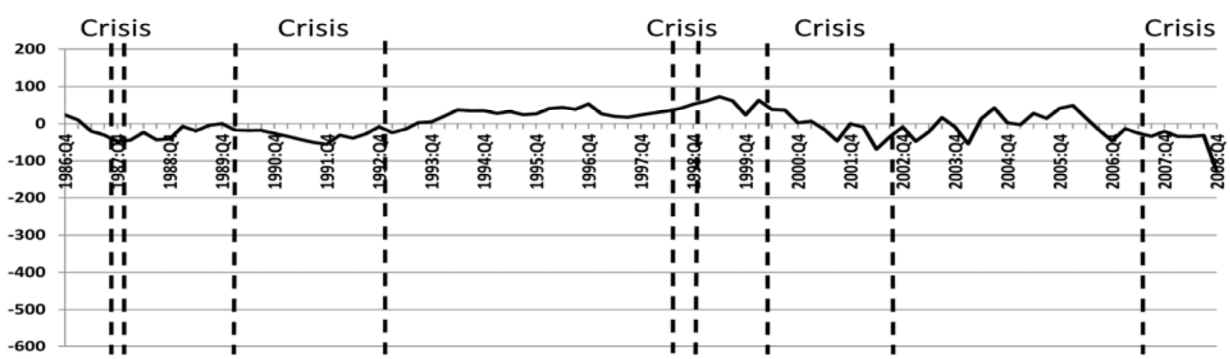
Figure 5: Detrended liquidity creation over the sample period

This figure shows the total amount of detrended liquidity created by the banking sector (Panel A) and its on- and off-balance sheet components (Panels B and C, respectively). The data is first deseasonalized using the X11 procedure developed by the U.S. Census Bureau, and then detrended using the Hodrick-Prescott (1997) (HP) filter. To ensure that the detrended amounts are purely based on historical data, we do the following. Since the HP filter requires that at least twelve quarterly observations are used, we first detrend the initial twelve quarters in the sample period (1984:Q1-1986:Q4). We drop the first eleven quarterly detrended amounts since they are in part based on forward-looking data. Thus, the first detrended amount in our sample is from the twelfth quarter, 1986:Q4. To obtain the detrended amount in the next quarter, we use data from 1984:Q1-1987:Q1 in our detrending process and only keep the result for 1987:Q1. We follow a similar procedure for every subsequent quarter and end up with a detrended liquidity creation series from 1986:Q4 – 2008:Q4 that is based on historical data in every quarter. All dollar values are expressed in real 2008:Q4 dollars. Each panel also shows the five financial crises studied in this paper (marked with dotted lines) – the 1987 stock market crash, the credit crunch of the early 1990s, the Russian debt crisis plus LTCM bailout in 1998, the bursting of the dot.com bubble plus Sept. 11, and the current subprime lending crisis.

Panel A: Detrended liquidity creation over time (*in $ billion*)



Panel B: Detrended *on-balance sheet liquidity* creation over time (*in $ billion*)



Panel C: Detrended *off-balance sheet liquidity* creation over time (*in $ billion*)