Bank Liquidity Creation, Monetary Policy, and Financial Crises

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Monetary policy efficacy depends largely on how it affects bank behavior. Recent events have cast doubt on how well monetary policy works in this regard, particularly during financial crises. Questions have also been raised about the role of banks in creating asset bubbles that burst and lead to crises. We address these issues by focusing on bank liquidity creation, a comprehensive measure of bank output that accounts for all on- and off-balance sheet activities. We find that: (1) during normal times, monetary policy affects liquidity creation only for small banks; (2) monetary policy effects are weaker for banks of all sizes during financial crises; (3) high liquidity creation (relative to trend) helps predict future crises after controlling for other 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., Holmstrom and Tirole 1998, Kashyap, Rajan, and Stein 2002).[2] Bank liquidity creation is important for the macroeconomy (e.g., Bernanke 1983, Dell'Ariccia, Detragiache, and Rajan 2008), and its prominence is typically heightened during financial crises (e.g., Acharya, Shin, and Yorulmazer 2009). For example, in the recent subprime lending crisis, liquidity seemed to dry up for a time, with severe consequences for the real sector.

To ameliorate liquidity concerns and to stimulate the economy, 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 extend more loans or – more generally – create more liquidity, something that 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.

The existing literature provides some evidence on the effect of monetary policy on banks' on-balance sheet activities during normal times. The bank lending channel literature finds monetary policy to be effective for small banks that lack significant access to non-deposit sources of funds, but less so for large banks (Kashyap and Stein, 2000). The effect of monetary policy on banks' on-balance sheet activities during financial crises has not been investigated, nor has the effect on off-balance sheet activities during either normal times or financial crises.

A further intriguing possibility is raised by the fact that bank liquidity creation and the

[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.

probability of the occurrence of a crisis may not be unrelated. Two papers have touched upon this issue in the context of on-balance sheet liquidity creation. Diamond and Rajan (2001) suggest that fragility is needed to create liquidity, which suggests that failures of individually fragile banks are more likely to occur precisely when these banks are creating high amounts of liquidity. Acharya and Naqvi (2012) argue that banks that create substantial liquidity may also pursue lending policies that generate asset price bubbles and thereby increase the fragility of the banking sector. The argument extends in a somewhat different way to off-balance-sheet liquidity creation. Thakor (2005) shows that excessive risk-taking and greater bank liquidity creation may occur off the balance sheet during economic booms, as banks shy away from exercising material adverse change clauses due to reputational concerns during such times. While all these papers model risk and liquidity creation at the individual bank level, recent papers have shown that liquidity creation facilitated by fragility-inducing mechanisms like leverage may involve banks making correlated asset portfolio choices when leverage is high (Acharya, Mehran, and Thakor 2010, Farhi and Tirole forthcoming). Such correlated choices can induce systemic risk and increase the probability of a systemwide crisis. Brunnermeier, Gorton, and Krishnamurthy (forthcoming) argue that models that assess systemic risk should include liquidity build-ups in the financial sector.

To understand these issues more deeply, we address 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 on-balance sheet activities, 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 during financial crises, monetary policy would generate an effect that is different than during other times because banks may hoard loanable funds and be less responsive to incentives to lend during financial crises (Diamond and Rajan 2011, Caballero and Simsek 2013). 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 follows directly from our earlier discussion of the posited theoretical link between fragility and liquidity creation at the bank and systemwide level.

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: 1) the 1987 stock market crash; 2) the credit crunch of the early 1990s; 3) the Russian debt crisis plus the Long-Term Capital Management meltdown in 1998; 4) the bursting of the dot.com bubble plus the September 11 terrorist attack of the early 2000s; and 5) the subprime lending crisis of the late 2000s. Our main analyses consider these crises collectively. A key strength of our approach is that we try to generalize across crises so that our results might be more predictive of the effects of monetary policy during future crises, the type of which is unknowable in advance. However, recognizing that differences across these crises exist, we also split them into crises that originated in the banking sector (2 and 5 above) and crises that originated in the financial market (1, 3, and 4), and find the results to be robust.

To examine the effect of monetary policy on liquidity creation, we use both a vector autoregression (VAR) model and a single-equation approach in the spirit of Romer and Romer (2004). The VAR model may be more appropriate if monetary policy responds significantly to bank liquidity creation, while the single-equation approach may be more suitable if monetary policy is essentially exogenous to bank liquidity creation. To account for both possibilities, we run the model both ways. As shown below, we obtain qualitatively similar results using both approaches.[3]

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

[3] This seems to be in line with the literature. For example, Romer and Romer (2004) also obtain comparable results using single-equation and VAR approaches.

developed in Romer and Romer (2004) takes such endogeneity into account.

The amount of liquidity created by the banking sector is calculated using Berger and Bouwman's (2009) preferred liquidity creation measure, which has been subsequently used in a number of studies (e.g., Distinguin, Roulet, and Tarazi, 2013; Horvath, Seidler, and Weill, 2014). We verify that similar results are obtained using an alternative liquidity creation measure that takes into account changes in banks' ability to securitize over time. 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 also split into liquidity created on versus off the balance sheet.

Our main findings, which generally support our hypotheses, are as follows. First, during normal times, monetary policy loosening (tightening) is associated with a statistically significant increase (decrease) in liquidity creation by small banks, driven largely by the impact on on-balance sheet liquidity creation, although this effect is economically small. Monetary policy does not seem to have a significant effect on total liquidity creation by medium and large banks, which create roughly 90% of aggregate bank liquidity, although the effects on- and off-balance sheet liquidity creation by these banks are sometimes significant. Our stronger results for small banks is consistent with the literature that uses bank lending rather than bank liquidity creation (e.g., Kashyap and Stein 2000).

Second, the efficacy of monetary policy declines during financial crises. For banks of all sizes, the effect of monetary policy is statistically significantly weaker relative to its intent during financial crises than during normal times and this is economically significant for large banks. These results are driven by the response of both on- and off-balance sheet liquidity creation to monetary policy.

Third, financial crises are preceded by levels of liquidity creation that tend to be high relative to a time trend, suggesting that abnormally high liquidity creation may be a harbinger of a crisis. We find the level of detrended liquidity creation to have incremental explanatory power in

[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.

predicting crises even after controlling for other macroeconomic factors such as GDP growth, monetary policy, and stock market returns. These results are driven primarily by off-balance sheet liquidity creation.

The remainder of this paper is organized as follows. Section 2 develops the hypotheses. Section 3 briefly describes the five financial crises,[5] 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. To motivate our hypotheses, we discuss demand-side and supply-side channels. Our data do not allow us to distinguish between these two channels. Fortunately, to test our hypotheses it is not important to disentangle the two effects -- it is sufficient to examine the net effect of monetary policy on liquidity creation.

2.1. Hypothesis related to the first question

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

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

On-balance sheet liquidity creation: MPL is expected to increase on-balance sheet liquidity creation through the bank lending channel by increasing both deposits and loans (see survey

[5] These crises are described in more detail in an Appendix.

papers by Bernanke and Gertler 1995, Kashyap and Stein 1997). To elaborate, MPL is expected to expand bank reserves, which may cause an increase in bank deposits. This may expand the loanable funds available and/or decrease the cost of funds by replacing higher-cost sources such as federal funds or large CDs with cheaper deposits (e.g., Bernanke and Blinder 1992, Stein 1998). Banks may respond by lending more, including granting credit to some loan applicants that might otherwise be rationed (e.g., Stiglitz and Weiss 1981).[6] The effect is expected to be greater for small banks because they have less access to non-deposit sources of funds (Kashyap and Stein 2000).

Off-balance sheet liquidity creation: The effect of MPL on off-balance sheet liquidity creation is ambiguous for banks of all size classes. On the one hand, customers who obtain more credit in the spot market may reduce their demand for loan commitments and other off-balance sheet guarantees (Thakor 2005). On the other hand, banks may supply more guarantees in reaction to MPL because of the greater availability of loanable funds and/or a reduction in the cost of these funds.[7] It is unclear ex ante which effect dominates.

Total liquidity creation: The effect of MPL on total liquidity creation by small banks is hypothesized to be positive. The positive effect of MPL on on-balance sheet liquidity creation is expected to dominate the ambiguous effect on off-balance sheet liquidity creation because these banks create the vast majority of their liquidity on the balance sheet (see Berger and Bouwman 2009). In contrast, medium and large banks create sizeable fractions of their liquidity off the balance sheet. Therefore, the ambiguous effect on off-balance sheet liquidity creation may dominate the positive effect on on-balance sheet liquidity creation, causing the effect of MPL on total liquidity creation by medium and 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) on-balance sheet liquidity creation; (b) off-balance sheet liquidity creation; and (c) total liquidity creation.

[6] Additionally, a decrease in market interest rates caused by MPL increases the present value of fixed-rate loans in a bank's portfolio, which improves the bank's net worth, thereby also enhancing bank credit supply.

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

Motivation: Monetary policy will affect on- and off-balance sheet liquidity creation differently during crises. Again, we 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 during crises banks may hoard loanable funds and be less responsive to incentives to lend. This could cause banks to not be willing to deploy the additional liquidity made available by MPL to increase lending very much. Problems of asymmetric information also typically become more acute during crises and the possibility of asset markets freezing up can also make banks more averse to taking positions in some assets or engaging in interbank lending that, in turn, could have enabled other banks to make loans (Diamond and Rajan 2011, Caballero and Simsek 2013).

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. At the same time, the supply of such guarantees may go up since banks have more access to funds at possibly cheaper rates. Thus, MPL results in an ambiguous overall effect during normal times, as discussed above. During crises, the reduction in demand for these off-balance sheet guarantees due to MPL is smaller because there is more rationing in the spot market due to greater asymmetric information and moral hazard frictions (Stiglitz and Weiss 1981), so some borrowers who would have gone to the spot market shift instead to loan commitments (Thakor 2005). Similarly, banks may increase the supply of these guarantees less in response to MPL during crises because they are less responsive to changes in loanable funds and the cost of funding during crises. Consequently, since MPL is predicted to have an ambiguous effect on off-balance sheet liquidity creation during normal times, it will have a smaller positive effect or a stronger negative effect during crises. For ease of exposition, we refer to this as a weaker effect (smaller movement in the intended direction).

Total liquidity creation: The effect of MPL 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 trend) liquidity creation is accompanied by a high likelihood of occurrence of a crisis.

Motivation: Diamond and Rajan (2001) argue that banks need to be highly levered and hence fragile to create liquidity. It is also intuitive that an excessive build-up of liquidity may itself be the precursor to a crisis, independent of bank leverage. Acharya and Naqvi (2012) provide a theoretical argument that formalizes this intuition. 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 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 leads to future bank failures. While these papers deal with on-balance-sheet liquidity creation, Thakor (2005) shows that banks may engage in excessive liquidity creation off the balance sheet. Specifically, reputational concerns will cause banks to shy away from exercising the material adverse change clause in loan commitment contracts during economic booms. This results in excessive risk taking and greater bank liquidity creation during such times. Thus, these papers collectively suggest that an increased supply of (on- and off-balance sheet) liquidity creation by banks in a given period may increase the probability of bank failures. When we additionally consider the finding that bank liquidity creation induced by high leverage may be associated with correlated asset portfolio and leverage choices in the sense that banks tend to become highly levered together and tend to cluster their portfolio choices (e.g., Acharya, Mehran, and Thakor 2010, Farhi and Tirole forthcoming), a link emerges between liquidity creation and the likelihood of a systemic financial crisis in a subsequent period. Some empirical evidence that the abundant availability of liquidity prior to the recent crisis may have contributed to the crisis by inducing banks to lower their credit standards has recently been provided by Keys, Mukherjee, Seru, and Vig (2010) and Dell'Ariccia, Igan, and Laeven (2012).

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, the change in the federal funds rate and Romer and Romer's monetary policy shocks, 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 subprime lending crisis of the late 2000s. The Appendix describes these crises in detail.[8]

We stop the data in 2008:Q4 because this marked the end of the monetary policy regime in which the Federal Reserve changed the federal funds rate as its main policy instrument. Afterwards, monetary policy was dominated by quantitative easing and other measures.

Our main analysis aggregates the data across these five crises. Recognizing that crises are heterogeneous, as a robustness check, we also split the data into banking crises versus market crises based on whether a crisis originated in the banking sector or in the financial market.[9] 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 change in the federal funds rate and the monetary policy shocks developed by Romer and Romer (2004).

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.[10] 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

[8] We limit ourselves to these five major crises because inclusion of minor crises would only dilute the results.
[9] See Section 4.4.
[10] 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.

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 (2013) extend the data through 2008:Q2, and Crowe provides a further extension to 2008:Q4.[11]

Figure 1 shows the change in the federal funds rate (*Panel A*) and the Romer and Romer monetary policy shocks (*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 rate, and in 58% of these quarters based on the Romer and Romer (2004) policy shocks. The reason why the fractions are 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 be based on the Federal Reserve's internal forecasts of inflation and growth. Conversely, an increase in the federal funds rate will always be recorded as MPT based on the change in the federal funds measure, but will be recorded as MPL based on the Romer and Romer policy shock measure only if the increase was less than expected.

3.3. Bank liquidity creation: preferred and alternative measures

To construct a measure of liquidity creation, we follow Berger and Bouwman's (2009) three-step

[11] We are grateful to Christopher Crowe for making these data available to us. Note that a strength of Romer and Romer's original measure is that it controls for the Federal Reserve's own Greenbook forecasts. However, since Greenbook forecasts are released only with a five-year lag, Barakchian and Crowe (2013) substitute the consensus forecast available from the Blue Chip Economic Indicators for the Greenbook forecasts towards the end of the sample.

procedure which is shown in *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.[12] To obtain the dollar

[12] 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.

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 (2011), 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.

3.4. Sample description

We include virtually all commercial and credit card banks in the U.S. in our study.[13] For each bank, we obtain quarterly Call Report data from 1984:Q1 to 2008:Q4. As noted in Section 3.1, we stop the data in 2008:Q4 because the Federal Reserve changed its operating procedures. 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

[13] 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.

(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 these three sets of banks. Small banks have gross total assets (GTA) up to $1 billion, medium banks have GTA exceeding $1 billion and up to $3 billion, and large banks have GTA exceeding $3 billion. Small banks correspond to the usual definition of community banks and the $3 billion cutoff between medium and large banks results in approximately equal numbers of banks in those two size classes.

3.5. Bank liquidity creation summary statistics

Figure 2 Panel A shows the dollar amount of liquidity created by the banking sector over our sample period, calculated using the preferred liquidity creation measure.[14] 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, primarily due to growth in unused loan commitments.

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 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).

[14] The amounts differ slightly from those reported in Berger and Bouwman (2009) for two reasons. First, the sample here is somewhat broader (see footnote 11). Second, dollar values are expressed in 2008:Q4 (instead of 2003:Q4) dollars.

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) and 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).

4.1. Monetary policy and bank liquidity creation – methodology

To examine the effect of monetary policy on liquidity creation, we use both a vector autoregression (VAR) model (e.g., Cochrane 1998, Christiano, Eichenbaum, and Evans 1999, Stock and Watson 2001) and a single-equation approach in the spirit of Romer and Romer (2004). In the single-equation approach, lagged monetary policy may affect liquidity creation, but lagged liquidity creation does not influence monetary policy. This model may be most appropriate if monetary policy is essentially exogenous to liquidity creation. Most models in the literature assume that monetary policy responds to inflation and output, but not to bank activity directly. In the VAR model, monetary policy is allowed to respond to bank liquidity creation. The VAR model may be more appropriate if monetary policy responds significantly to aggregate bank liquidity creation. To account for both possibilities, we run the model both ways. As shown below, the results from both models yield essentially the same conclusions.[15]

4.1.1. Single-equation approach

Because it is simpler, we explain our single-equation approach first. Our single-equation approach includes four quarterly lagged values of all the variables.[16] 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:

$$\%\Delta LC_{X,t} = \alpha_0 + \sum_{i=1}^{4} \beta_i \, \Delta MONPOL_{t-i} + \sum_{j=1}^{4} \gamma_j \, \%\Delta LC_{X,t-j} + \sum_{k=1}^{4} \theta_k \, \Delta MONPOL_{t-k} * D\ CRIS_{t-k}$$

[15] This is in line with Romer and Romer (2004, p. 1079), who study the effect of a monetary policy shock on output (GDP) using a single-equation approach and a VAR model, and find the effect to be "broadly similar."

[16] In lag-order tests discussed below, we verify that four quarterly lags are sufficient.

$$+ \sum_{l=1}^{4} \delta_l \, D\ CRIS_{t-l} + \sum_{m=1}^{3} \lambda_m \, D\ SEASON_m \qquad (1)$$

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 the change in the federal funds rate ($\Delta FEDFUNDS_{t-i}$) and Romer and Romer's monetary policy shocks ($RR\ POLICYSHOCKS_{t-i}$). In both cases, a negative number reflects monetary policy loosening and a positive number indicates monetary policy tightening. $D\ CRIS_{t-l}$ is a crisis dummy that equals one if there was a crisis in quarter t-l and is zero otherwise. $\Delta MONPOL_{t-k} * D\ CRIS_{t-k}$ 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 ($\Delta MONPOL_{t-i}$) pick up the effect of monetary policy during normal times. Negative coefficients indicate that MPL increases bank liquidity creation, as loosening is indicated by negative values of $\Delta MONPOL_{t-i}$. The coefficients on the interaction terms ($\Delta MONPOL_{t-k} * D\ CRIS_{t-k}$) 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.

Note that even in this single-equation approach, the effects of monetary policy on liquidity creation over time are complicated because of the lags of liquidity creation in equation (1). For example, the predicted effect of a monetary policy shock two quarters ago on the percentage change in liquidity creation in the current quarter will have a direct effect through the coefficient of the second lag of $\Delta MONPOL$ plus a feedback effect through the effect on the first lag of $\%\Delta LC$, which also affects current $\%\Delta LC$. Thus, while the predicted effect of a monetary policy shock one quarter ago on liquidity creation in the current quarter during normal times (i.e., when lagged $D\ CRIS = 0$) is simply β_1, the predicted effect of $\Delta MONPOL_{t-2}$ on $\%\Delta LC_t$ is given by $\beta_2 + \beta_1\gamma_1$. Similarly, the one- and two-quarter impulse response functions when the lagged quarters are during financial crises (i.e., lagged $D\ CRIS = 1$) are $\beta_1 + \theta_1$ and $\beta_2 + \theta_2 + (\beta_1 + \theta_1)\gamma_1$, respectively. The differential crisis effects are simply the difference between the crisis and normal times effects,

θ_1 and $\theta_2 + \theta_1\gamma_1$, respectively.[17] In the interest of brevity, we follow the applied macroeconomic literature and simply show the impulse response functions and their confidence intervals in the figures below.[18]

4.1.2. VAR model

VAR models come in three varieties: reduced form, recursive, and structural (e.g., Stock and Watson 2001). We use a reduced-form VAR. In such a VAR, each variable is simply a linear function of its own past values, the past values of all other endogenous variables, possibly exogenous variables, and a serially uncorrelated error term. In our VAR, the percentage change in liquidity creation, the change in monetary policy, and the change in monetary policy interacted with the crisis dummies are treated as endogenous, while the crisis dummies and seasonal effects are viewed as exogenous.[19] We thus end up with the following three-equation VAR:

$$\%\Delta LC_{X,t} = \alpha_0^2 + \sum_{i=1}^{4} \beta_i^2\, \Delta MONPOL_{t-i} + \sum_{j=1}^{4} \gamma_j^2\, \%\Delta LC_{X,t-j} + \sum_{k=1}^{4} \theta_k^2\, \Delta MONPOL_{t-k} * D\ CRIS_{t-k} + \sum_{l=1}^{4} \delta_l^2\, D\ CRIS_{t-l} + \sum_{m=1}^{3} \lambda_m^2\, D\ SEASON_m \quad (2)$$

$$\Delta MONPOL_t = \alpha_0^3 + \sum_{i=1}^{4} \beta_i^3\, \Delta MONPOL_{t-i} + \sum_{j=1}^{4} \gamma_j^3\, \%\Delta LC_{X,t-j} + \sum_{k=1}^{4} \theta_k^3\, \Delta MONPOL_{t-k} * D\ CRIS_{t-k} + \sum_{l=1}^{4} \delta_l^3\, D\ CRIS_{t-l} + \sum_{m=1}^{3} \lambda_m^3\, D\ SEASON_m \quad (3)$$

$$\Delta MONPOL_t * D\ CRIS_t = \alpha_0^4 + \sum_{i=1}^{4} \beta_i^4\, \Delta MONPOL_{t-i} + \sum_{j=1}^{4} \gamma_j^4\, \%\Delta LC_{X,t-j} + \sum_{k=1}^{4} \theta_k^4\, \Delta MONPOL_{t-k} * D\ CRIS_{t-k} + \sum_{l=1}^{4} \delta_l^4\, D\ CRIS_{t-l} + \sum_{m=1}^{3} \lambda_m^4\, D\ SEASON_m \quad (4)$$

The variables are as explained above. Equation (2) replicates equation (1) from the single-equation approach, and equations (3) and (4) allow for lagged liquidity creation changes to affect monetary policy differently in normal times and financial crises, respectively. Again, in the interest of brevity, we will only show the impulse response functions and their confidence intervals in the figures below.[20]

Importantly, we use two lag-order selection criteria to assess whether four lags are

[17] Similarly, the third- and fourth-quarter impulse response functions during normal times are $\beta_3 + \beta_1\gamma_2 + (\beta_2 + \beta_1\gamma_1)\gamma_1$ and $\beta_4 + \beta_1\gamma_3 + (\beta_2 + \beta_1\gamma_1)\gamma_2 + (\beta_3 + \beta_1\gamma_2 + (\beta_2 + \beta_1\gamma_1)\gamma_1)\gamma_1$, respectively. As explained in the main text, the differential crisis effects can simply be found by replacing every β with θ in these equations.

[18] Tables with all the regression coefficients are available from the authors upon request.

[19] Our VAR is non-standard in that it includes monetary policy measures and monetary policy measures interacted with crisis dummies to pick up the differential crisis effect. We emphasize, however, that we also use a single-equation model which includes similar variables and yields similar results.

[20] Tables with all the regression coefficients are available from the authors upon request.

sufficient. The results suggest they are.[21]

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

Figures 3 and *4* show how monetary policy affects total liquidity creation using the VAR model and the single-equation approach, respectively. Specifically, both figures show the implied response of percentage changes in bank liquidity creation to a one percentage point change in the federal funds rate (*Panels A*) and a one percentage point Romer and Romer monetary policy shock (*Panels B*), together with 90% confidence intervals (±1.645 standard errors).[22] Each panel shows the results separately for the three size classes (small, medium, and large banks) – the top row focuses on normal times and the bottom row presents the differential crisis effect. Below, 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 (c) – the effect of monetary policy on total liquidity creation during normal times – we focus on the top row in *Figures 3* and *4*, *Panels A* and *B*. During normal times, using the VAR model, the estimated impulse responses of a change in the federal funds rate on total liquidity creation for small banks are negative and significant after one, two, and three quarters; they are also negative and significant after two quarters based on a Romer and Romer monetary policy shock. In contrast, the estimated impulse responses are not significant for medium and large banks. The results for normal times are similar using the single-equation approach.[23] This suggests that during normal times, monetary policy is effective in the intended direction in impacting liquidity creation by small banks, but not liquidity creation by medium and large banks. That is, after MPL (a decrease in the federal funds rate or a negative Romer and Romer shock) during normal times, only small banks create significantly more liquidity. This evidence is consistent with Hypothesis 1 Part (c), which predicts that during normal times, MPL

[21] Ivanov and Kilian (2005) show that "for quarterly VAR models, the Hannan-Quinn Criterion (HQC) appears to be the most accurate criterion with the exception of sample sizes smaller than 120, for which the Schwarz Information Criterion (SIC) is more accurate." Since all our VAR estimations include 95 quarterly observations, we used both. In all cases, they suggest that four lags are sufficient.

[22] Three confidence intervals are generally used in monetary policy papers that use a VAR setup: 95% (e.g., Christiano, Eichenbaum, and Evans 2005; Christiano and Vigfusson 2003), 90% (e.g., Bernanke, Boivin, and Eliasz 2005; Steinsson 2008), and 68% (e.g., Romer and Romer 2004; Stock and Watson 2001). At the 95% level, we find less significance than reported, while at the 68% level, we find more.

[23] One notable exception is that for large banks, the single-equation approach yields a small positive, significant effect for large banks after four quarters (based on a change in the federal funds rate), indicating that the effect of monetary policy might go in the opposite way of intentions for these banks during normal times.

will increase total liquidity creation by small banks, but will have an ambiguous effect on medium and large banks.

Our normal-times results are consistent with Kashyap and Stein (2000), who examine the effect of monetary policy on individual banks' lending. First, like us, they find that monetary policy affects small banks most. Second, they also find that (small) banks react within one to two quarters to changes in monetary policy, with the effect dying out shortly thereafter. It is interesting to note that monetary policy affects bank behavior far more quickly (if at all) than it affects GDP and other non-bank variables typically studied in the macro literature (e.g., Christiano, Eichenbaum and Evans 2005). The quick reaction of bank behavior to monetary policy of bank behavior to monetary policy is not surprising because changes in monetary policy directly affect banks' funding costs.

To test Hypothesis 2 Part (c), we examine the bottom row of *Figures 3* and *4, Panels A* and *B*, which shows the differential effect of monetary policy during financial crises. The hypothesis is that the effect of monetary policy is weaker during crises. That is, MPL is predicted to be followed by a smaller increase or a greater decrease in liquidity creation during crises than during normal times. This implies positive impulse responses (i.e., the lines in the pictures in the bottom row of *Figures 3* and *4*, *Panels A* and *B* should be above zero). These impulse responses are indeed generally positive for banks of all size classes. They are significant in at least one case for medium and large banks based on the VAR model, and in one case for small and large banks using the single-equation approach. This suggests that monetary policy is generally less effective during financial crises for banks of all sizes. This evidence is consistent with Hypothesis 2 Part (c).

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. For the sake of brevity, we focus on the VAR model. We discuss the small-bank results first. The statistically significant impulse responses of the change in the federal funds rate of -0.022, -0.016, and -0.013 after one to three quarters (top left picture in *Figure 3 Panel A*) suggest that if the federal funds rate decreases by one percentage point, the cumulative increase in liquidity creation by small banks is 2.2%, 1.6%, and 1.3% after one, two, and three quarters, respectively. Evaluated at the average dollar amount of liquidity created by small banks of $333 billion, this translates into a cumulative increase in liquidity creation of $7.49 billion, $5.43 billion, and $4.34 billion after one, two, and three quarters, respectively. Thus, while the effect of monetary policy on liquidity creation by small banks is statistically significant during normal times, the magnitudes are relatively small from an economic viewpoint. The differential crisis effect for small banks is positive in all cases using the federal funds rate but not statistically significant, so we do not evaluate its economic significance.

We next discuss the economic significance of the results for medium and large banks. For these banks, the effects of monetary policy are not significant during normal times. However, the differential crisis effect is positive and statistically significant in two cases: after three quarters for medium banks and after two quarters for large banks. As discussed above, a positive impulse response implies a weaker effect of monetary policy during a crisis. We now quantify this weaker effect. The respective impulse responses of 0.044 and 0.024 suggest that if the federal funds rate decreases by one percentage point during crises, the decrease in liquidity creation by these banks relative to normal times is 4.4% and 2.4%, 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 decrease in liquidity creation relative to normal times of $7.77 billion and $61.41 billion after three and two quarters, respectively. Thus, while we do not find overwhelming statistical significance for medium and large banks, the economic significance of the effect appears to be sizeable for large banks.

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

Figure 5 shows how monetary policy affects on-balance sheet liquidity creation (*Panel I*) and off-balance sheet liquidity creation (*Panel II*) using the VAR model. The results are similar using the single-equation approach, but are not shown for brevity's sake. *Figure 5* shows the implied responses of on- and off-balance sheet liquidity creation to a one percentage point change in the federal funds rate (*Subpanel A*) and a one percentage point Romer and Romer monetary policy shock (*Subpanel B*).

To examine how monetary policy affects on- and off-balance sheet liquidity creation during normal times (Hypothesis 1 Parts (a) and (b)), we focus on the top rows in *Figure 5 Panels I-A, I-B, II-A* and *II-B*. We first consider small banks. As discussed above, monetary policy is generally statistically significant for these banks during normal times. The results in *Figure 5* provide strong evidence that this is largely driven by the effect of monetary policy on on-balance sheet liquidity creation. Specifically, MPL increases on-balance sheet liquidity creation of small banks,[24] but generally does not have a significant effect on off-balance sheet liquidity creation of these banks.[25] 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 5* provide some evidence that MPL increases the on-balance sheet liquidity created by medium and large banks,[26] and off-balance sheet liquidity creation by large banks during normal times.[27] These results are consistent with Hypothesis 1 Parts (a) and (b), which states that MPL will increase 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 either or both on- and off-balance sheet liquidity creation during crises (Hypothesis 2 Parts (a) and (b)). Again, the hypothesis that the effect of monetary policy is weaker during crises predicts positive impulse responses (i.e., as before, the lines in the pictures in the bottom row of *Figure 5 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[28] and off-balance sheet liquidity creation[29] for both monetary policy measures for banks of all size classes. The results support Hypothesis 2 Parts (a) and (b) – 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.

4.4. Robustness check: banking crises versus market crises

As indicated above, a key strength of our approach is that we try to generalize across crises so that our results might be more predictive of the effects of monetary policy during future crises, the type

[24] Significance for several lags based on both monetary policy measures – see the top left pictures in *Figure 5 Panels I-A* and *I-B*.
[25] The effect is generally negative but never significant based on the federal funds rate and only significant after two quarters based on the Romer and Romer monetary policy shock measure – see the top left pictures in *Figure 5 Panels II-A* and *II-B*.
[26] 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 5 Panel I-A*.
[27] Significance after two quarters based on both monetary policy measures. See the top right pictures in *Figure 5 Panels II-A* and *II-B*.
[28] Significance after one quarter based on the Romer and Romer monetary policy shock measure for large banks – see the bottom right picture in *Figure 5 Panel I-B*.
[29] Significance after three quarters for medium banks and after two quarters for large banks based on the change in the federal funds rate – see the bottom middle and right pictures in *Figure 5 Panel II-A*.

of which is unknowable in advance. Nonetheless, our approach might obscure important information since the effect of monetary policy on liquidity creation may be different during banking crises versus market crises. So as a robustness check, we now split the five crises into banking crises (the credit crunch of the early 1990s and the subprime lending crisis of the late 2000s) 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.

The single-equation approach estimates the following model:

$$\begin{aligned}
\%\Delta LC_{X,t} &= \alpha_0^5 + \textstyle\sum_{i=1}^{4} \beta_i^5 \,\Delta MONPOL_{t-i} + \sum_{j=1}^{4} \gamma_j^5 \,\%\Delta LC_{X,t-j} \\
&\quad + \textstyle\sum_{n=1}^{4} \theta_n^5 \,\Delta MONPOL_{t-n} * D\ CRIS\ BANK_{t-n} + \sum_{p=1}^{4} \eta_p^5 \,\Delta MONPOL_{t-p} * D\ CRIS\ MKT_{t-p} \\
&\quad + \textstyle\sum_{q=1}^{4} \delta_q^5 \,D\ CRIS\ BANK_{t-q} + \sum_{r=1}^{4} \tau_r^5 \,D\ CRIS\ MKT_{t-r} \\
&\quad + \textstyle\sum_{m=1}^{3} \lambda_m^5 \,D\ SEASON_m \qquad (5)
\end{aligned}$$

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 lag dummies (four banking crisis lag dummies and four market crisis lag dummies), and eight interaction terms. For the VAR model, the first equation takes the same form as equation (5) and the other three equations have the current (time t) values of *ΔMONPOL, ΔMONPOL * D CRIS BANK,* and *ΔMONPOL * D CRIS MKT* and the same right-hand-side variables as equation (5). In the interest of brevity, we merely describe the results rather than showing figures with pictures of the impulse response functions. 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 liquidity creation. We now find that these results – especially for small and medium banks – seem to be driven by the weaker effects of monetary policy during *both* banking and market crises.[30] This indicates that aggregating across banking and market crises in our main analysis did not qualitatively affect our conclusions and validates our combining of both sets of crises.

[30] For large banks, the weaker effects tend to be manifested more during market 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.

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.[31] 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 would be based on historical data, the detrended amount in the first quarter would be 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.

[31] 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.

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 analyses 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 time period.

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

Figure 6 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 subprime lending crisis of the late 2000s.[32]

Figure 6 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 high liquidity creation (relative to trend) an indicator of an impending crisis? (Hypothesis 3)

We now formally examine whether abnormally high detrended liquidity creation presages a

[32] Detrended liquidity creation peaked in 2006:Q2, then dropped for three quarters afterward (until 2007:Q1). It rose dramatically in 2007:Q2. Importantly, as discussed in Section 5.3, the predictability of crises is driven by the level of detrended liquidity creation (which was high even after it dropped).

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. At this point in time, it is reasonable to assume that the start of the first four crises is generally known and thus could be used as historical data in a forecasting model. We therefore regress 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 subprime lending crisis of the late 2000s) 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.

Specifically, we estimate the following regression equations:[33]

$$\log\left(\frac{Prob(CRISIS_t)}{1-Prob(CRISIS_t)}\right) = \beta_0^6 + \beta_1^6 DETRENDED\ LC_{t-1} + \beta_2^6 DETRENDED\ GDP_{t-1} + \beta_3^6 MONPOL_{t-1} + \beta_4^6 MKTRETURN_{t-1} \quad (6)$$

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.[34]

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 liquidity creation is not increasing. For consistency, the other variables are expressed in levels as well.[35] 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 2 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 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 odds ratios of about 1.03 for $DETRENDED\ LC\ TOTAL_{t-1}$ in almost all the models suggest that a $1 billion increase in detrended liquidity creation increases the odds of a crisis occurring one quarter hence by about 3.0%. 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 a higher federal funds rate is associated with a higher probability of a

[33] 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).
[34] Regressions based on the equal-weighted CRSP index or the S&P 500 yield similar results.
[35] As an exception, we include market returns rather than the level of the stock market.

crisis occurring.[36] 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 2 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 probability of a crisis occurring in the next quarter was close to 25%. Two quarters before the subprime lending crisis started, the probability of a crisis striking had increased to over 90%, although this dropped to 33% the quarter before the crisis.[37]

These results clearly suggest that high total liquidity creation relative to trend presages a crisis. This supports Hypothesis 3. We also run two additional sets of 19 logit regressions based on detrended on- and off-balance sheet liquidity creation to examine whether our findings 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 and empirically tests hypotheses regarding the effect of monetary policy on bank liquidity creation during normal times, whether the effect is different during financial crises versus normal times, and whether the amount of liquidity created by the banking sector at any point in time can be a predictor 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, the change in the federal funds rate and Romer and Romer monetary policy shocks, are used in the analyses. Two models of the effects of monetary policy on liquidity creation (a single-equation approach and a VAR model) are estimated, and the results are broadly consistent between these models. We distinguish between banks based on size, since we anticipate that the effect of monetary policy on banks will be size-dependent. Our main findings are as follows.

[36] 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.
[37] This drop in the last quarter is driven primarily by an increase in detrended GDP.

First, during normal times, monetary policy has a statistically significant effect on liquidity creation by small banks in that a loosening (tightening) of monetary policy is associated with an increase (a reduction) in liquidity creation by these banks, but this effect is economically small. This result is primarily driven by the response of on-balance sheet liquidity creation to monetary policy. During normal times, monetary policy does not seem to have a significant effect on total liquidity creation by medium and large banks.

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

Third, liquidity creation tends to be high (relative to trend) prior to financial crises, pointing to the possibility that the amount of liquidity created by banks can be a predictor of an impending crisis. Its level has incremental explanatory power in predicting crises even after controlling for various other macroeconomic factors. These results are driven primarily by off-balance sheet liquidity creation.

Our results raise interesting questions for future research. For example, should policy makers consider instruments other than changing the federal funds rate to affect the behavior of medium and large banks, especially during financial crises? 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? These are difficult questions, but addressing them has great policy relevance.

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.[38] 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

[38] 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.

regardless of whether prices were rising or falling. When Russia defaulted on its sovereign debt on August 17, 1998, investors 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.coms 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.coms 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. The supply of liquidity by banks dried up, as did the provision of liquidity in the interbank market. Many banks experienced substantial losses in capital. Massive loan losses at Countrywide resulted in a takeover by Bank of America. Bear Stearns suffered a fatal loss of confidence among its financiers 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 substantial losses and depositors had started to run on the bank. The FDIC sold all deposits and most of the assets to OneWest Bank, FSB, and incurred an estimated loss of about $13 billion. The Federal Reserve also intervened in some unprecedented ways in the market (e.g., Gertler and Karadi 2011), including quantitative easing in which the Federal Reserve purchased long-term treasury securities and mortgages in an effort to push down long-term interest rates. It also extended its safety-net privileges to investment banks and one insurance company (AIG), and intervened in the commercial paper market. The Treasury initially set aside $250 billion out of its $700 billion bailout package (TARP program) to enhance capital ratios of selected banks. This included $10 billion and $25 billion increments to each of eight large banking organizations. Some of these banks used these funds to acquire lesser-capitalized peers. For example, PNC Bank used TARP funds to acquire National City Bank, and Bank of America bought Merrill Lynch. In all, the Treasury invested over $300 billion in over 700 financial institutions (as well as over $80 billion in the automobile industry). During 2009, 140 U.S. banks failed, and the FDIC Bank Insurance Fund fell into a deficit position. By the first quarter of 2010, much of the TARP funds invested in financial institutions had been repaid, order had been restored to most of the financial markets, and the Federal Reserve began rolling back expansions to the discount window and concluded term auction facility auctions.

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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: 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 subprime lending crisis of the late 2000s, 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

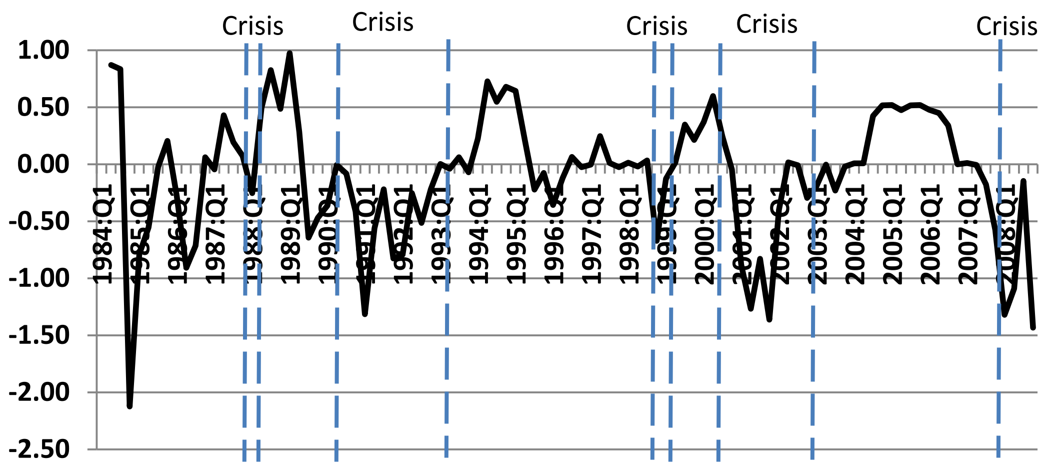
Panel B: Predicted probability of the occurrence of a crisis one quarter hence

	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 change in the federal funds rate (Panel A) and the Romer and Romer monetary policy shocks (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 subprime lending crisis of the late 2000s.

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



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

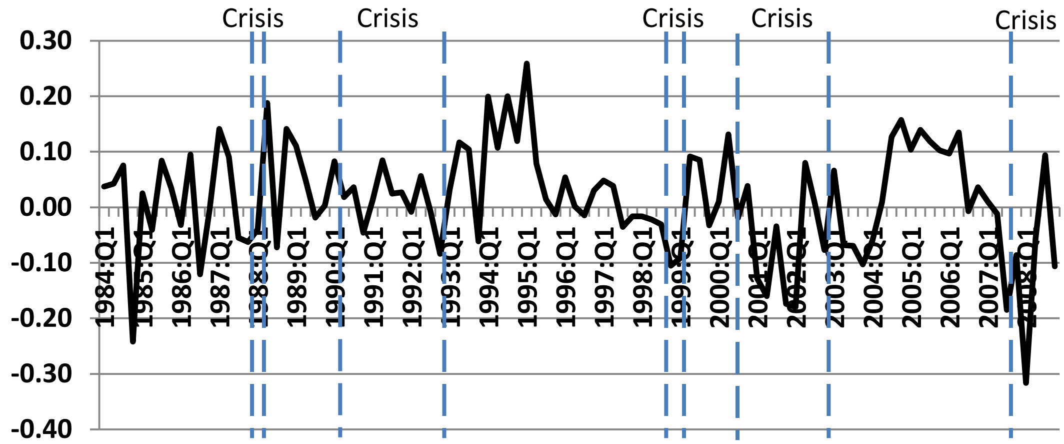
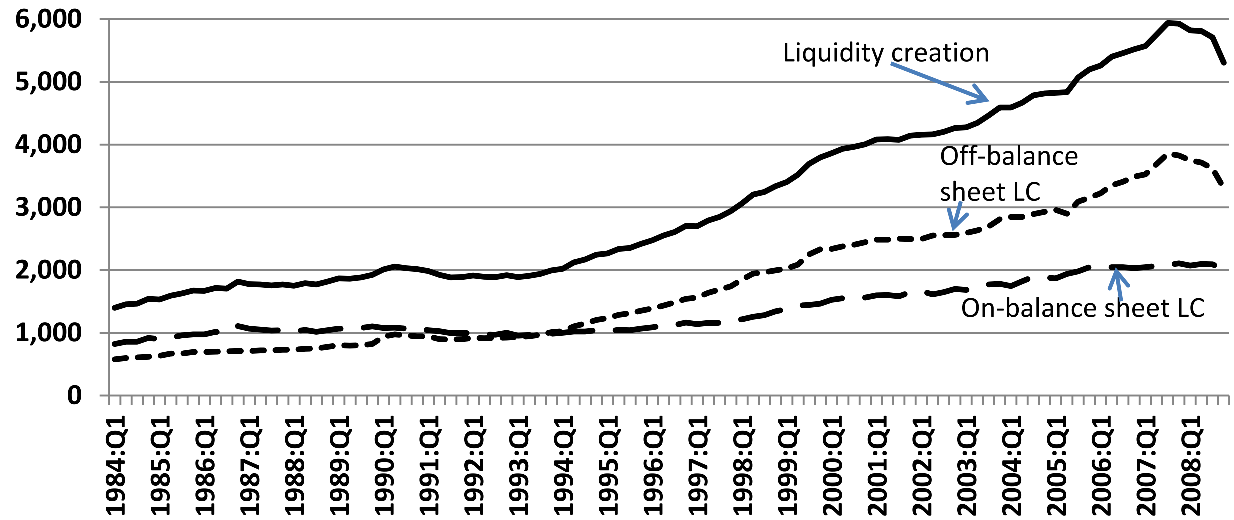


Figure 2: Liquidity creation over time

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 total liquidity created by the banking sector, calculated using Berger and Bouwman's (2009) preferred liquidity creation measure, as well as on- and off-balance sheet liquidity creation (LC). 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

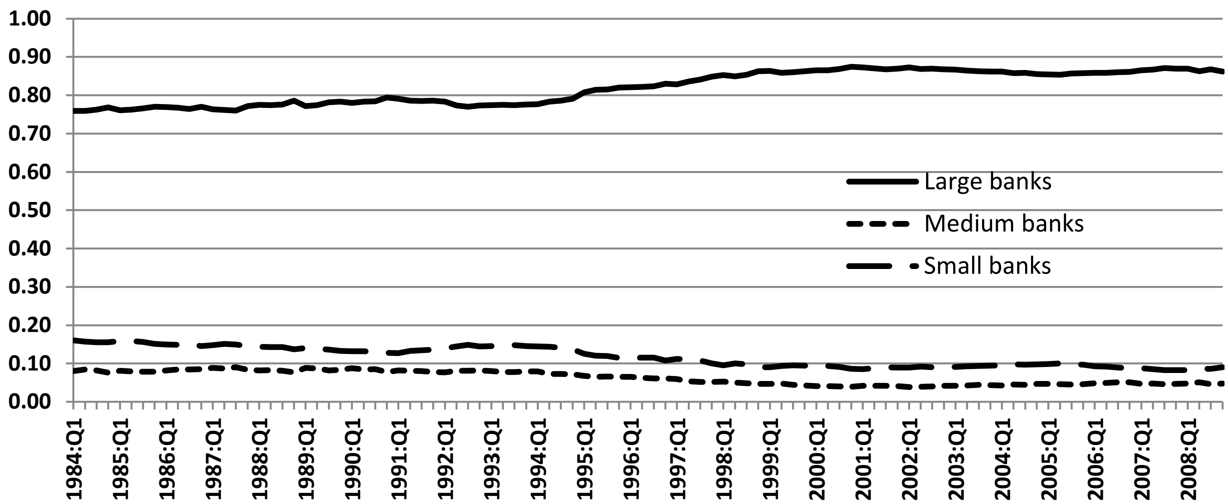
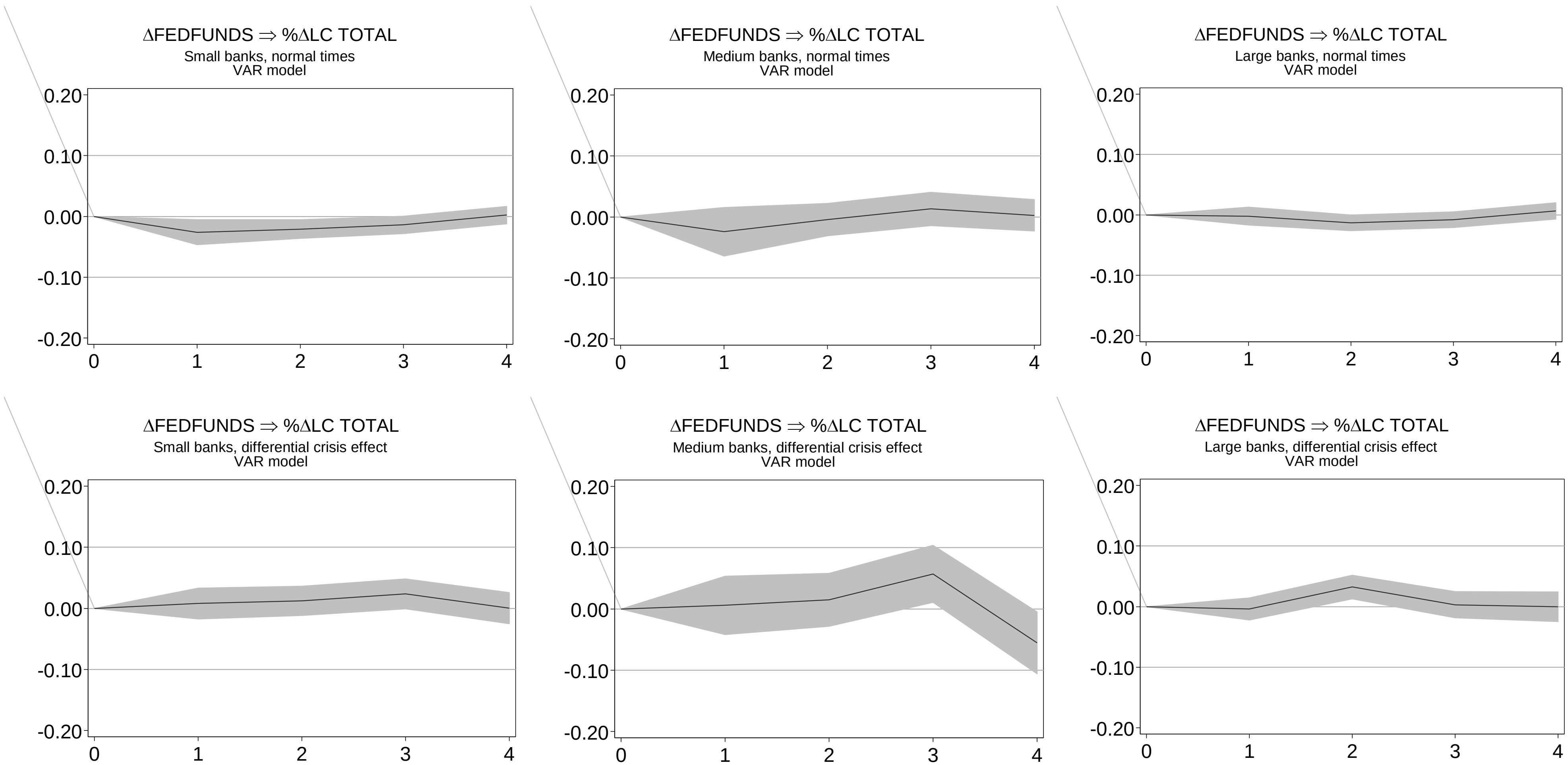


Figure 3: The effect of monetary policy on liquidity creation (VAR model)
This figure shows the impulse responses of bank liquidity creation (%ΔLC TOTAL) to a one percentage point change in the federal funds rate (ΔFEDFUNDS - Panel A) and a one percentage point Romer and Romer monetary policy shock (RR POLICYSHOCKS - Panel B), together with a 90% confidence band (±1.645 standard errors), using the vector autoregression (VAR) model. In each panel, the top row shows the impulse responses for small, medium, and large banks during normal times. This is used to test Hypothesis 1(c). The bottom row shows the differential effect of monetary policy on liquidity creation during financial crises. This is used to test Hypothesis 2(c).

Panel A: The effect of a change in the federal funds rate on liquidity creation (VAR model)



Panel B: The effect of Romer and Romer monetary policy shocks on liquidity creation (VAR model)

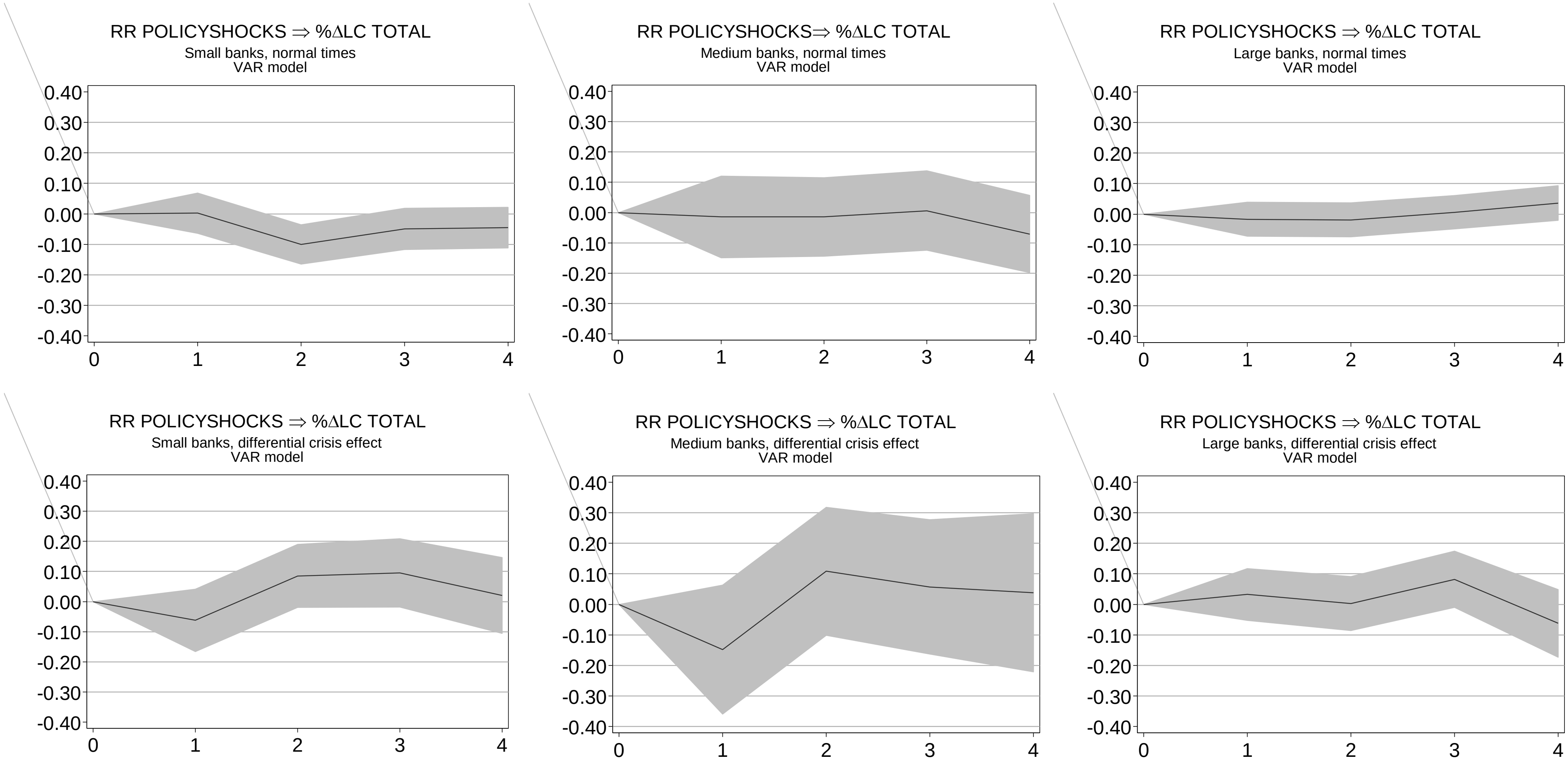
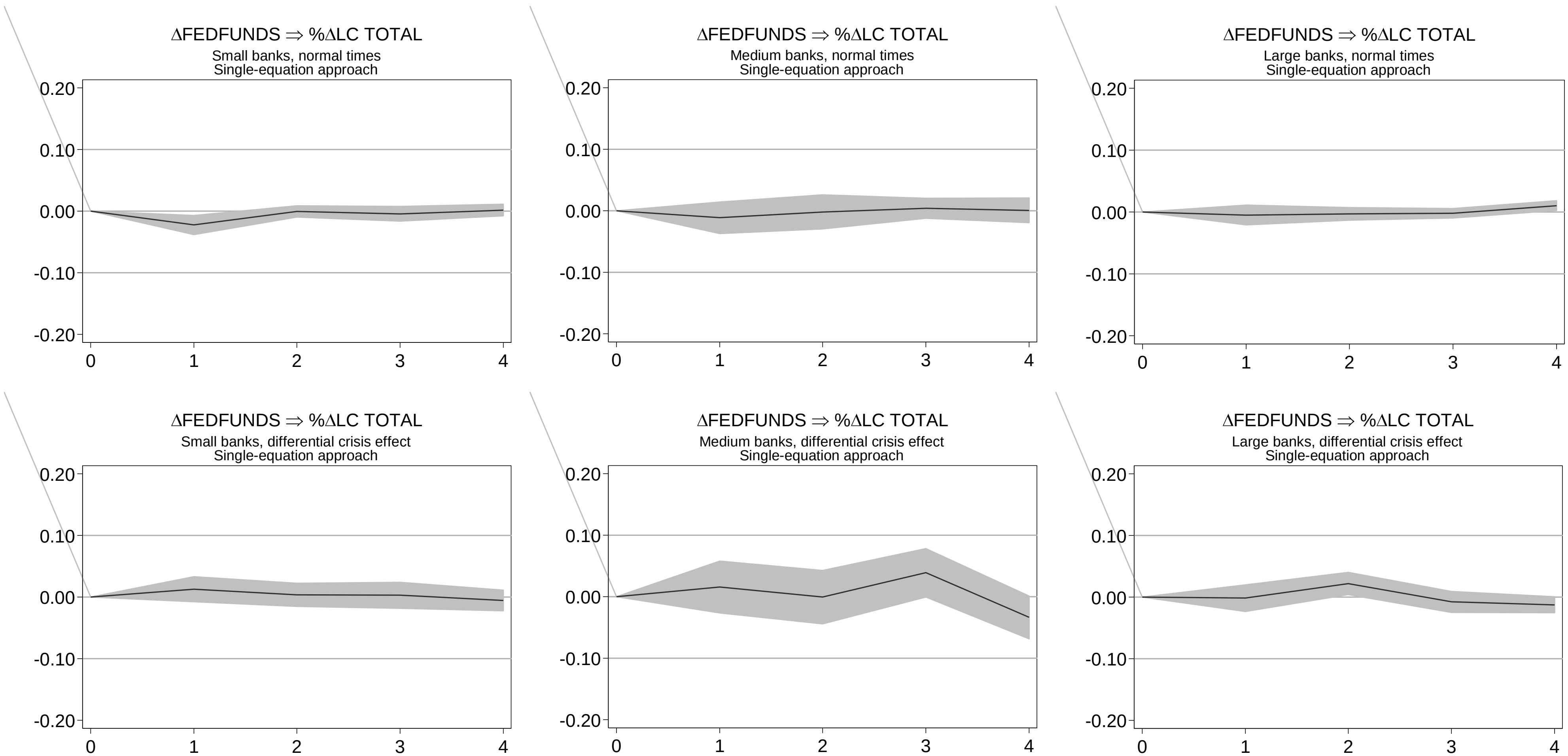


Figure 4: The effect of monetary policy on liquidity creation (single-equation approach)

This figure shows the impulse responses of bank liquidity creation (%ΔLC TOTAL) to a one percentage point change in the federal funds rate (ΔFEDFUNDS - Panel A) and a one percentage point Romer and Romer monetary policy shock (RR POLICYSHOCKS - Panel B), together with a 90% confidence band (±1.645 standard errors), using the single-equation approach. In each panel, the top row shows the impulse responses for small, medium, and large banks during normal times. This is used to test Hypothesis 1(c). The bottom row shows the differential effect of monetary policy on liquidity creation during financial crises. This is used to test Hypothesis 2(c).

Panel A: The effect of a change in the federal funds rate on liquidity creation (single-equation approach)



Panel B: The effect of Romer and Romer monetary policy shocks on liquidity creation (single-equation approach)

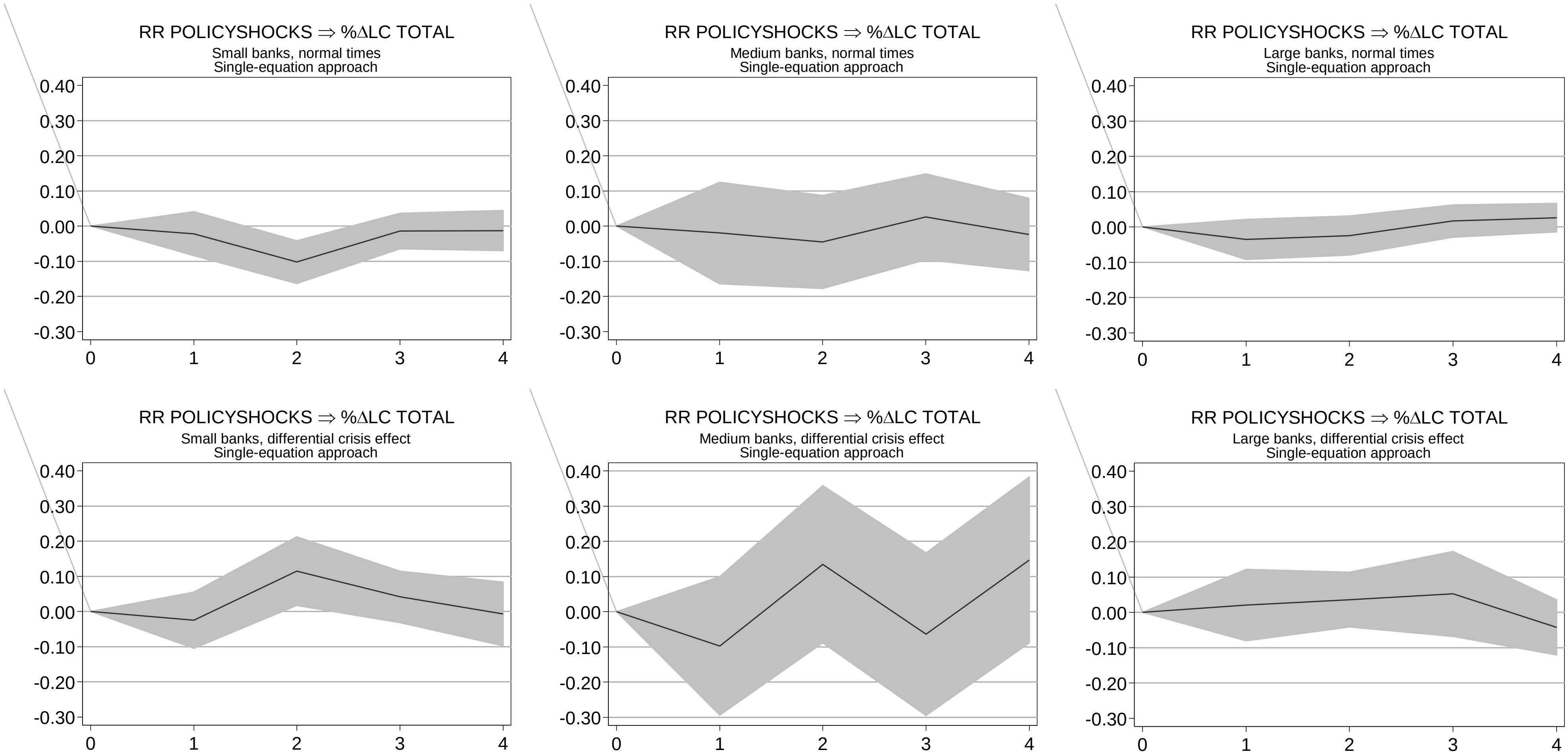
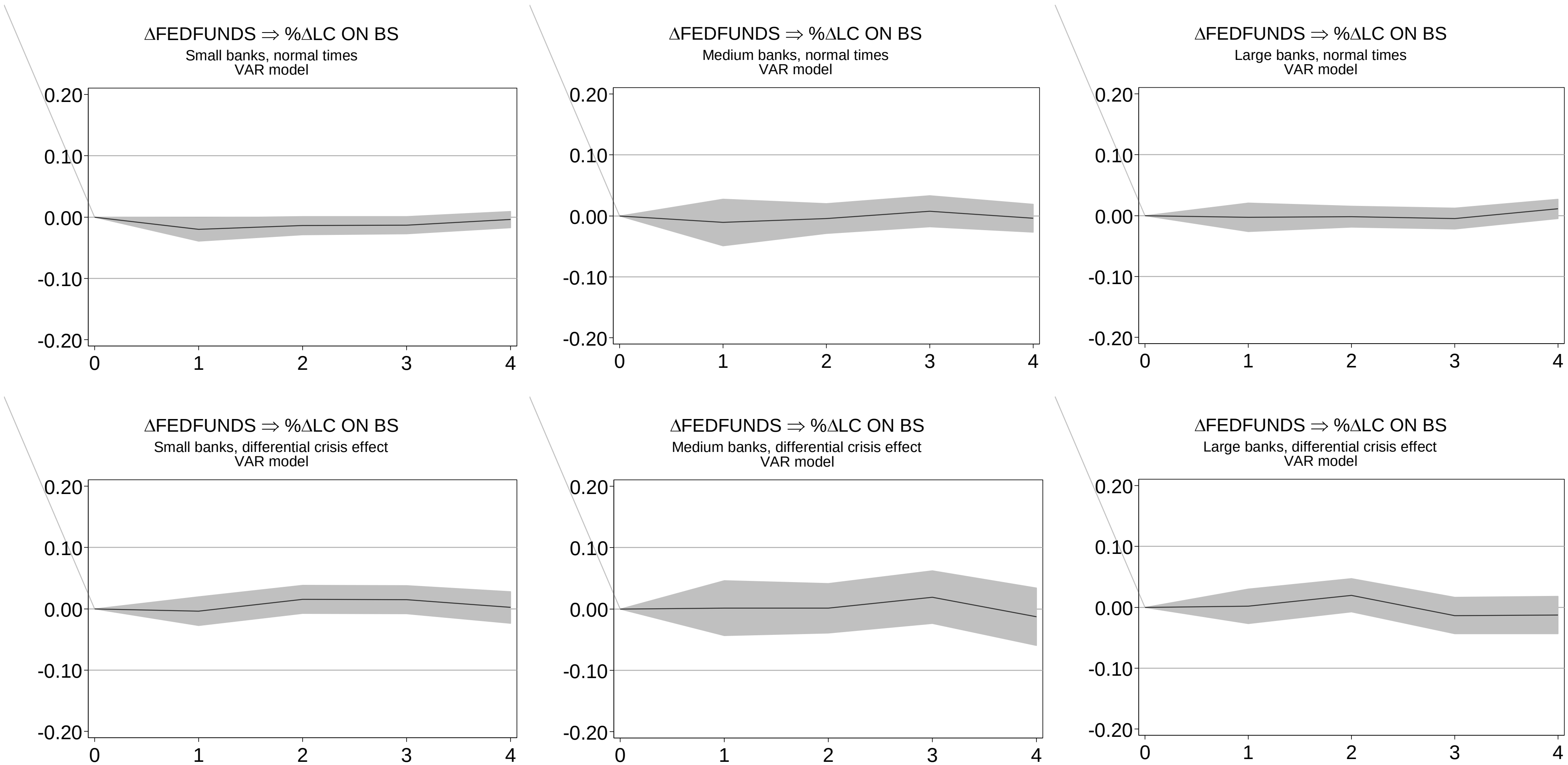


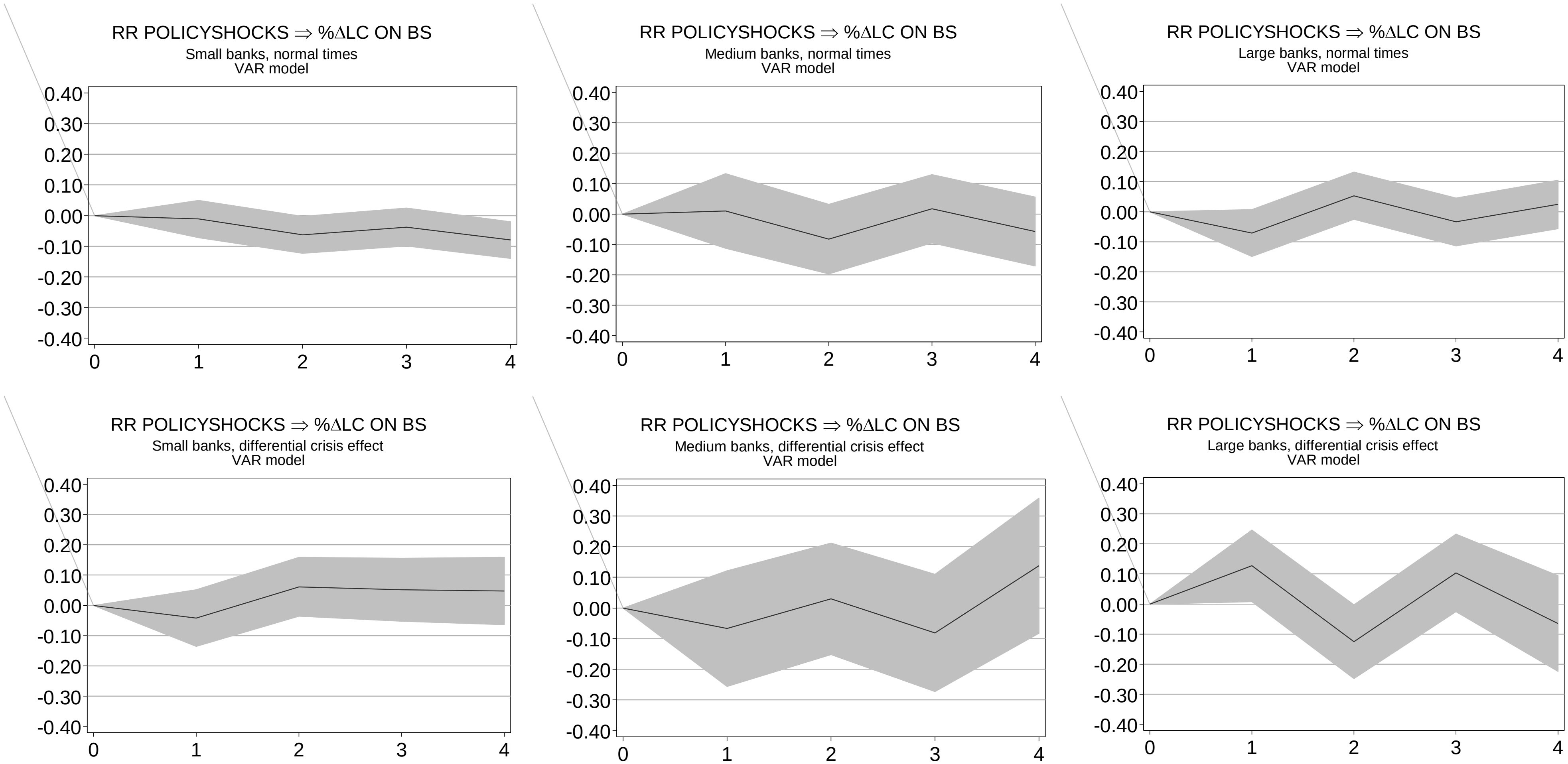
Figure 5: The effect of monetary policy on *on- and off-balance sheet liquidity* creation (VAR model)

This figure shows the impulse responses of on- and off-balance sheet liquidity creation (%ΔLC ON BS in Panel I and %ΔLC OFF BS in Panel II, respectively) to a one percentage point change in the federal funds rate (ΔFEDFUNDS - Subpanel A) and a one percentage point monetary policy shock (RR POLICYSHOCKS - Subpanel B), together with a 90% confidence band (±1.645 standard errors) using the VAR model. In each subpanel, the top row shows the impulse responses for small, medium, and large banks during normal times. This is used to test Hypothesis 1(a) (see Panel I) and 1(b) (see Panel II). The bottom row shows the differential effect of monetary policy on on- and off-balance sheet liquidity creation during financial crises. This is used to test Hypothesis 2(a) (see Panel I) and 2(b) (see Panel II).

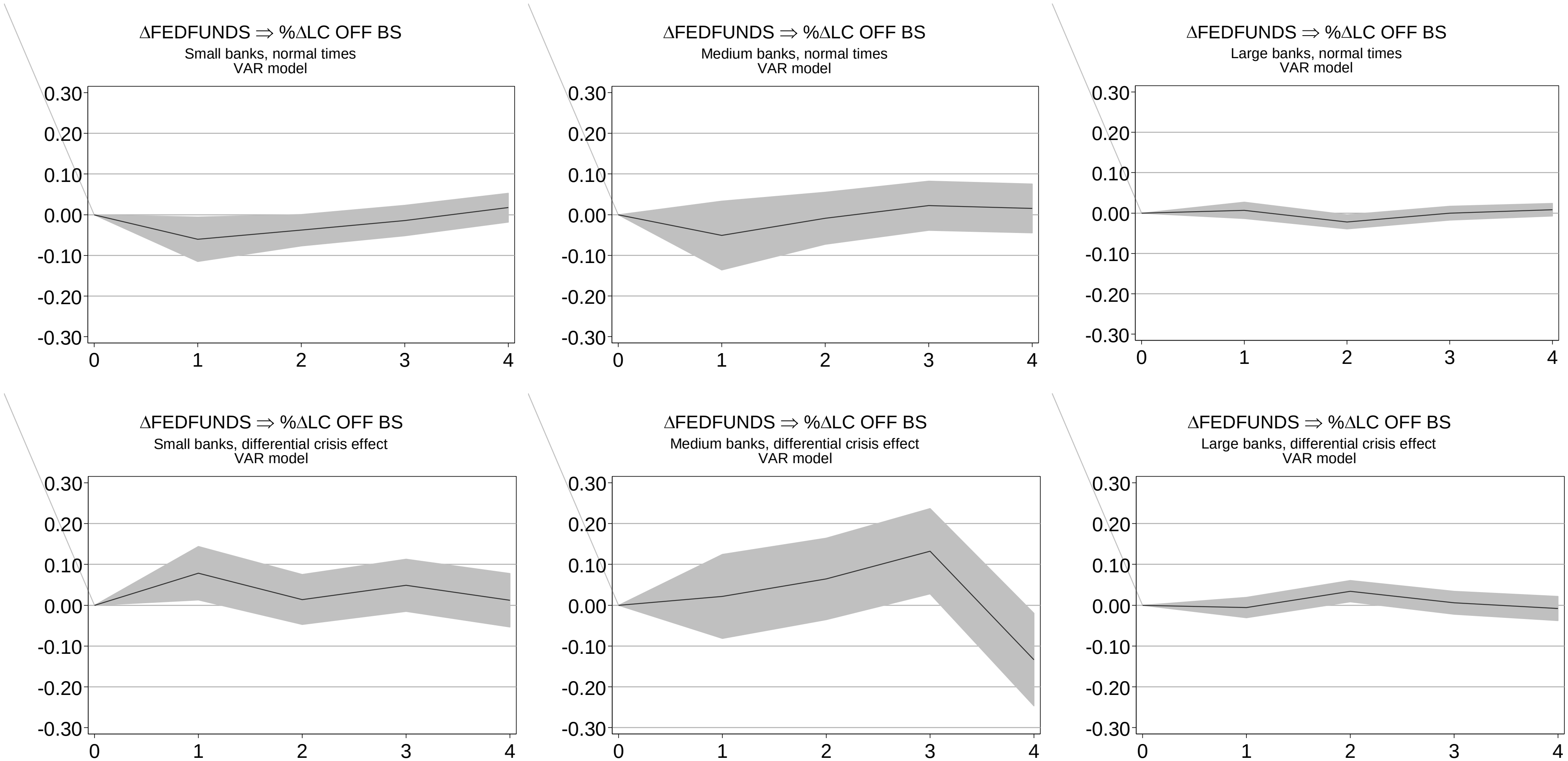
Panel I-A: The effect of changes in the federal funds rate on *on-balance sheet liquidity* creation (VAR model)



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



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



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

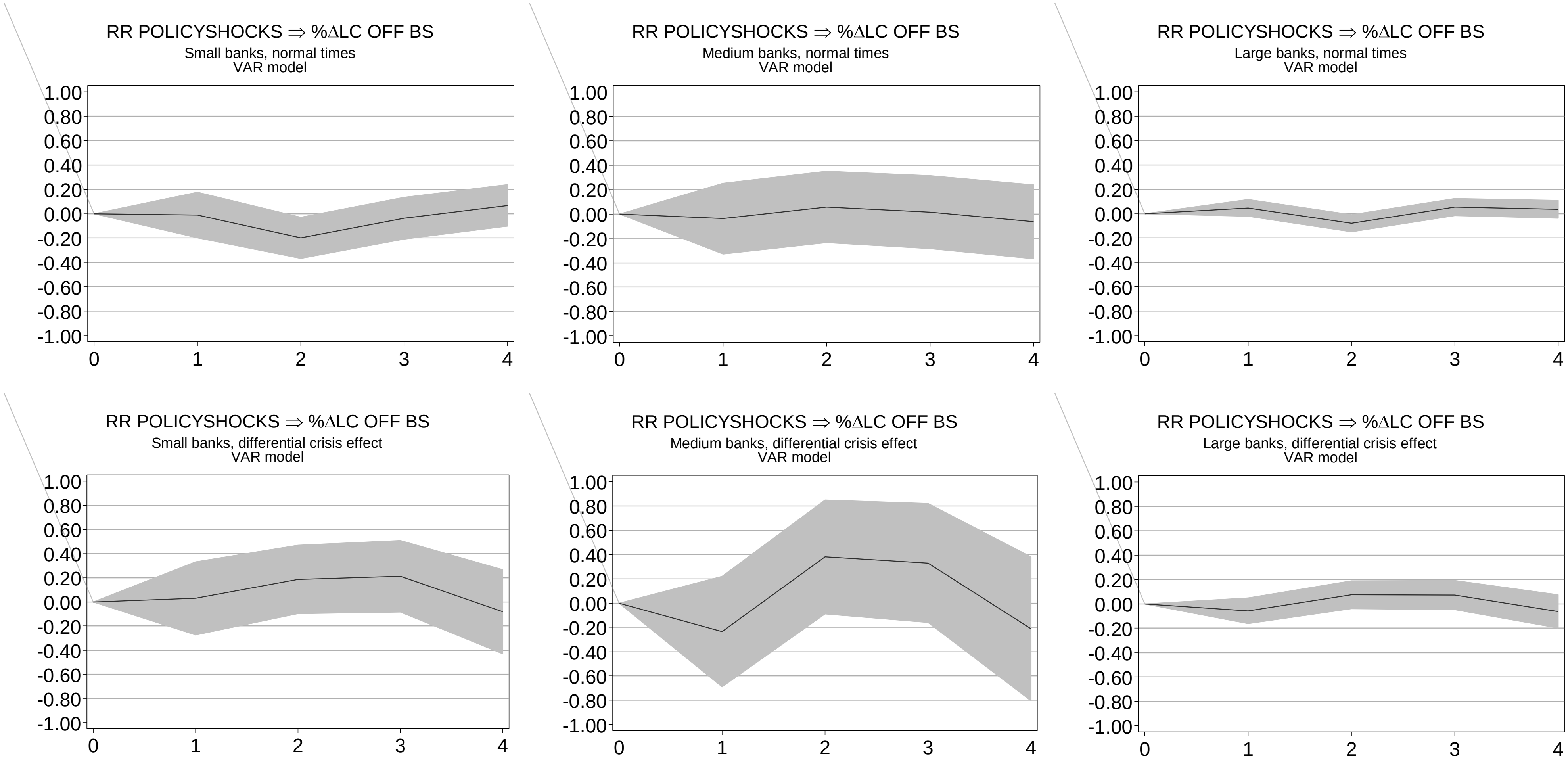
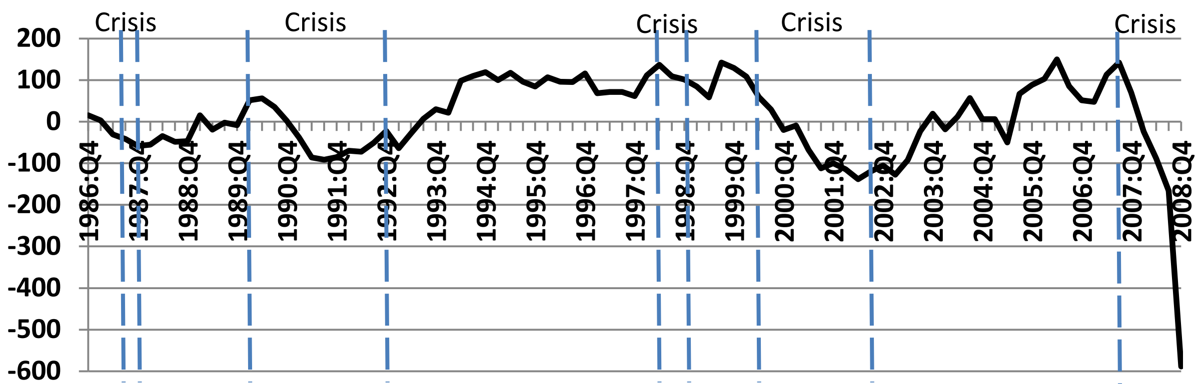


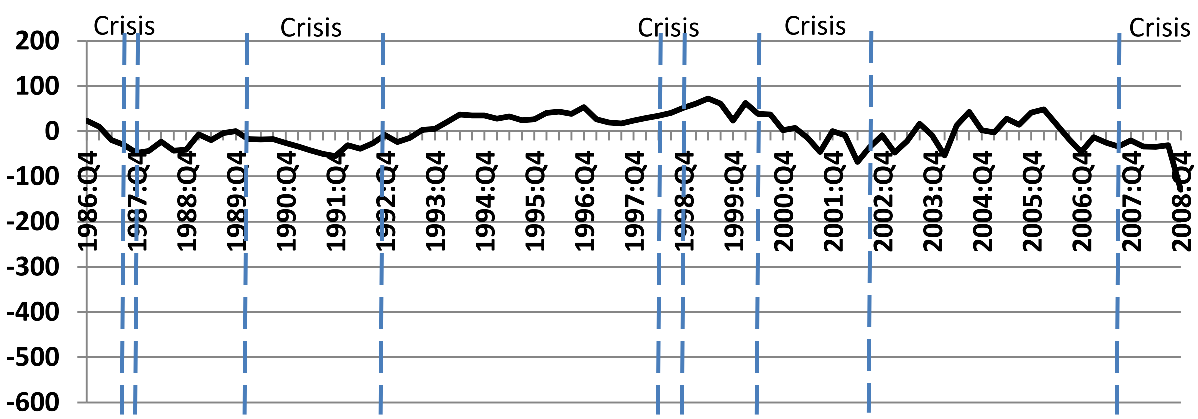
Figure 6: Detrended liquidity creation over the sample period

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 subprime lending crisis of the late 2000s.

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*)