The Effect of Bank Capital on Lending: Does Liquidity Matter?

Dohan Kim
Economist, Bank of Korea, 110 Namdaemoonro, Seoul, Korea

Wook Sohn*
Professor, KDI School of Public Policy and Management, 85 Hoegiro, Seoul, Korea

Abstract

This paper examines whether the effect of bank capital on lending differs depending on the level of bank liquidity. On the basis of the 2003 to 2010 quarterly data of 1,050 US commercial banks, we find that bank capital exerts a significant positive effect on lending when banks retain sufficient liquid assets. This liquidity effect has remained during the recent financial crisis and is more prominent for large banks. The results suggest that bank capital and liquidity are complementary measures for increasing bank lending.

JEL classification: G01, G21

Keywords: Bank capital, Bank liquidity, Lending behavior, Financial crisis

---

* Corresponding author. Tel. : +82 2 3299 1062; fax: +82 2 3299 1129. *E-mail address*: wooksohn@ kdischool.ac.kr.

The Effect of Bank Capital on Lending: Does Liquidity Matter?

Abstract

This paper examines whether the effect of bank capital on lending differs depending on the level of bank liquidity. On the basis of the 2003 to 2010 quarterly data of 1,050 US commercial banks, we find that bank capital exerts a significant positive effect on lending when banks retain sufficient liquid assets. This liquidity effect has remained during the recent financial crisis and is more prominent for large banks. The results suggest that bank capital and liquidity are complementary measures for increasing bank lending.

JEL classification: G01, G21

Keywords: Bank capital, Bank liquidity, Lending behavior, Financial crisis

1. Introduction

After the recent financial crisis, ensuring the financial stability of banking systems has been issued as an imperative to be adhered to by regulators, academics, and policymakers. In particular, with the Basel Committee on Banking Supervision (BCBS) at the center of deliberations, regulators and policymakers have highlighted the criticality of sufficient capital buffers[1] and sound liquidity risk management to such stability. A result of these efforts is the international endorsement of Basel III, which requires enhanced quality and quantity of capital, a sufficient amount of stable funding, and the liquidity of bank assets. This initiative is based on the belief that banks with sufficient capital, liquid assets, and stable funding structures can more effectively maintain their intermediation capacity in response to external negative economic shocks.

As emphasized by the Basel Committee, one of the main objectives of reforms to strengthen global capital and liquidity rules is to build a foundation for sustainable economic growth with a strong and resilient banking system (BCBS, 2011). That is, losses caused by spillovers from negative shocks in the financial sector to the real economy should be prevented. In this context, considerable research has examined the effects of financial shocks on real economic activity and the procyclical features of risk-based capital ratios, which may further worsen financial shocks by driving banks to reduce credit supply when needed the most.

Above all, understanding the relationship between bank capital and lending is a key issue discussed in other bank-related studies. As Berrospide and Edge (2010) point out, quantifying the effect of bank capital on bank credit supply is one of the most fundamental

[1] Federal Reserve Chairman Ben Bernanke said in press on 7 June 2012: “Capital is important to banking organizations and the financial system because it acts as a financial cushion to absorb a firm’s losses.”

research issues that require resolution in verifying the link between the financial sector and real activity. For example, bank capital is a principal component of Bayoumi and Malander's (2008) framework for macro-financial linkage. In this framework, the relationship between bank capital ratio and lending standards is the first link. Banks tighten their lending standards in response to a negative shock on capital ratio, thereby reducing credit volume. The authors find that a reduction in bank capital ratio by 1 percentage point results in a 2.5% decrease in change in credit to GDP ratio and ultimately causes a 1.5% reduction in the GDP. Another important consideration is to understand the "bank-capital channel" of monetary policy. Van den Heuvel (2007), Gambacorta and Mistrulli (2004), and Meh (2011) emphasize the importance of the bank-capital channel, through which monetary policy and shocks to bank capital affect bank lending. Comprehending the effect of monetary policy on real economy is therefore difficult without verifying the relationship between bank capital and lending.

Figure 1 shows that the growth rate of bank lending has significantly dropped in 2008 and 2010, which are considered the most severe crisis periods. A shortage of capital is observed as one of the key factors that limit banks' ability to issue loans. For this reason, many studies that examine the effect of changes in bank capital on lending have recently emerged (see Berrospide and Edge, 2010; Gambacorta and Marques-Ibanez, 2011; Carlson *et al.*, 2011; Brei *et al.*, 2013). Conversely, some scholars focus on other factors that have slowed down bank lending during the recent financial crisis. Corentt *et al.* (2011) and Ivashina and Scharfstein (2010) highlight the effect of bank liquidity on lending. Cornett *et al.* (2011) find that banks' efforts to manage liquidity have caused a decline in bank lending during the recent crisis. Similarly, Ivashina and Scharfstein (2010) show that a drop in bank lending is greater for banks with less access to deposit financing and higher exposure to credit line drawdowns.

The current work is grounded on the conclusions presented in the literature that emphasizes the importance of other bank-specific characteristics on bank lending (Berrospide and Edge, 2010; Gambacorta and Marques-Ibanez, 2011). To date, research has focused on a linear relationship between bank capital ratios and bank lending or has examined whether a structural change in response to external shocks exists. To the best of our knowledge, no studies have examined the interaction effect of bank capital and liquidity on lending. In this regard, we use the 2003 Q1 to 2010 Q4 balanced quarterly data of 1,050 US commercial banks to determine whether the effect of bank capital on lending changes depending on the level of bank liquidity.

The main results are as follows. The effect of bank capital on credit, defined as net loans on the balance sheet plus unused commitments off the balance sheet, is positively related to the level of bank liquidity. The findings suggest that an increase in the effect of bank capital increases bank lending only after banks retain enough liquid assets. This interaction effect has not changed during the recent crisis and is more prominent for large banks. These results suggest three important policy implications. First, policy actions such as capital injections and liquidity support for sustainable bank lending are complementary and should be harmoniously implemented for them to be effective. Second, capital injection is more effective in increasing credit supply for banks with high liquid assets than those with low liquid assets. Third, recent international regulatory reform efforts that emphasize the importance of both sufficient capital and liquidity management are necessary to sustainable bank lending. BCBS (2011) underlines the importance of liquidity management because banks that fail to effectively manage their liquidity have suffered during the recent financial crisis despite having adequate capital. These results imply that banks with a high amount of capital and liquid assets cut credit supply to a lesser extent in response to external shocks than do banks with deficient capital and liquid assets; however, newly imposed liquidity regulations may change bank behavior in an unexpected manner.

This paper makes two contributions to the literature. First, it shows a significant interaction effect of bank capital and liquidity on credit supply—an effect suggesting that bank capital and lending exhibit a complicated rather than linear relationship. Research to date has focused on the linear relationship between bank capital and lending. Second, the present study demonstrates that the role of unused commitments should be considered in analyzing the effect of bank capital on lending. The main results of this paper hold only when unused commitments are included in the definition of lending, implying that credit is an appropriate measure for bank lending. This view is consistent with Cornett *et al.* (2011) and Ivashina and Scharfstein (2010).

The rest of the paper is organized as follows. Section 2 presents the review of literature and Section 3 discusses our hypotheses. Section 4 briefly presents the data used, and Section 5 describes the empirical methodology and variables. Section 6 discusses the regression results and addresses robustness issues. Section 7 concludes with a discussion of policy implications.

2. Literature review

Use of actual capital ratio versus gap between actual and target capital ratio

Two strands of the literature examine the effect of bank capital on lending given the issue on the manner by which banks are evaluated in terms of capital reserves. One may compare actual capital ratio to absolute figures, such as minimum regulatory requirements (i.e., 8%, and 10%), which are the levels regarded as reflective of adequate capitalization, as indicated in capital adequacy guidelines (see, e.g., Bernanke and Lown, 1990; Gambacorta and

Mistrulli, 2004; Carlson *et al.*, 2011; Das and Sy, 2012; Brei *et al*., 2013; Kapan and Minoiu, 2013). By contrast, some researchers prefer using the gap between estimated target capital ratio and actual capital ratio in evaluating capital adequacy (see, e.g., Furlong, 1992; Hancock and Wilcox, 1994; Wall and Peterson, 1995; Jacques and Nigro, 1997; Flannery and Rangan, 2008; Maurin and Toivanen, 2012; Francis and Osborne, 2012; Shim, 2013: Martín-Oliver *et al.*, 2013).

Berrospide and Edge (2012) and Carlson *et al*. (2011) discuss the merits and shortcomings of each approach. They argue that a potential problem with analysis that uses target capital ratio is that any model used to estimate this ratio can be misspecified. A poorly specified model easily causes bias in the results derived using the estimated target capital ratio. Conversely, Carlson *et al*. (2011) indicate that using this variable can explain why some banks adjust lending policies to move toward higher capital ratios even under currently sufficiently high capital ratios.

Researchers generally agree that banks actively manage their capital ratios to reach implicit target capital ratios, and many scholars use bank target capital ratio as one of the determinants of actual capital ratio. Nevertheless, the current study uses only actual capital ratio for two reasons. First, we estimate target capital ratio by using a partial adjustment model, which has been extensively used in literature (see, e.g., Furlong, 1992; Hancock and Wilcox, 1994; Flannery and Rangan, 2008; Berrospide and Edge, 2010; Maurin and Toivanen, 2012; Francis and Osborne, 2012; Martín-Oliver *et al.*, 2013), but find that this ratio is too volatile for low adjustment speeds; that is, it generates 10% to 20% of adjustment speed on a quarterly basis. This result increases concerns over the bias generated by estimates of target capital ratio. Second, we are primarily interested in the relationship between lending and observable actual capital ratio rather than an implicit and unobservable target capital ratio. Policies based on observable values are also preferred.

Effect of bank capital on lending

Many empirical studies have examined the effect of bank capital on lending, with most indicating a positive effect, albeit to various degrees. In the early literature, Bernanke and Lown (1991) estimate that the effect of a 1 percentage point increase in bank capital on bank lending is about 2 to 3 percentage point increases per year in loan growth. Although the authors conclude that bank capital and lending exhibit a smaller relationship than expected and that capital shortage is a minor factor in lending slowdown, their estimates are somewhat larger than those presented in related studies. Berrospide and Edge (2010) explain that the larger estimates by Bernanke and Lown (1991) may be attributed to their model's exclusion of other bank-specific control variables. Under this scenario, the coefficient of capital ratio captures the effects of other variables.

Berrospide and Edge (2010) explore the relationship between bank capital and lending in various ways. Using the unbalanced 1992 Q1 to 2008 Q3 quarterly data of 140 US Bank Holding Companies (BHCs), they estimate an increase of around 0.7 to 1.2 percentage points in loan growth in response to a 1 percentage point increase in bank capital ratio on a yearly basis. The authors also employ the VAR model, along with fixed effect regressions, and find relatively modest effects of bank capital on loan growth. Interestingly, they also find that the modest effects stabilize over time, as indicated by rolling-window panel regressions. Nonlinear and interaction effects with the output gap are also examined, but none of these factors are statistically significant.

Furlong (1992) and Hancock and Wilcox (1994) suggest a positive effect of bank capital on lending. Furlong (1992) finds that the ratio of bank capital to target capital is positively associated with the growth in bank loans. Hancock and Wilcox's (1994) estimate shows that in 1991 in the US, a shortfall in each US$1 of bank capital resulted in a reduction of about US$4.50 in bank credit.

The above-mentioned studies are based on US data, but Gambacorta and Mistrulli (2004) and Francis and Osborne (2010) focus on Italian and UK banks, respectively. On the basis of the 1992 to 2001 quarterly data of Italian banks, Gambacorta and Mistrulli (2004) find that excess capital exerts a significantly positive effect on lending and that the effects of monetary policy and output shocks on bank lending differ depending on the level of bank capitalization. Francis and Osborne (2012) find that banks raise their target capital ratios when capital requirements increase, and vice versa. Thus, banks increase their actual capital ratios in response to tightened capital requirements by adjusting their portfolios toward less risky assets. This approach enables them to reduce the gap between internal target capital ratios and actual capital ratios, suggesting that bank lending positively depends on the gap between actual and target ratios. A partial adjustment model is used with the 1996 to 2007 quarterly data for individual UK banks.

Carlson *et al.* (2011) estimate the effect of capital ratio on loan growth; this effect is smaller than that presented in previous literature. On the basis of 2001 to 2009 annual US bank data, the authors find that the effect of a 1 percentage point increase in capital ratio on loan growth is an increase of about 0.05 to 0.2 percentage points on an annual basis. This positive relationship, however, is not found prior to the recent financial crisis and become significant only in 2008 and 2009. Thus, the authors suggest that capital is a more important factor in loan growth than credit during the crisis period. This result corresponds to those of Gambacorta and Marques-Ibanez (2011) and Cornett *et al.* (2011), although capital is not a focal point in these studies.

Other literature

The Basel Accord, which is the international bank regulatory framework, sets the minimum capital requirement that banks should maintain; since the Basel Committee's adoption of this regulation in 1988, many studies have been devoted to analyzing its effects on bank risk-taking behavior, lending, and the overall soundness and safety of individual banks, as well the banking system. Specifically, many researchers have examined whether capital requirements increase bank capital ratios and restrain bank risk-taking. These studies are closely related to the main issue tackled in the present work.

VanHoose (2008) surveys previous academic research on this matter and concludes that no strong evidence exist as to the significant contribution of stringent capital requirements to increases in bank capital ratios. This finding is consistent with Jackson *et al.* (1999), who explore previous studies over the 1980s and 1990s to investigate whether banks increase capital ratios in response to regulatory capital requirements. The authors express difficulty in conclusively determining whether capital requirements drive banks to hold higher capital ratios than they otherwise would, although a broad consensus is that low-capital banks tend to more rapidly increase their capital ratios than do well-capitalized banks. Gropp and Heider (2009) also find that capital regulation is only a second-order determinant of banks' capital structures. The authors use a sample comprising 200 of the largest publicly traded banks from 16 countries, namely, the US and 15 EU countries, for the period 1991 to 2004.

Using a three-stage least squares model, Jacques and Nigro (1997) find a contrasting result in their examination of 2,570 commercial banks insured by the Federal Deposit Insurance Corporation (FDIC) for the period 1990 to 1991. The authors reveal that risk-based capital regulation increases capital ratios and decreases bank portfolio-related risks. Analyzing the annual panel data of 666 publicly traded US BHCs from 1992 to 2006, Berger *et al.* (2008) show that BHCs actively manage their capital ratios toward target capital ratios that are set substantially above the minimum capital requirements. In particular, the authors demonstrate that low-capital banks more quickly adjust their capital ratios toward target ratios than do well-capitalized banks; the former allow adjustment speeds to vary in accordance with BHC-specific characteristics in their partial adjustment models. Given this backdrop, studies provide somewhat mixed results.

A more important matter is that considerable research looks into whether capital regulations contribute to credit shocks. Jackson *et al.* (1999) conclude that banks respond to tightened capital regulations in the least costly manner, therefore possibly driving these financial institutions to reduce lending in response to external shocks to capital. Such reduction is prompted by the fact that issuing new equity is costly and constrained during economic downturns. VanHoose (2007) also argues that the theoretical literature reflects a general agreement that the short-run effects of capital regulation reduces loan supply. Furfine (2001) suggests that capital regulation is a key factor in the credit crunch of the 1990s because of its influence on the optimal portfolio allocation of banks. The results imply that actively managing capital ratios through adjustments in portfolio composition establishes a strong relationship between bank capital and lending.

3. Hypotheses

The majority of the literature cited in Section 2 focuses on the linear relationship between bank capital ratio and lending or examine whether a structural change occurs in response to external shocks. Studies that revolve around the second issue use models that enable the incorporation of an interaction term of bank capital ratio and a crisis dummy to determine whether well-capitalized banks allow more lending than do low-capital banks during crises.

Brei *et al.* (2013) incorporate a quadratic term of capital ratio in their equations to capture the nonlinear effects of a change in capital ratio on lending. They find that increased capital ratio exerts a positive effect on bank lending and that this effect marginally decreases in normal situations, but increases during crises. An important contribution of this study is its suggestion that the effect of bank capitalization on loan growth becomes positive during crises only after bank capital ratio exceeds a threshold. Thus, recapitalization should be sufficient for it to be effective. Carlson *et al.* (2011) also find that capital ratio imposes a nonlinear effect on loan growth, indicating that this effect is greater when capital ratio is relatively low and closer to the regulatory minimum requirement.

Under this context, the present study starts from the assumption that the effect of a change in capital ratio may differ depending on other bank-specific characteristics given that this factor differs depending on the level of capital ratio itself. Among various bank-specific characteristics, liquidity level is examined.

Figure 2 shows a negative relationship between liquid assets and loans, indicating that banks with a high proportion of loans on balance sheets are likely to hold a low level of liquid assets, such as cash and securities. Acharya *et al.* (2010) state that banks hold liquid assets for various reasons even when liquid assets usually generate lower returns than do illiquid assets, such as loans. Banks generally want to hold sufficient liquid assets as a precautionary measure for surviving a crisis. Banks that face a shortage of liquid assets experience difficulty in raising external finances, thereby suffering from fire-sale discounts, especially during distress periods. Nevertheless, because illiquid assets generate attractive profits, banks may set a certain preferred level of liquidity ratio on the basis of the tradeoff relationship between low- and high-level liquidity. Acharya *et al.* (2010) argue that bank liquidity is countercyclical, causing banks to have low liquidity during economic boom periods and high liquidity during crises. Cornett *et al.* (2011) also find that banks build up liquidity buffers in response to increased risk during crises. Thus, banks' efforts to increase liquidity buffers during the recent financial crisis reduce credit supply. In this context, whether banks expand credit supply depends on the level of bank liquidity. That is, the effect of capital ratio on bank credit supply may differ depending on the level of liquidity ratio. To understand the possible responses of banks to increased capital ratios, an elementary balance sheet arithmetic is presented in the succeeding paragraph.

Suppose two banks A and B exist. Bank A has assets 100, liquid assets 50, loans 50, debt 90, and equity 10, while bank B holds assets 100, liquid assets 10, loans 90, debt 90, and equity 10. Now, let us assume that a positive capital shock occurs, thereby increasing capital by 1 in both banks. If the banks want to stay at the same level of leverage, they should increase debt by 9. Whether the banks maintain the leverage level is unimportant because the focus of this paper is asset composition. The assets of both banks increase by 10. We are interested in which bank increases loans to a higher extent. With all factors being equal, bank A, which has more liquid assets, is expected to supply more credit than bank B. Capital increase therefore imposes a greater effect on lending for bank A. Banks similar to bank B are likely to invest more resources in liquid assets rather than supply loans until they acquire sufficient liquid assets, although adequacy may depend on other bank-specific characteristics. This view is consistent with Kashyap and Stein (2000), who argue that less liquid banks are likely to reduce loans to keep their liquid asset holdings above a dangerously low level. Given these considerations, our core hypothesis is as follows.

(*Hypothesis*) Changes in capital ratio and liquidity ratio positively affect bank lending and these effects positively depend on the level of each ratio type. In other words, capital ratio and liquidity ratio exhibit a positive interaction, thereby causing additional capital (liquid assets) to exert a greater effect on credit supply for banks with more liquid assets (capital).

The expectation of the positive effects of capital ratio and liquidity ratio on lending is also based on the following ideas. Liquidity can be defined from either a funding or operating perspective, or both.[2] The definitions of NCR and NSFR, which have recently been suggested by the BCBS, incorporate both funding and operating perspectives, but the liquidity ratio used in the present paper represents only the liquidity level of bank operations.[3] Capital ratio may represent the liquidity level of funding. From an operating perspective, marketable banks with assets that have short maturities are considered of good liquidity status. By contrast, banks with liabilities comprising long maturities that cannot be easily accessed by creditors and investors are viewed as exhibiting good liquidity from a funding perspective. Thus, banks with a high capital ratio are expected to be capable of supplying more credit than are banks with a low capital ratio given the stable liability structures of the former. For this reason, banks with more liquid assets can supply more credit because they hold sufficient liquid assets. These expectations are consistent with previous empirical results (see, e.g., Kashyap and Stein, 2000; Berrospide and Edge, 2010; Cornett *et al.*, 2011; Brei *et al.*, 2013).

4. Data

This study uses US commercial bank data obtained from the FDIC Statistics on Depository Institutions, which provide the detailed financial reports of FDIC-insured institutions in

---

[2]This view is consistent with Brunnermeier and Pedersen (2009) and Brunnermeier (2009). They define liquidity in two categories: "funding liquidity" and "market liquidity." The former describes how easily expert investors and arbitrageurs can raise money from financiers, whereas the latter describes how easily money can be raised by selling assets.

[3]The Liquidity Coverage Ratio (NCR) and Net Stable Funding Ratio (NSFR) are developed to ensure that banks have sufficiently high-quality liquid assets and a sustainable maturity structure of assets and liabilities to survive a severe stress scenario that lasts for one month and a year, respectively (BCBS, 2011).

standardized formats. In the dataset, 9,328 institutions at 2003 Q1 and 7,667 institutions at 2010 Q4 are reported, but this study covers only banks with a bank charter class "N." A classification code is assigned by the FDIC on the basis of an institution's charter type, charter agent, status of Federal Reserve membership, and primary federal regulator. Classification code "N" indicates a national charter and the Federal Reserve member commercial banks that are supervised by the Office of the Comptroller of the Currency. Banks that are classified under code "N" account for 63.2% of all banks in terms of asset size; focusing on these banks is therefore a reasonable approach. Applying this criterion leaves us with 2,065 banks at 2003 Q1 and 1,383 banks at 2010 Q4. The explanation of bank classification is summarized in Table 1.

The sample for this study features quarterly data that correspond to a balanced panel of US commercial banks that have operated continuously from 2003 Q1 to 2010 Q4. We choose the period 2003 to 2010 for two reasons. First, it covers two different economic periods in the US: an economic boom period (2003 Q1 to 2007 Q2) and the recent crisis (2007 Q3 to 2010 Q4). To determine whether a structural change occurs during the crisis, only one period of economic boom and one crisis are included in the analysis. The years before 2003 are excluded because of the "dot-com crush" from 2000 to 2002. Second, Papanikolaou and Wolff (2010) state that no considerable regulatory changes are observed in the US during the examined period; these changes could have changed bank behavior. For instance, US banks and BHCs still report their regulatory capital ratios under Basel I, adopted in 1988 and enacted in 1992,[4] as well in accordance with the conventions outlined in the General Accepted Accounting Principles. A balanced panel is used given that this study intends to look into the behavior of normal banks that have operated continuously during the

[4]See Wall and Peterson (1996) and Lee and Stebunovs (2012) for an overview of major changes in capital regulation in the US.

examined period without experiencing any violations of regulatory capital requirement or significant structural changes even though the use of such panel is subject to survivorship bias. Newly established banks or decaying banks may behave differently, leading us to unexpected conclusions.

Some adjustments are applied to mitigate the influence of missing or outlier values, as well as possible mergers and acquisitions. First, banks that are in violation of regulatory capital requirements during the examined period are excluded because institutions that are regarded as undercapitalized are constrained by various mandatory and discretionary supervisory actions, such as restrictions on asset growth and dividend payments. Thus, observations are excluded at a total risk-based capital ratio of less than 8%, at a tier 1 risk-based capital ratio of less than 4%, or at a leverage ratio less than 4%. Banks that report a total risk-based capital ratio of more than 40% are also excluded because this percentage is considered abnormally high. In terms of liquidity, observations are excluded for liquidity ratios less than 0%. To reduce the effect of possible mergers and acquisitions, another exclusion implemented is that of banks that exhibit a quarterly asset, loan, and credit growth greater than 50% or less than –50%. Finally, banks with a risk-weighted asset-to-total-asset ratio of more than 100% are disregarded. These exclusions leave us with a final sample of 1,050 US commercial banks. A description of the dataset is presented in Table 2.

For macroeconomic data, real GDP data are obtained from the US Bureau of Economic Analysis and 3-month federal fund effective rates are taken from the Federal Reserve Bank.

5. Econometric models

Econometric model specification

To validate our hypothesis on whether the relationship between bank capital and lending depends on the level of liquidity, a bank capital ratio variable is interacted with a bank liquidity ratio variable. This approach enables the coefficient of the bank capital ratio variable to fluctuate as liquidity ratio changes. To this end, the econometric model used by Brei *et al.* (2013) is employed with some adjustments. First, a quadratic term of capital ratio is excluded; instead, an interaction term of capital ratio and liquidity ratio is used to verify the main hypothesis. In addition, some variables that are disregarded by Brei *et al*. (2013) are incorporated into the interaction. The empirical model used in the present research is given by

$$L_{i,t} = \alpha_i + \beta_0 L_{i,t-1} + \beta_1 CAP_{i,t-1} + \beta_2 LIQ_{i,t-1} + \beta_3 CAP * LIQ_{i,t-1} + \gamma \mathbf{X}_{i,t-1}$$
$$+\delta_1 \Delta GDP_{t-1} + \delta_2 \Delta MP_{t-1} + \sum_{s=2}^{4} \varphi_s \mathrm{Q}_s + \varepsilon_{i,t} \qquad , \qquad (1)$$

where *i* denotes the number of banks and *t* represents the quarterly time dimension.

In this econometric model, each coefficient captures the short-term effect on lending in response to a change in the variable. By contrast, the long-term influence is expressed by dividing each coefficient by (1-β_0). For example, $\Delta L_{i,t}/\Delta \mathbf{X}_{i,t-1} = \gamma/(1-\beta_0)$ indicates the long-term effect on loan growth rate in response to a change in the variable in vector X.

The dependent variable ($L_{i,t}$) is the quarterly growth rate of lending of bank i in period t. Following the majority of the literature (e.g., Kashyap and Stein, 1995); Gambacorta and Mistrulli, 2004; Berrospide and Edge, 2010; Drehmann and Gambacorta, 2011; Brei *et al.*, 2013; Kapan and Minoiu, 2013), we use the growth rate of the dependent variable instead of the variable in levels to mitigate spurious correlation.

Bank-specific characteristic variables and macroeconomic control variables are included as explanatory variables. The bank-specific variables used by Brei *et al.* (2013) are all included, except for the square term of the regulatory capital ratio. These variables are bank regulatory capital ratios ($CAP_{i,t-1}$), bank liquidity ratio ($LIQ_{i,t-1}$), market funding ratio ($MFUND_{i,t-1}$) and log of total assets ($SIZE_{i,t-1}$). With these variables, we use the additional bank-specific characteristic variables that are considered by the previous literature as important control variables that affect bank lending. For example, the ratio of unused commitments ($COMMIT_{i,t-1}$) is included because according to Cornett *et al.* (2011), unused commitments are important explanatory variables that influence bank lending by exposing banks to liquidity risk. The ratio of return on total assets (ROA_{t-1}) is used as a bank profitability proxy, and the ratio of noncurrent loans to total loans is used as an indicator of bank asset quality. Bank-specific characteristics, except capital ratio and liquidity ratio, are included in vector $\mathbf{X}_{i,t-1}$. All bank-specific characteristic variables, except capital ratios, are normalized to their mean values. Capital ratios are normalized to the minimum regulatory requirements (i.e., 8% for total risk-based capital ratio and 4% for both tier 1 risk-based capital ratio and leverage ratio).

In addition, a quarterly growth rate of real GDP (ΔGDP_{t-1}) and a change in the 3-month federal fund effective rate (ΔMP_{t-1}) are included to account for the effects of macroeconomic conditions and loan demands. When these macroeconomic control variables are omitted, yearly time fixed dummies are used instead. Finally, α_i represents bank-level fixed effects that capture unobserved bank characteristics; quarterly dummies (Q_s) are included in all the regressions to capture seasonal influences. All bank-specific variables and macroeconomic control variables are lagged one period to mitigate possible endogeneity bias.

This study focuses only on the fixed effects panel method, whereas Brei *et al.* (2013) employ Blundell and Bond's (1998) approach, which features the generalized method of moments (GMM) panel, to ensure efficiency and consistency. Brei *et al.* (2013) and Gambacorta and Mistrulli (2004) argue that this method ensures efficiency and consistency as long as the models do not suffer from an order-two serial correlation and as long as valid instruments are used.

Roodman (2006), however, recommends fixed effects estimators as better alternatives to GMM under a large time dimension T because under such a condition, dynamic panel bias becomes nonsignificant and number of instruments tends to considerably increase as time dimension T increases. Furthermore, Judson and Owen (1999) suggest that fixed effects estimators perform well or better when the time dimension of panel data T is greater than 30. Judson and Owen (1999) also argue that fixed effects estimators may be chosen even when the time dimension is 20 for balanced panel data. Given that the time dimension of datasets is 30 for most regressions and that the minimum time dimension is 22, we adopt the bank fixed effects panel model. The fixed effects method has been extensively used in the literature (see, e.g., Berrospide and Edge, 2010; Francis and Osborne, 2010; Cornett *et al.*, 2011).

Meanwhile, fixed effects are chosen over random effects on the basis of unreported Hausman test results. This approach is also reasonable because bank effects are likely to be time invariant during the examined period, which is considered an insufficient interval for changes to occur on each bank's inherent characteristics. As argued by Brei *et al.* (2013), nonrandomly choosing a sample from the population of banks also supports the choice of fixed effects estimations.

Before moving on to the main regression, we examine the linear regressions that exclude the interaction term of capital ratio and liquidity ratio. Furthermore, the crisis dummy is interacted with all bank-specific characteristics variables to determine whether a structural change in the coefficients of these variables occur in response to external economic shocks.

Variables and expected signs

***Loan growth* (L_t)**: To examine whether an increase in bank capital ratio increases bank lending, the quarterly growth rates of net loans and credit are used. Variables are calculated as $100 \times (\ln(L_t) - \ln(L_{t-1}))$, where L_t represents net loans and credit in the on and off balance sheets at time t. As Cornett *et al.* (2011) and Ivashina and Scharfstein (2010) point out, the drawdowns of unused commitments that are not caused by the expiration of the term do not affect the total amount of credit because the same amount of loans increases. For this reason, credit lines that are opened before the crisis are useful for borrowers because they can employ unused commitments when banks are reluctant to lend. Thus, an increase in loans caused by the drawdowns of unused commitments is likely to affect bank lending behavior and the relationship between bank capital and lending. This study follows Cornett *et al.*'s (2011) approach in analyzing these changes from off balance sheets to on balance sheets; we add the credit growth variable as a dependent variable.

***Capital* (CAP_{t-1})**: Various capital ratios are available, but only regulatory capital ratios are considered in this work. Minimum capital requirements are set on three types of capital ratio measurements: total risk-based capital ratio, tier 1 risk-based capital ratio, and leverage ratio. Total risk-based capital ratio is defined as core capital (tier 1) plus supplementary capital (tier 2) over risk-weighted assets; this ratio should be at least 8% for banks to be regarded as adequately capitalized. Tier 1 risk-based capital ratio includes only core capital in the numerator and is divided by risk-weighted assets; it should be at least 4%. Leverage ratio is defined as core capital (tier 1) over total average assets rather than risk-weighted assets. All these capital ratios are considered in the regressions; the coefficients of these regulatory capital ratios are expected to be positive. The coefficients of the interaction term with the crisis dummy are also expected to be positive because well-capitalized banks can more effectively absorb the negative effects of shocks on bank lending (see Meh and Moran, 2010; Gambacorta and Mistrulli, 2004; Carlson *et al.*, 2011; Kapan and Minoiu, 2013).

Liquidity (LIQ_{t-1}): As mentioned in the discussion of the hypotheses, liquidity can be defined in various ways, but in this paper, this definition is limited to operations. That is, liquidity pertains to the sufficiency of liquid assets that banks hold in the assets indicated in their balance sheets. What assets, then, are treated as liquid assets? Cash and securities are generally regarded as liquid assets, but researchers adjust definitions on the basis of the availability of specific information and their evaluations. For example, Berrospide and Edge (2010) and Das and Sy (2012) use a securities-over-assets ratio as a proxy for liquidity ratio, whereas Drehmann and Gambacorta (2011) and Gambacorta and Mistrulli (2004) classify cash and securities as liquid assets. Brei *et al.* (2013) treat cash, trading securities, and interbank lending with a maturity of less than 3 months as liquid assets.

Despite these comprehensive definitions, that used by Shim (2013) is the most reasonable. The author defines cash and balances due from depository institutions, securities, federal funds, and trading account assets minus pledged securities as liquid assets. Regarding only the assets that are pledgeable and available for sales as liquid assets is a rational approach; thus, this paper subscribes to this definition. The coefficients of liquidity ratio are expected to be positive for the reasons discussed earlier in Section 3; these positive effects on bank lending are greater during a crisis period, at which banks desperately need liquid assets.

Interaction term ($CAP*LIQ_{t-1}$): Verifying the coefficients of this interaction term is the main interest of this study. As previously discussed in Section 3, the expected sign on this term is positive. The effects of additional capital (liquid assets) on bank lending are greater for banks with more liquid assets (capital). When the interaction term is included in the regressions, bank capital ratios and liquidity ratio variables are normalized to the minimum regulatory capital ratios and their average across all banks in the sample. This normalization enables the acquisition of meaningful coefficients. The procedure involves interpreting the coefficients of capital ratios as the effects on banks with an average liquidity ratio, and interpreting the coefficients of liquidity ratio as the effects on banks with minimum regulatory capital ratios (i.e., 8% for total risk-based capital ratio, 4% for both tier 1 risk-based capital ratio and leverage ratio).

Bank size (*$SIZE_{t-1}$*): Bank size is measured by the natural logarithm of total assets. The expected sign on this variable is ambiguous. According to the "too big to fail" theory, large banks have incentives to take on more risk given high expectations on government bailout; this bailout is designed to prevent systemic risk, thereby enabling the supply of more credit. However, large banks can diversify their portfolio by investing various types of securities and involve themselves in various activities, while small banks tend to focus on traditional lending activities. From this perspective, the size effect may be negative.

Funding structure (*$MFUND_{t-1}$*): Broadly speaking, liabilities encompass deposits and nondeposits. This variable is measured as the ratio of total liabilities minus total deposits to total assets. Although the expected sign on this variable is uncertain, the positive sign is expected before the crisis and the negative sign is expected during the crisis. This strategy is adopted because banks may more strongly rely on market funding in expanding their balance sheets; such funding is usually considered more cost-effective and easier to accumulate during economic boom periods. Conversely, Brei *et al.* (2013), Ivashina and Scharfstein (2010), Cornett *et al.* (2011), and Gambacorta and Marques-Ibanez (2011) contend that banks that more strongly depend on market funding cut back on lending to a greater extent during the crisis because they are more vulnerable to external shocks. That is, banks with better access to deposit financing cut lending to a lesser extent than do banks that rely on market funding during the crisis period.

Unused commitments (*$COMMIT_{t-1}$*): Cornett *et al.* (2011) and Ivashina and Scharfstein (2010) show that this variable, which is measured by the ratio of unused commitments to total assets, is an important determinant of bank lending behavior. Interestingly, the expected sign on this variable differs depending on the type of dependent variable. The expected sign is positive for the growth rate of loans but negative for the growth rate of credit because the drawdowns of unused commitments increase loans without affecting credit amount. These effects are expected to be greater during the crisis. Banks that are exposed to a higher level of unused commitments more unwillingly supply loans given that the increased credit line drawdowns during the crisis transfer assets from off-balance sheets to on-balance sheets. As a result, these banks reduce the supply of new credit to a greater extent than do other banks.

Profitability (ROA_{t-1}): Profitability is measured as the ratio of net income after taxes and extraordinary items to total assets. Banks with high profitability are likely to have strong balance sheets because profitability is related to the quality and quantity of capital ratios. By contrast, a higher profitability may imply a greater risk on assets, thereby inspiring the provision of more loans. In either scenario, a positive relationship between profitability and bank lending is expected.

Loan quality (NPL_{t-1}): The ratio of noncurrent loans to total loans reflects the quality of bank loan portfolio. The higher the level, the worse the portfolio quality. Banks cut lending to a more substantial degree as loan quality worsens. Thus, the expected sign on this variable is negative.

Macroeconomic variables: To incorporate the effects of business cycle and monetary policy, a growth rate of real GDP (ΔGDP_{t-1}) and changes in the 3-month federal fund effective rate (ΔMP_{t-1}) are used. The expected sign on the growth rate of real GDP is positive because of the inherent procyclicality of bank lending and increased loan demands. Alternatively, the effect of changes in interest rate on bank lending is expected to be negative given that an increase in market rates decreases loan demands.

Crisis dummy ($CRISIS_t$): To examine whether a structural change occurs in response to external economic shocks, the crisis dummy is interacted with bank-specific characteristic variables. The crisis dummy is an indicator variable that takes a value of 1 for the crisis period and 0 otherwise. The crisis period is difficult to delineate and is commonly defined as beginning at 2007 Q3; the period at which it ends is debatable.

This paper employs two definitions of the crisis period. The first is based on the definition used by Cornett *et al.* (2011); that is, the period 2007 Q3 to 2009 Q2. The credit spread between the 3-month commercial paper market rate and the 3-month T-bill secondary market rate reflects this view (Figure 3). However, the growth rates of loans and commercial and industrial loans (Figure 1) show that 2007 Q3 to 2010 Q4 can sufficiently be considered the crisis period in terms of banks' responses to external shocks. This period reflects the most severe decreases in loan supply by banks.

6. Estimation results

Linear regression results

Before discussing the main regression results, we present the baseline regressions, which examine the linear relationship between bank lending and bank-specific characteristic variables. Table 5 reports the linear regression results. In Eqs. (1) and (2), the growth rate of net loans is used as the dependent variable, whereas in Eqs. (3) and (4), the growth rate of credit is used as the dependent variable instead of the growth rate of loans.

First, the estimated coefficients of capital ratio and liquidity ratio are positive and statistically significant. As expected, additional capital and liquid assets exert positive effects on loan growth rate. This finding supports the view that banks with a high capital ratio and liquidity can more sufficiently supply credit than can banks with a low capital ratio and liquidity; this observation is confirmed by the strong balance sheets of the well-capitalized banks. In terms of magnitude of coefficients, the results in Eqs. (1) and (2) suggest that a 1 percentage point increase in capital ratio boosts annualized loan growth by about 0.6 to 0.7 percentage points. Interestingly, capital ratio poses a minimal and statistically less significant effect on credit, suggesting that banks are less constrained by the regulatory capital ratio when they expand their credit by supplying credit lines to their customers. This relaxed condition is attributed to the lower risk-weights for off-balance sheet activities than those for on-balance sheet activities.

All the additional variables ($COMMIT_{t-1}$, ROA_{t-1}, NPL_{t-1}) are statistically significant with expected signs, supporting the assumption that these variables are important determinants of bank lending. In all the regressions, the expected signs of the coefficients of the other control variables are obtained. The size effect is negative, implying that small banks focus on traditional lending activity and therefore supply lending relatively more willingly than do large banks. The market funding effect is positive, albeit nonsignificant in Eqs. (3) and (4), suggesting that US commercial banks rely on market funding during the examined period to boost their lending, even if such dependence exerts a relatively modest effect. The results also reflect the importance of unused commitment ratio on loan growth. As previously discussed, changes in unused commitments exerts a positive effect on loan growth but a negative influence on credit growth. The magnitude of coefficients is considerable and highly statistically significant, indicating that lending by banks that are more strongly exposed to credit line risk increase through credit line drawdowns. Then, these banks reduce the supply of new loans or credit lines in response to increased takedown demands. Unused commitments therefore exert contrasting effects on loan growth and credit growth. The coefficients of profitability (ROA_{t-1}) and loan quality (NPL_{t-1}) also have expected signs and are statistically significant and consistent in all the regressions. Although increased profitability positively affects loan growth, the low quality of loans diminishes the ability of banks to supply loans.

Finally, macroeconomic variables are used when yearly time dummies are excluded—an approach that does not significantly affect the results. A half percentage point increase in the changes in the 3-month federal fund effective rate, which is a proxy for monetary policy, is associated with about a 0.2 percentage point decrease in loan growth and a 0.12 percentage point decrease in credit growth in the succeeding quarter. As expected, the effect is negative and strongly significant. In later regressions, the coefficient of this variable is positive (Table 9), albeit statistically nonsignificant for large banks. This result is in line with Kashyap and Stein (1995), showing that small banks respond more sensitively than do large banks to monetary policy.

Conversely, none of the coefficients of the growth rate of the real GDP variable are significant and they do not deviate from 0. Interestingly, in later regressions carried out on the basis of bank size (Table 9), the coefficients of the GDP growth for large banks are positive and statistically significant; by contrast, the coefficients are nonsignificant for medium and small banks. These findings suggest that large banks are more procyclical than medium and small banks in a business cycle. Large banks supply more credit during the economic boom and cut credit supply to a more substantial degree during the crisis than do medium and small banks. Given that the capital ratios of large banks is much lower than those of medium and small banks, the aforementioned finding is consistent with the result of Gambacorta and Mistrulli (2004), suggesting that well-capitalized banks supply credit less procyclically under GDP shocks.

Table 6 reports the linear regression results with crisis interactions. All the bank-specific characteristic variables are interacted with the crisis dummy. As previously discussed in the section 5 on the econometric model and variables, two types of crisis dummies are used. The first defines the crisis period as 2007 Q3 and 2009 Q2, and is used in Eqs. (1) and (2). The second dummy covers the period 2007 Q3 to 2010 Q4, and is used in Eqs. (3) and

(4). Overall, the results do not significantly differ, but the second definition seems to capture the crisis period better in light of the previous literature. Well-capitalized banks and more liquid banks supply more lending than do low-capital banks and less liquid banks in response to external economic shocks (see Cornett *et al.*, 2011; Brei *et al.*, 2013; Gambacorta and Mistrulli, 2004; Gambacorta and Marques-Ibanez, 2011; Kapan and Minoiu, 2013; Carlson *et al.*, 2011). The regression results in Eqs. (3) and (4) are more pronounced than those in Eqs. (1) and (2). The effects of capital ratio and liquid assets on loan and credit growth are greater during the crisis; thus, they are more important factors in banks' decision to supply credit in response to external economic shocks.

Interaction effect of bank capital and liquidity ratio

Table 7 presents the interaction effects of capital ratios and liquid assets on loan growth and credit growth for all types of regulatory capital ratios. In the regression models with an interaction term, the coefficients of capital ratios and liquidity ratio reflect the conditional effects of these variables on loan growth and credit growth. Liquidity ratio is normalized to its mean value; therefore, the coefficients of capital ratios are interpreted as the effect of capital ratios on loan and credit growth for banks with an average liquidity ratio. In the same manner, the coefficients of liquidity ratio pertains to the effect of liquidity ratio on loan and credit growth for banks with minimum regulatory capital requirements given that capital ratios are normalized to their minimum regulatory requirements.

The results in Table 7 differ depending on the type of dependent variable. Although positive interaction effects of capital ratio and liquid assets on loan growth are found in Eqs. (1) to (3), the coefficients are small and statistically nonsignificant. By contrast, the coefficients of the interaction terms in Eqs. (4) to (6), where credit growth is used as a dependent variable, are positive and statistically significant. A standard deviation increase in liquidity ratio of one from its mean elevates the effects of capital ratio on credit growth by about 0.04 to 0.06 percentage points, although the coefficient of the interaction term of leverage ratio is statistically nonsignificant. Considering that the effects of capital ratio on credit growth amount to about 0.05 to 0.07 percentage points, such effects are meaningful. On the contrary, these interaction effects are negligible for the effects of liquidity ratio on credit growth in light of the relatively low volatility of capital ratios. Figure 4 illustrates how the effects of capital ratio on credit growth change depending on the level of liquidity ratio and how the effect of liquidity ratio on credit growth changes depending on the level of capital ratios.

As shown in Table 8, the crisis dummy is interacted with all the bank-specific characteristic variables, including the interaction term, to examine whether a structural change occurs in response to external shocks. The coefficients of the interaction term slightly increase, but are nonsignificantly different from the results in Table 7. Furthermore, the coefficients of the interaction term with the crisis dummy are statistically nonsignificant. Thus, the interaction effects of capital ratio and liquidity ratio do not change during the crisis period.

The regression results derived on the basis of bank size are presented in Table 9. Large banks are institutions with assets greater than US$10 billion; medium banks are institutions with assets between US$1 and US$10 billion; and small banks are those with assets less than US$1 billion at 2003 Q1. Given this classification, 56, 540, and 454 banks are categorized as large, medium, and small banks, respectively. Interestingly, the previously discussed results hold only for large banks, for which the interaction effects of capital ratios and liquidity ratio are much greater than the results derived with Eqs. (4) to (6) in Table 7. A standard deviation increase in liquidity ratio of 1 from its mean increases the effects of capital ratios on credit growth by more than 0.1 percentage points. This finding also suggests that capital ratios can exert nearly no effect or a negative influence on credit growth at a very low liquidity ratio. Furthermore, the negative signs for the coefficients of liquidity ratio suggest that the effect of liquidity ratio on credit growth becomes positive only after capital ratios exceed a certain level. This finding is depicted in Figure 5.

The fact that the interaction effects are significant only for large banks implies that such banks more actively and simultaneously manage their capital ratios and liquidity ratio. This observation is inferred from the context that large banks tend to maintain low capital ratios and liquidity ratio than do medium and small banks. This strategy enables large banks to be more sensitive to changes in capital ratios and liquidity ratio.

Robustness checks

With regard to the estimation period, including the Troubled Asset Relief Program (TARP) implementation period can potentially distort results. TARP was one of the major programs implemented by the Treasury in response to the recent financial crisis in an effort to stabilize the financial system. The program was initiated on 28 October 2008, at which the Treasury injected capital into the nine largest banks under the Capital Purchase Program (CPP) (Black and Hazelwood, 2012).

Black and Hazelwood (2012) and Berrospide and Edge (2010) state that one of the objectives of the CPP is to boost bank lending by injecting capital through purchases of preferred stock with warrants. As a result, the capital ratios of US banks significantly increase after 2008 Q4. Figure 6 shows the regulatory capital ratios of the examined banks have significantly increased after TARP capital injections. For this reason, Berrospide and Edge (2010) adopt the period before 2008 Q4 as the cutoff for the estimation period, which was the beginning of TARP capital injections; the authors use this period to prevent it from distorting regression results. Black and Hazelwood (2012) argue that bank recipients of TARP funds are encouraged to increase loans. Using an event study methodology and loan-level regressions, they find that TARP poses a positive effect on bank risk-taking for large banks but a negative effect for small banks. Therefore, the period that excludes the time after the implementation of TARP capital injections are examined to validate the robustness of the main results.

The results are reported in Table 10. The interaction effects remain at a similar level for the sample (all the banks). The regression results for large banks show that the coefficients of the interaction terms increase, except for total risk-based ratio. Therefore, the effect of capital ratio on credit growth is positively associated with the level of liquidity ratio even after the period after the implementation of TARP capital injections is excluded.

7. Conclusions and policy implications

Using the 2003 Q1 to 2010 Q4 balanced quarterly data of 1,050 US commercial banks, this study examines the effect of bank capital on lending in various ways. First, bank capital exerts a statistically positive effect on loan growth. The results suggest that a 1 percentage point increase in capital ratio boosts annualized loan growth by about 0.6 to 0.7 percentage points. This positive effect is also found for another dependent variable, credit growth, albeit at a relatively modest magnitude. To determine whether a structural change occurs during the recent financial crisis, a crisis dummy is interacted with all the bank-specific characteristic variables. The effects of bank capital ratios on loan growth and credit growth are stronger during the crisis period. These results are consistent with the previous literature.

More important, this study examines whether the effect of changes in bank capital ratios on lending differs depending on the level of liquidity. The effect of bank capital on credit growth is positively related to the level of bank liquid assets. Moreover, the positive effect of an increase in bank capital on credit growth is significant only after banks retain enough liquid assets. This interaction effect does not change during the recent financial crisis, and is more prominent for large banks.

The results suggest three important policy implications. First, policy actions intended to sustain bank lending (e.g., capital injections and liquidity support) are complementary and should be congruously implemented for them to be effective. Second, using capital injection alone effectively increases credit supply for banks with high liquid assets. Finally, recent international regulatory reform efforts to encourage banks to hold more liquid assets as well as capital are appropriate measures for sustainable credit supply of banks. The results imply that banks with more liquid assets and capital can supply more credit owing to their increased capability to absorb negative economic shocks.

This study contributes to the literature in two ways. First, it shows that the interaction effect of bank capital and liquidity on credit supply is significant, implying that bank capital and lending exhibits a complicated rather than linear relationship. Second, this study demonstrates that unused commitments should be considered in examining the effect of bank capital on lending. The main results of this paper hold only when unused commitments are included in the definition of lending, implying that credit is a more appropriate measure for bank lending than capital.

References

Acharya, Viral V., Hyun Song Shin, and Tanju Yorulmazer. "Crisis Resolution and Bank Liquidity," *Review of Financial Studies* 24 (6) (2011): 2166-2205.

Basel Committee on Banking Supervision. "Basel III: A Global Regulatory Framework for More Resilient Banks and Banking Systems," *Bank for International Settlements (BIS) publications* (2011).

Bayoumi, Tamim, and Ola Melander. "Credit Matters: Empirical Evidence on U.S. Macro-Financial Linkages," *IMF Working Paper* No. 08/169 (2008).

Berger, Allen N., and Christa H.S. Bouwman. "Bank Liquidity Creation," *Review of Financial Studies* 22 (9) (2009): 3779-3837.

Berger, Allen N., and Gregory F. Udell. "Did Risk-based Capital Allocate Bank Credit and Cause a 'Credit Crunch' in the United States?," *Journal of Money, Credit, and Banking* 26 (3) (1994): 585-628.

Berger, Allen N., Robert De Young, Mark J. Flannery, David Lee, and Özde Öztekin. "How Do Large Banking Organizations Manage Their Capital Ratios?," *Journal of Financial Services Research* 34 (2008): 123-149.

Bernanke, Ben S., and Cara S. Lown. "The Credit Crunch," *Brookings Papers on Economic Activity* 2 (1991): 205-247.

Berrospide, Jose M., and Rochelle M. Edge. "The Effects of Bank Capital on Lending: What Do We Know, and What Does It Mean?," *International Journal of Central Banking* 6 (4) (2010): 5-54.

Black, Lamont, and Lieu Hazelwood. “The Effects of TARP on Bank Risk-Taking,” *Federal Reserve International Finance Discussion Paper* No. 1043 (2012).

Blundell, Richard, and Stephen Bond. “Initial Conditions and Moment Restrictions in Dynamic Panel Data Models,” *Journal of Econometrics* 87 (1998): 115-143.

Brei, Michael, Leonardo Gambacorta, and Goetz von Peter. “Rescue Packages and Bank Lending,” *Journal of Banking and Finance* 37 (2013): 490-505.

Brunnermeier, Markus K., and Lasse Heje Pedersen. “Market Liquidity and Funding Liquidity,” *Review of Financial Studies* 22 (6) (2009): 2201-2238.

Brunnermeier, Markus K.. “Deciphering the Liquidity and Credit Crunch 2007-2008,” *Journal of Economic Perspectives* 23 (1) (2009): 77-100.

Carlson, Mark, Hui Shan, and Missaka Warusawitharana. “Capital Ratios and Bank Lending: A Matched Bank Approach,” *Federal Reserve Finance and Economics Discussion Series* 2011-34 (2011).

Cornett, Marcia Millon, Jamie John McNutt, Philip E. Strahan, and Hassan Tehranian. “Liquidity Risk Management and Credit Supply in the Financial Crisis,” *Journal of Financial Economics* 101 (2011): 297-312.

Distinguin, Isabelle, Caroline Roulet, and Amine Tarazi. “Bank Regulatory Capital and Liquidity: Evidence from US and European Publicly Traded Banks,” *Journal of Banking and Finance* 37 (2013): 3295-3317.

Drehmann, Mathias, and Leonardo Gambacorta. “The Effects of Countercyclical Capital Buffers on Bank Lending,” *Applied Economics Letters* 19 (2012): 603-608.

Federal Reserve Bank of Kansas City. *Basics for Bank Directors*, 2010.

Flannery, Mark J., and Kasturi P. Rangan. "What Caused the Bank Capital Build-up of the 1990s," *Review of Finance* 12 (2008): 391-429.

Francis, William B., and Matthew Osborne. "Capital Requirements and Bank Behavior in the UK: Are There Lessons for International Capital Standards?," *Journal of Banking and Finance* 36 (2012): 803-816.

Furfine, Craig. "Bank Portfolio Allocation: The Impact of Capital Requirements, Regulatory Monitoring, and Economic Conditions," *Journal of Financial Services Research* 20 (2001): 33-56.

Furlong, Frederick T.. "Capital Regulation and Bank Lending," *Federal Reserve Bank of San Francisco Economic Review* No. 3 (1992): 23-33.

Gambacorta, Leonardo, and David Marques-Ibanez. "The Bank Lending Channel: Lessons from the Crisis," *Economic Policy* 26 (2011): 135-182.

Gambacorta, Leonardo, and Paolo Emilio Mistrulli. "Does Bank Capital Affect Lending Behavior?," *Journal of Financial Intermediation* 13 (2004): 436-457.

Gropp, Reint, and Florian Heider. "The Determinant of Bank Capital Structure," *European Central Bank Working Paper Series* No. 1096 (2009).

Hancock, Diana, and James A. Wilcox. "Bank Capital and the Credit Crunch: The Roles of Risk-weighted and Unweighted Capital Regulations," *Journal of the American Real Estate and Urban Economics Association* 22 (1994): 59-94.

Hyun, Jung-Soon, and Byung-Kun Rhee. "Bank Capital Regulation and Credit Supply," *Journal of Banking and Finance* 35 (2011): 323-330.

Ivashina, Victoria, and David Scharfstein. "Bank Lending During the Financial Crisis of 2008," *Journal of Financial Economics* 97 (2010): 319-338.

Jackson, Patricia, Craig Furfine, Hans Groeneveld, Diana Hancock, David Jones, William Perraudin, Lawrence Radecki, and Masao Yoneyama. "Capital Requirements and Bank Behavior: The Impact of the Basel Accord," *Basel Committee on Banking Supervision Working Paper* No. 1 (1999).

Jacques, Kevin, and Peter Nigro. "Risk-based Capital, Portfolio Risk, and Bank Capital: A Simultaneous Equations Approach," *Journal of Economics and Business* 49 (1997): 533-547.

Jokipii, Terhi, and Alistair Milne. "Bank Capital Buffer and Risk Adjustment Decisions," *Journal of Financial Stability* 7 (2011): 165-178.

Judson, Ruth A., and Ann L. Owen. "Estimating Dynamic Panel Data Models: A Guide for Macroeconomists," *Economics Letters* 65 (1999): 9-15.

Kapan, Tümer, and Camelia Minoiu. "Balance Sheet Strength and Bank Lending During the Global Financial Crisis," *IMF Working Paper* No. 13/102 (2013).

Kashyap, Anil K., and Jeremy C. Stein. "The Impact of Monetary Policy on Bank Balance Sheets," *Carnegie Rochester Conference Series on Public Policy* 42 (1995): 151-195.

__________. "What Do a Million Observations on Banks Say About the Transmission of Monetary Policy?," *The American Economic Review* 90 (3) (2000): 407-428.

Lee, Seung Jung, and Viktors Stebunovs. "Bank Capital Ratios and the Structure of Nonfinancial Industries," *Federal Reserve Finance and Economics Discussion Series* 2012-53 (2012).

Martín-Oliver, Alfredo, Sonia Ruano, and Vicente Salas-Fumás. “Banks’ Equity Capital Frictions, Capital Ratios, and Interest Rates: Evidence from Spanish Banks,” *International Journal of Central Banking* 9 (1) (2013): 183-225.

Maurin, Laurent, and Mervi Toivanen. “Risk, Capital Buffer and Bank Lending: A Granular Approach to the Adjustment of Euro Area Banks,” *European Central Bank Working Paper Series* No. 1499 (2012).

Meh, Césaire, and Kevin Moran. “The Role of Bank Capital in the Propagation of Shocks,” *Journal of Economic Dynamics and Control* 34 (3) (2010): 555-576.

Meh, Césaire. “Bank Balance Sheets, Deleveraging and the Transmission Mechanism,” *Bank of Canada Review* Summer (2011): 23-34.

Papanikolaou, Nikolaos I., and Christian C.P. Wolff. “Leverage and Risk in US Commercial Banking in the Light of the Current Financial Crisis,” *Central Bank of Luxembourg Financial Stability Review* April (2010): 111-125.

Peek, Joe, and Eric Rosengren. “The Capital Crunch: Neither a Borrower nor a Lender Be,” *Journal of Money, Credit, and Banking* 27 (3) (1995): 625-638.

Roodman, David. “How to Do xtabond2: An Introduction to ‘Difference’ and ‘System’ GMM in Stata,” *Center for Global Development Working Paper* No. 103 (2006).

Shim, Jeungbo. “Bank Capital Buffer and Portfolio Risk: The Influence of Business Cycle and Revenue Diversification,” *Journal of Banking and Finance* 37 (2013): 761-772.

Valencia, Fabian. “Bank Capital and Uncertainty,” *IMF Working Paper* No. 10/208 (2010).

VanHoose, David. “Bank Capital Regulation, Economic Stability, and Monetary Policy: What Does the Academic Literature Tell Us?,” *Atlantic Economic Journal* 36 (2008): 1-14.

__________. “Theories of Bank Behavior under Capital Regulation,” *Journal of Banking and Finance* 31 (2007): 3680-3697.

Wall, Larry D., and David R. Peterson. “Bank Holding Company Capital Targets in the Early 1990s: The Regulators Versus the Markets,” *Journal of Banking and Finance* 19 (1995): 563-574.

Wall, Larry D., and Pamela P. Peterson. “Banks’ Responses to Binding Regulatory Capital Requirements,” *Federal Reserve Bank of Atlanta Economic Review* 81 (2) (1996): 1-17.

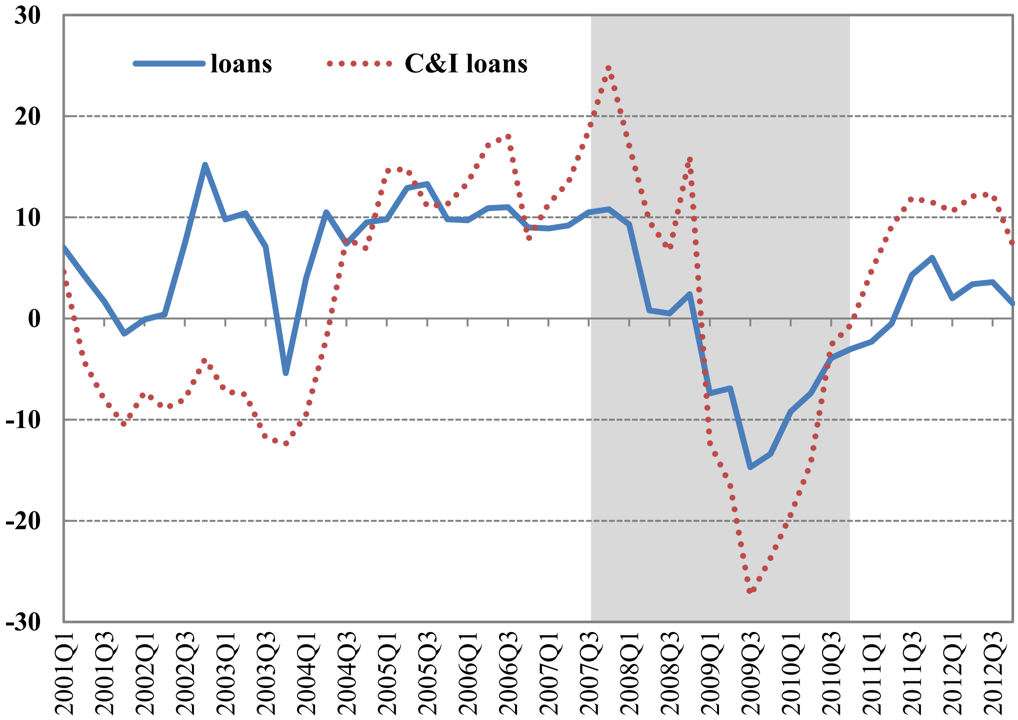
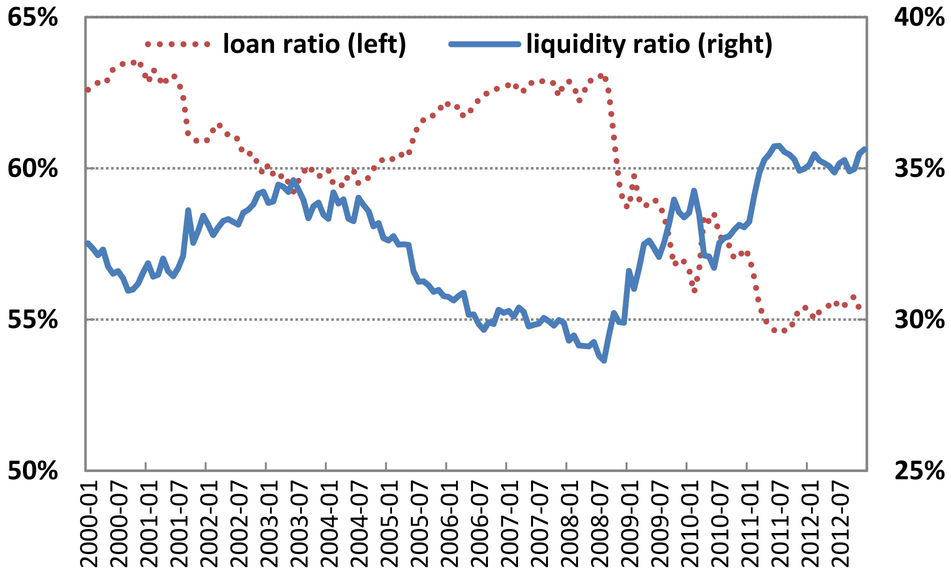


Figure 1. Growth rates of loans and Commercial and Industrial loans

Source: Federal Reserve Bank H.8.
Note: Annual growth rates, seasonally adjusted. A shaded area is from 2007q3 to 2010q4.

(a)



(b)

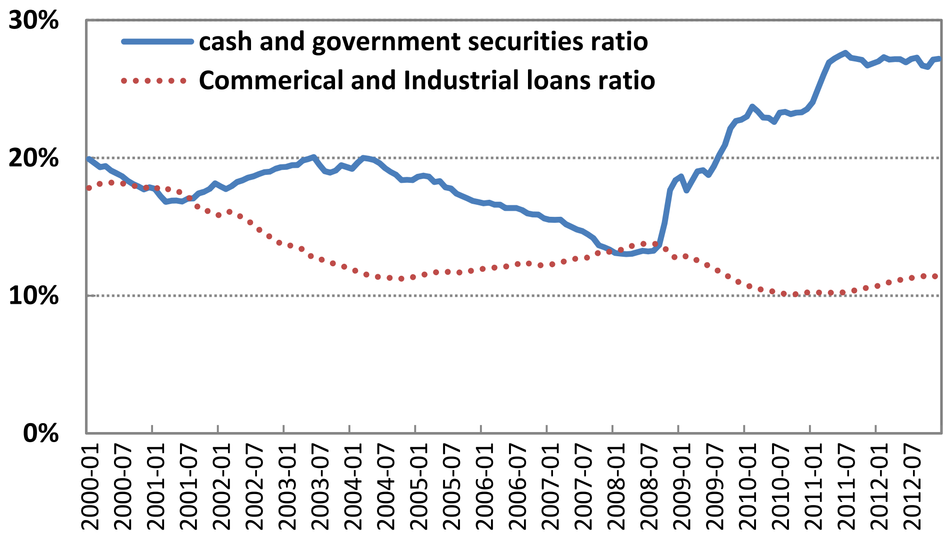


Figure 2. The trend of the proportions of liquid assets and loans

Source: Federal Reserve Bank H.8. Assets and liabilities of commercial banks in the United States.
Note: Liquidity ratio = (cash + securities + interbank loans + fed funds and reverse RPs with banks) / total assets

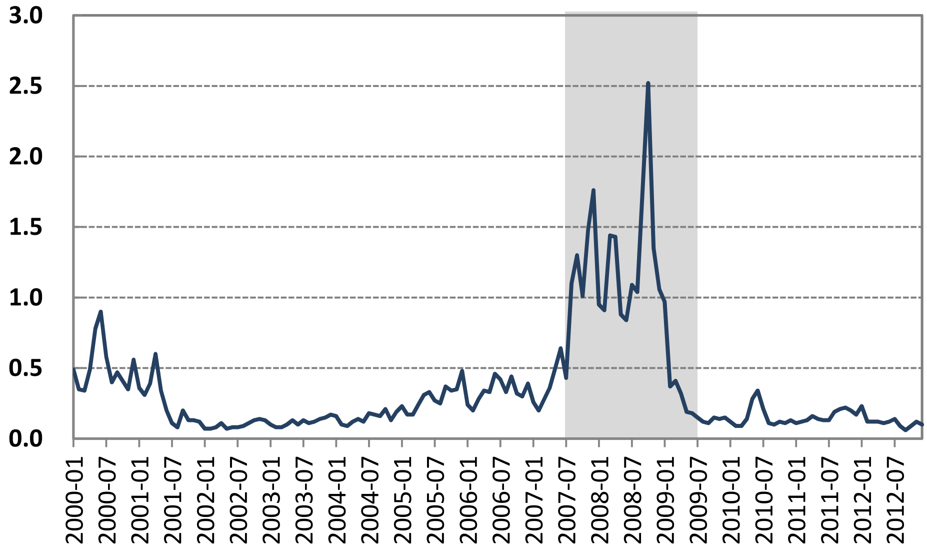


Figure 3. Credit spread

Source: Federal Reserve Bank H15.
Note: 3-month commercial paper (Financial) market rate – 3-month T-bill secondary market rate. A shaded area is from 2007q3 to 2009q2.

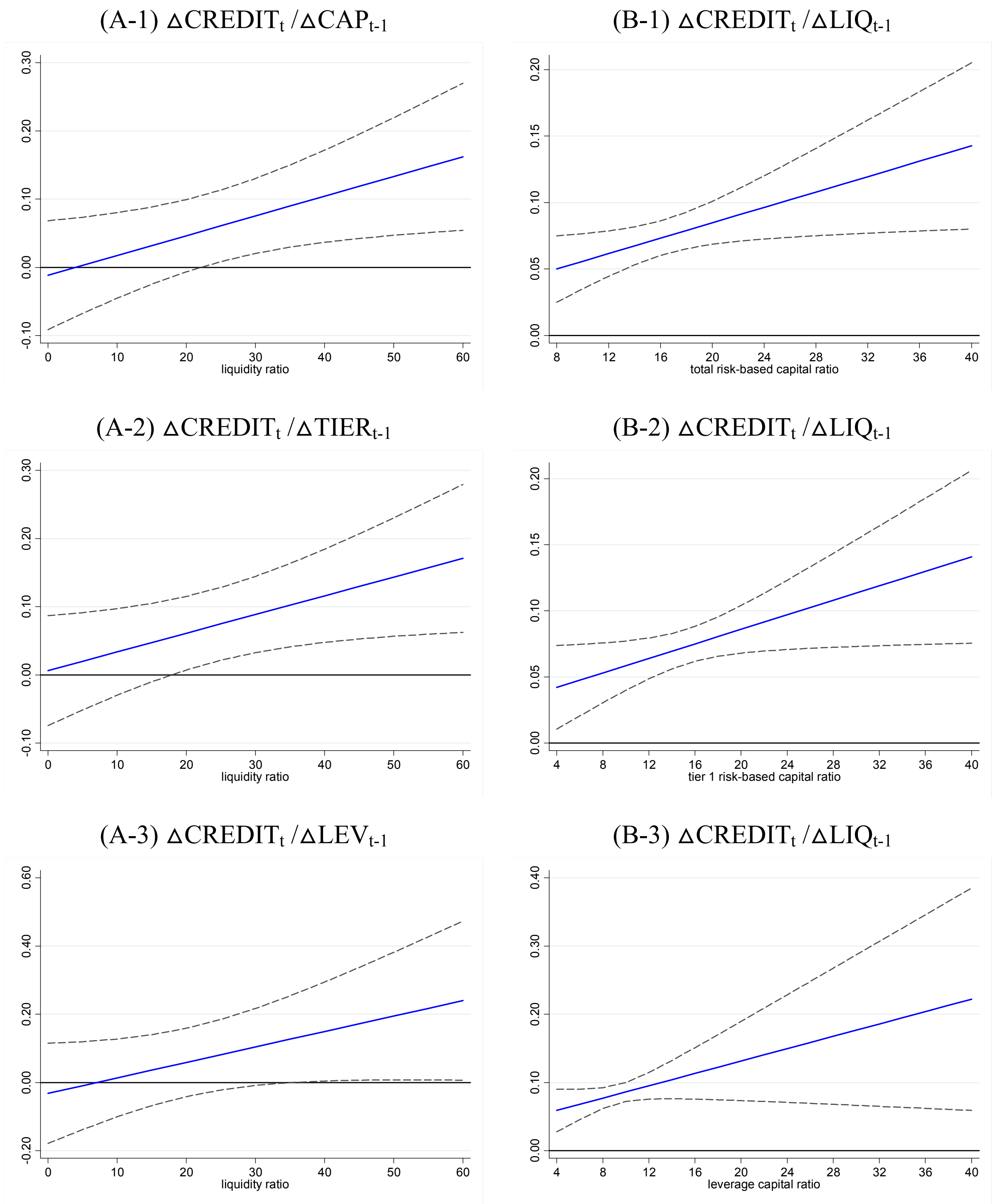


Figure 4. The effects of capital ratio and liquidity ratio on credit growth for all banks

Note: The figures illustrate the results of Eqs (4)-(6) in the table 7. The change in the growth rate of credit for a 1 percentage point increase in the regulatory capital ratio (left column). The change in the growth rate of credit for a 1 percentage point increase in the liquidity ratio (right column). The dashed lines are 10% and 90% confidence intervals calculated with the delta method.

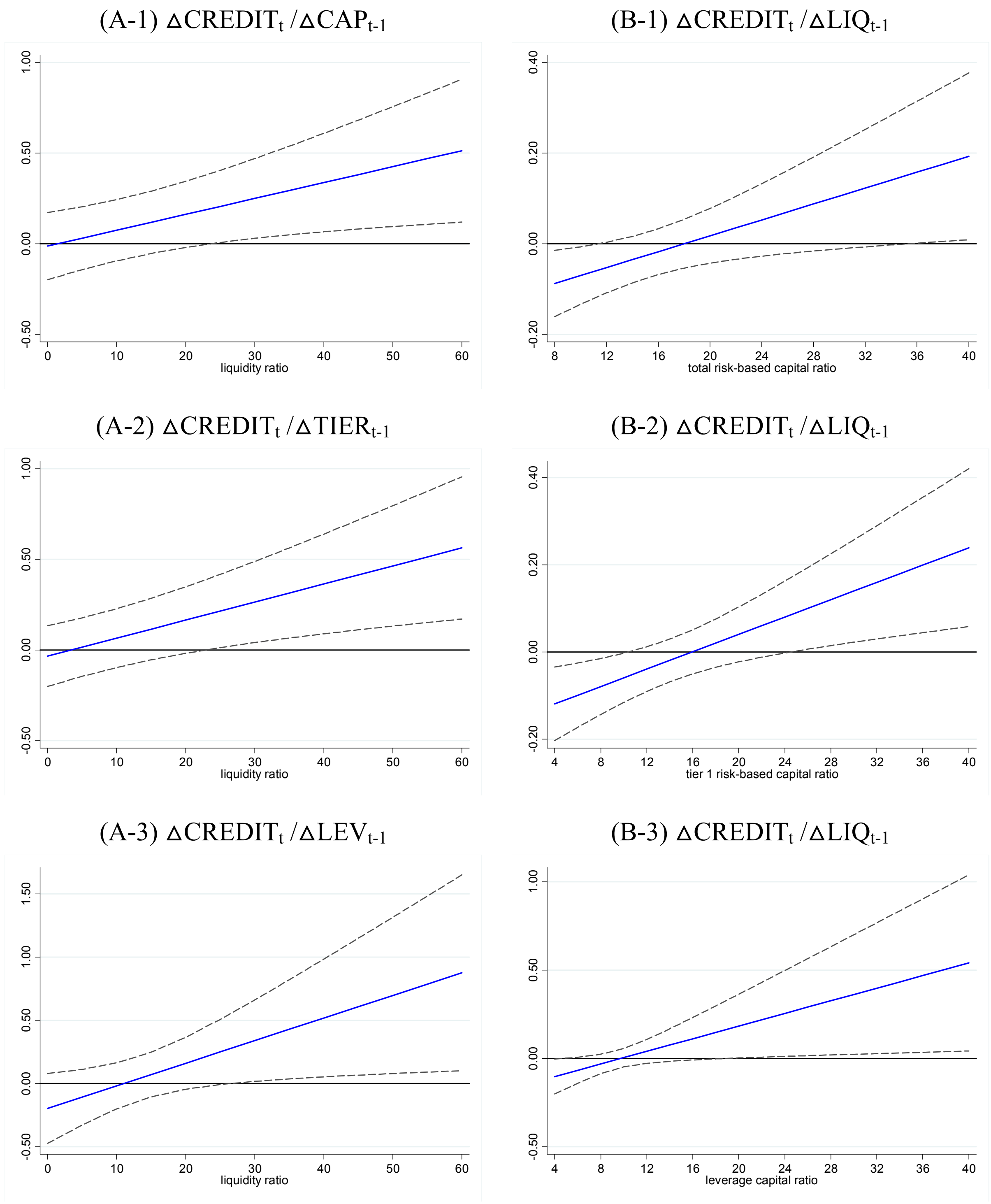


Figure 5. The effects of capital ratio and liquidity ratio on credit growth for large banks

Note: The figures illustrate the results of Eqs (1)-(3) in the table 9. The change in the growth rate of credit for a 1 percentage point increase in the regulatory capital ratio (left column). The change in the growth rate of credit for a 1 percentage point increase in the liquidity ratio (right column). The dashed lines are 10% and 90% confidence intervals calculated with the delta method.

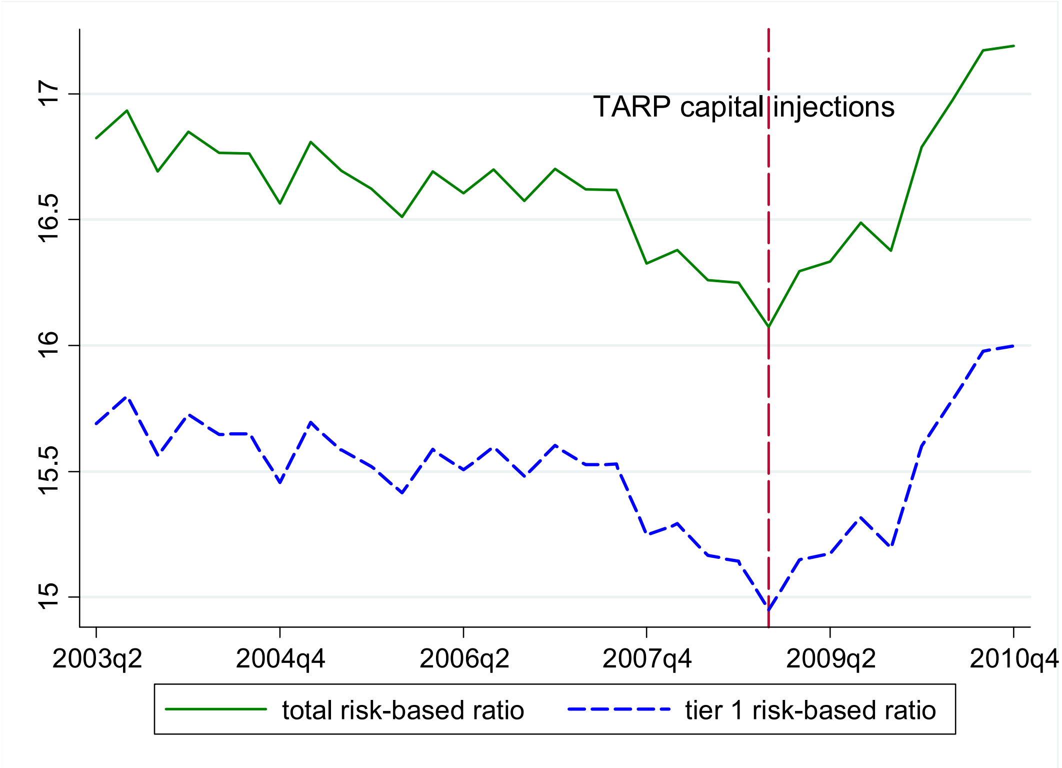


Figure 6. Regulatory capital ratios and TARP capital injections

Source: FDIC SDI.
Note: The graph is obtained from the sample, all the examined 1,050 banks.

Table 1. Definition of bank charter class and the share of assets

code	Description	No. of banks	Share
N	National(federal) charter and Fed member commercial banks that are supervised by the OCC	1,383	63.2%
NM	State charter and Fed nonmember commercial banks that are supervised by the FDIC	4,318	14.5%
SM	State charter and Fed member commercial banks that are supervised by the Federal Reserve	829	12.7%
SA	FDIC supervised state chartered thrifts and OCC supervised federally chartered thrifts	731	7.0%
SB	State charter saving banks that are supervised by the FDIC	397	2.4%
OI	Insured U.S. branch of a foreign chartered institution	9	0.2%

Note: Descriptions are taken from the FDIC SDI variable definitions. Data are as of 2010q4.

Table 2. Description of the dataset

	Whole periods (2003q1~2010q4)				Pre-Crisis	Crisis 1	Crisis 2
	All Banks (1)	Large Banks (2)	Medium Banks (3)	Small Banks (4)	2003q1 ~2007q2 (5)	2007q3 ~2009q2 (6)	2007q3 ~2010q4 (7)
Assets (mil. USD)	2,821.12	48,931.89	347.66	75.44	2,317.51	3,370.18	3,432.63
Growth rate of assets	1.31	1.68	1.30	1.27	1.44	1.42	1.15
Growth rate of loans	1.28	1.64	1.27	1.24	1.85	1.23	0.59
Growth rate of credit	1.25	1.55	1.24	1.22	1.97	0.96	0.37
Growth rate of C&I loans	0.65	1.28	0.55	0.68	1.56	-0.01	-0.46
Net loans to assets	60.81	63.38	63.00	57.89	60.63	62.22	61.04
C&I loans to assets	9.33	13.93	9.46	8.60	9.62	9.44	8.97
Credit to assets	71.37	89.09	74.02	66.03	71.56	73.12	71.14
Securities to assets	25.14	21.35	24.69	26.15	25.99	23.86	24.11
Liquid assets to assets	22.70	16.00	20.04	26.69	23.07	21.13	22.25
Non-deposits to assets	6.29	16.87	7.10	4.03	6.31	6.85	6.27
Net interest margin	4.10	3.86	4.01	4.23	4.19	4.04	3.99
Return on assets	1.00	0.98	1.05	0.95	1.19	0.91	0.78
Return on equity	10.08	10.91	10.78	9.16	12.11	9.11	7.62
Net loans to deposits	80.33	80.56	78.54	71.05	82.82	83.99	78.26
Net charge-offs to loans	0.32	0.68	0.33	0.27	0.19	0.34	0.49
Loss allowance to loans	1.40	1.61	1.35	1.44	1.34	1.32	1.48
Noncurrent loans to loans	1.39	1.50	1.42	1.35	0.92	1.49	1.98
Equity capital to assets	10.33	9.75	10.00	10.79	10.20	10.43	10.48
Leverage ratio	9.98	8.25	9.66	10.57	9.98	10.04	9.97
Tier 1 risk-based capital ratio	15.50	11.07	14.49	17.25	15.59	15.21	15.39
Total risk-based capital ratio	16.63	12.77	15.60	18.32	16.70	16.32	16.54
No. of banks	1,050	56	540	454	1,050	1,050	1,050
No. of observations	32,550	1,736	16,740	14,074	17,850	8,400	14,700

Source: FDIC SDI.
Note: The sample period goes from 2003q1 to 2010q4. Large banks are banks with assets greater than $10 billion, medium banks are banks with assets between $1 billion and $10 billion, and small banks are banks with assets less than $1 billion at the first quarter of 2003.

Table 3. Definition and source of the variables used in the regressions

Variable	Description	Source
Dependent variables		
$LOAN_t$	Quarterly growth rate of loans (%)	FDIC SDI
$CREDIT_t$	Quarterly growth rate of loans and unused commitments (%)	FDIC SDI
Bank-specific characteristic variables		
CAP_{t-1}	Total risk-based ratio (%)	FDIC SDI
$TIER_{t-1}$	Tier 1 risk-based ratio (%)	FDIC SDI
LEV_{t-1}	Leverage ratio (%)	FDIC SDI
LIQ_{t-1}	Ratio of liquid assets to total assets (%)	FDIC SDI
$SIZE_{t-1}$	Logarithm of total assets	FDIC SDI
$MFUND_{t-1}$	Ratio of non-deposit liabilities to total assets (%)	FDIC SDI
$COMMIT_{t-1}$	Ratio of unused commitments to total assets (%)	FDIC SDI
ROA_{t-1}	Return on total assets (%)	FDIC SDI
NPL_{t-1}	Noncurrent loans to total loans (%)	FDIC SDI
Macroeconomics controls		
$\triangle GDP_{t-1}$	Quarterly growth rate of real GDP (%)	BEA
$\triangle MP_{t-1}$	Change in the 3-month federal funds effective rate (%)	FRB
$CRISIS_t$	Dummy, 1 for the period between 2007q3 and 2009q2 (or 2010q4)	

Note: Liquid assets = (cash and balances due from depository institutions + securities + federal funds sold and reverse repurchases – pledged securities)

Table 4. Summary statistics of the variables used in the regressions

Variable	Mean	Std	Min	p25	p75	Max
Dependent variables (L_t)						
$LOAN_t$	1.28	4.92	-42.01	-1.22	3.48	48.59
$CREDIT_t$	1.25	5.05	-46.70	-1.33	3.48	49.80
Bank-specific characteristic variables						
CAP_{t-1}	16.62	5.33	8.16	12.60	19.31	39.87
$TIER_{t-1}$	15.50	5.38	6.08	11.46	18.22	39.17
LEV_{t-1}	9.98	2.41	4.03	8.24	11.22	27.18
LIQ_{t-1}	22.73	13.50	0.49	12.44	30.64	79.16
$SIZE_{t-1}$	12.04	1.29	8.89	11.23	12.63	21.14
$MFUND_{t-1}$	6.31	7.15	0.00	0.90	9.37	88.61
$COMMIT_{t-1}$	10.59	13.14	0.00	4.94	13.43	315.71
ROA_{t-1}	1.02	0.97	-20.69	0.69	1.42	57.32
NPL_{t-1}	1.34	1.89	0.00	0.26	1.69	31.50
Macroeconomic controls						
$\triangle GDP_{t-1}$	0.40	0.76	-2.33	0.33	0.81	1.63
$\triangle MP_{t-1}$	-0.04	0.49	-1.66	-0.04	0.45	0.52

Note: This table reports the summary statistics of the variables used in the regressions. Data source are presented in the table 3 and the sample period goes from 2003q1 to 2010q4. The data are a balanced panel of 31,500 quarterly observations for 1,050 U.S. commercial banks. $LOAN_t$ and $CREDIT_t$ are quarterly growth rates of loans and credit, which is defined as loans plus unused commitments, respectively. Growth rates are calculated as $100\times(\ln(L_t)-\ln(L_{t-1}))$. CAP_{t-1} is the lagged total risk-based capital ratio, $TIER_{t-1}$ is the lagged tier 1 risk-based capital ratio, and LEV_{t-1} is the lagged leverage ratio. LIQ_{t-1} is the lagged liquidity ratio, which is defined as the liquid assets share of the total assets. Liquid assets are cash and balance due from depository institutions plus securities plus federal funds sold and reverse repurchases less pledged securities. $SIZE_{t-1}$ is measured by the logarithm of the lagged total assets. Market funding ($MFUND_{t-1}$) is the lagged ratio of non-deposit liabilities to total assets. $COMMIT_{t-1}$ is the lagged ratio of unused commitments to total assets. ROA_{t-1} is the lagged return on total assets and NPL_{t-1} is the lagged ratio of noncurrent loans to total loans. For the macroeconomic controls, quarterly growth rate of real GDP ($\triangle GDP_{t-1}$) and a change in the 3-month federal funds effective rate ($\triangle MP_{t-1}$) are used. These macroeconomic variables are also lagged by one quarter.

Table 5. Linear regressions

Dependent variables	$LOAN_t$		$CREDIT_t$	
	(1)	(2)	(3)	(4)
$LOAN(CREDIT)_{t-1}$	0.089***	0.089***	0.062***	0.058***
	(0.012)	(0.012)	(0.015)	(0.015)
CAP_{t-1}	0.134***	0.153***	0.051	0.081**
	(0.034)	(0.032)	(0.035)	(0.034)
LIQ_{t-1}	0.123***	0.113***	0.095***	0.077***
	(0.008)	(0.008)	(0.008)	(0.008)
$SIZE_{t-1}$	-4.541***	-3.625***	-5.785***	-4.701***
	(0.413)	(0.272)	(0.458)	(0.299)
$MFUND_{t-1}$	0.031**	0.029**	0.009	0.008
	(0.014)	(0.014)	(0.016)	(0.015)
$COMMIT_{t-1}$	0.271***	0.281***	-0.156***	-0.130***
	(0.030)	(0.030)	(0.024)	(0.023)
ROA_{t-1}	0.141**	0.119*	0.333***	0.322***
	(0.064)	(0.062)	(0.080)	(0.076)
NPL_{t-1}	-0.427***	-0.420***	-0.612***	-0.628***
	(0.035)	(0.035)	(0.037)	(0.037)
$\triangle GDP_{t-1}$		-0.000		0.010
		(0.036)		(0.041)
$\triangle MP_{t-1}$		-0.379***		-0.234***
		(0.064)		(0.068)
Constant	-1.042***	-0.358	-0.766**	0.162
	(0.300)	(0.303)	(0.305)	(0.313)
Bank dummies	Yes	Yes	Yes	Yes
Year dummies	Yes	No	Yes	No
Quarter dummies	Yes	Yes	Yes	Yes
Observations	31,500	31,500	31,500	31,500
Number of banks	1,050	1,050	1,050	1,050
Adjusted R-squared	0.156	0.154	0.122	0.116

Note: This table reports fixed effects regression results not including an interaction term of capital ratio and liquidity ratio. The sample period goes from 2003q1 to 2010q4. For the capital ratio variable (CAP_{t-1}), only total risk-based capital ratio is used. Capital ratio is normalized to the minimum regulatory requirement, 8%. All other bank-specific characteristic variables are normalized to their mean values. All the regressions include quarterly dummies to control for seasonal influences. Yearly dummies are included when macroeconomic control variables are not included. Robust standard errors, clustered at the bank-level, are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 6. Linear regressions with crisis interactions

Dependent variable	$LOAN_t$	$CREDIT_t$	$LOAN_t$	$CREDIT_t$
	(1)	(2)	(3)	(4)
$LOAN(CREDIT)_{t-1}$	0.089***	0.059***	0.087***	0.056***
	(0.012)	(0.015)	(0.012)	(0.015)
CAP_{t-1}	0.148***	0.076**	0.134***	0.071**
	(0.033)	(0.034)	(0.033)	(0.035)
CAP_{t-1}×CRISIS	0.027*	0.024	0.042**	0.043**
	(0.015)	(0.016)	(0.018)	(0.018)
LIQ_{t-1}	0.115***	0.081***	0.107***	0.069***
	(0.008)	(0.008)	(0.009)	(0.009)
LIQ_{t-1}×CRISIS	0.002	-0.001	0.017**	0.015*
	(0.007)	(0.007)	(0.008)	(0.008)
$SIZE_{t-1}$	-3.691***	-4.786***	-4.027***	-4.821***
	(0.275)	(0.307)	(0.354)	(0.391)
$SIZE_{t-1}$×CRISIS	0.098	0.062	0.043	-0.076
	(0.063)	(0.073)	(0.080)	(0.083)
$MFUND_{t-1}$	0.028**	0.009	0.029*	0.006
	(0.014)	(0.015)	(0.015)	(0.015)
$MFUND_{t-1}$×CRISIS	-0.001	-0.008	0.009	0.009
	(0.011)	(0.011)	(0.011)	(0.011)
$COMMIT_{t-1}$	0.279***	-0.134***	0.279***	-0.130***
	(0.029)	(0.023)	(0.028)	(0.022)
$COMMIT_{t-1}$×CRISIS	0.002	-0.011***	0.011*	-0.010***
	(0.004)	(0.003)	(0.006)	(0.004)
ROA_{t-1}	0.119*	0.325***	0.059	0.193**
	(0.064)	(0.084)	(0.084)	(0.090)
ROA_{t-1}×CRISIS	-0.005	-0.032	0.153	0.252**
	(0.098)	(0.108)	(0.102)	(0.111)
NPL_{t-1}	-0.397***	-0.591***	-0.494***	-0.644***
	(0.037)	(0.041)	(0.053)	(0.055)
NPL_{t-1}×CRISIS	-0.098**	-0.145***	0.090	0.031
	(0.043)	(0.049)	(0.059)	(0.062)
ΔGDP_{t-1}	0.022	0.077*	0.016	0.028
	(0.039)	(0.044)	(0.036)	(0.041)
ΔMP_{t-1}	-0.202***	0.120	-0.208***	-0.110
	(0.075)	(0.083)	(0.080)	(0.083)
CRISIS	0.074	0.440***	0.030	-0.110
	(0.164)	(0.170)	(0.211)	(0.214)
Constant	-0.393	0.028	-0.380	0.146
	(0.308)	(0.321)	(0.310)	(0.321)
Bank dummies	Yes	Yes	Yes	Yes
Quarter dummies	Yes	Yes	Yes	Yes
Observations	31,500	31,500	31,500	31,500
Number of bank	1,050	1,050	1,050	1,050
Adjusted R-squared	0.154	0.118	0.156	0.119

Note: This table reports fixed effects regression results with crisis dummy interactions, where crisis dummy takes the value of 1 for the period from 2007q3 to 2009q2 in Eq (1)-(2) and from 2007q3 to 2010q4 in Eq (3)-(4) and 0 elsewhere, respectively. The sample period goes from 2003q1 to 2010q4. For the capital ratio variable (CAP_{t-1}), only total risk-based capital ratio is used. Capital ratio is normalized to the minimum regulatory requirement, 8%. All other bank-specific characteristic variables are normalized to their mean values. All the regressions include quarterly dummies to control for seasonal influences. Robust standard errors, clustered at the bank-level, are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 7. Interaction effect of capital and liquidity

Dependent variable	$LOAN_t$			$CREDIT_t$		
Definition of CAP	Total risk-based ratio	Tier 1 risk-based ratio	Leverage ratio	Total risk-based ratio	Tier 1 risk-based ratio	Leverage ratio
	(1)	(2)	(3)	(4)	(5)	(6)
$LOAN(CREDIT)_{t-1}$	0.089***	0.089***	0.083***	0.059***	0.059***	0.057***
	(0.012)	(0.012)	(0.012)	(0.015)	(0.015)	(0.015)
CAP_{t-1}	0.143***	0.155***	0.100*	0.054*	0.069**	0.071
	(0.028)	(0.029)	(0.052)	(0.032)	(0.032)	(0.061)
LIQ_{t-1}	0.103***	0.100***	0.108***	0.050***	0.042**	0.059***
	(0.016)	(0.020)	(0.018)	(0.015)	(0.019)	(0.019)
$CAP_{t-1} \times LIQ_{t-1}$	0.001	0.001	0.003	0.003*	0.003*	0.005
	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)
$SIZE_{t-1}$	-3.649***	-3.618***	-3.791***	-4.766***	-4.736***	-4.754***
	(0.273)	(0.274)	(0.271)	(0.300)	(0.302)	(0.300)
$MFUND_{t-1}$	0.028**	0.029**	0.028**	0.004	0.005	0.007
	(0.014)	(0.014)	(0.014)	(0.015)	(0.015)	(0.015)
$COMMIT_{t-1}$	0.280***	0.280***	0.273***	-0.134***	-0.133***	-0.134***
	(0.029)	(0.029)	(0.029)	(0.023)	(0.023)	(0.022)
ROA_{t-1}	0.122**	0.118*	0.143**	0.332***	0.328***	0.333***
	(0.062)	(0.062)	(0.065)	(0.077)	(0.077)	(0.078)
NPL_{t-1}	-0.418***	-0.417***	-0.409***	-0.624***	-0.624***	-0.622***
	(0.035)	(0.035)	(0.035)	(0.038)	(0.038)	(0.037)
ΔGDP_{t-1}	-0.000	0.001	-0.003	0.010	0.011	0.011
	(0.036)	(0.036)	(0.037)	(0.041)	(0.041)	(0.042)
ΔMP_{t-1}	-0.379***	-0.376***	-0.367***	-0.234***	-0.233***	-0.224***
	(0.064)	(0.064)	(0.063)	(0.068)	(0.068)	(0.067)
Constant	-0.320	-0.865**	0.355	0.266	-0.054	0.402
	(0.281)	(0.364)	(0.337)	(0.303)	(0.397)	(0.391)
Bank dummies	Yes	Yes	Yes	Yes	Yes	Yes
Quarter dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	31,500	31,500	31,500	31,500	31,500	31,500
Number of banks	1,050	1,050	1,050	1,050	1,050	1,050
Adjusted R-squared	0.154	0.154	0.151	0.116	0.117	0.115

Note: This table reports fixed effects regression results including an interaction term of capital ratio and liquidity ratio. The sample period goes from 2003q1 to 2010q4. For the capital ratio variable (CAP_{t-1}), all three types of regulatory capital ratios are used, respectively. Capital ratios are normalized to their minimum regulatory requirements. All other bank-specific characteristic variables are normalized to their mean values. All the regressions include quarterly dummies to control for seasonal influences. Robust standard errors, clustered at the bank-level, are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 8. Interaction effect of capital and liquidity with crisis interactions

Dependent variable	LOAN$_t$			CREDIT$_t$		
Definition of CAP	Total risk-based ratio	Tier 1 risk-based ratio	Leverage ratio	Total risk-based ratio	Tier 1 risk-based ratio	Leverage ratio
	(1)	(2)	(3)	(4)	(5)	(6)
LOAN(CREDIT)$_{t-1}$	0.087***	0.087***	0.082***	0.057***	0.057***	0.055***
	(0.012)	(0.011)	(0.012)	(0.015)	(0.014)	(0.014)
CAP$_{t-1}$	0.115***	0.125***	0.050	0.035	0.047	0.060
	(0.030)	(0.030)	(0.059)	(0.034)	(0.034)	(0.069)
CAP$_{t-1}$×CRISIS	0.050**	0.053***	0.066**	0.051**	0.058***	0.050
	(0.020)	(0.020)	(0.033)	(0.020)	(0.020)	(0.035)
LIQ$_{t-1}$	0.088***	0.081***	0.095***	0.034**	0.024	0.053**
	(0.016)	(0.021)	(0.021)	(0.016)	(0.020)	(0.022)
LIQ$_{t-1}$×CRISIS	0.026**	0.029**	0.023	0.021*	0.023	0.004
	(0.012)	(0.014)	(0.018)	(0.012)	(0.014)	(0.018)
CAP$_{t-1}$×LIQ$_{t-1}$	0.002	0.002	0.004	0.004**	0.004**	0.004
	(0.002)	(0.002)	(0.004)	(0.002)	(0.002)	(0.004)
CAP$_{t-1}$×LIQ$_{t-1}$×CRISIS	-0.001	-0.001	-0.000	-0.001	-0.001	0.003
	(0.001)	(0.001)	(0.003)	(0.001)	(0.001)	(0.003)
SIZE$_{t-1}$	-4.085***	-4.042***	-4.360***	-4.941***	-4.887***	-4.951***
	(0.354)	(0.355)	(0.362)	(0.392)	(0.393)	(0.398)
SIZE$_{t-1}$×CRISIS	0.050	0.055	0.065	-0.067	-0.061	-0.078
	(0.081)	(0.081)	(0.078)	(0.085)	(0.085)	(0.082)
MFUND$_{t-1}$	0.027*	0.027*	0.027*	0.002	0.002	0.005
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.016)
MFUND$_{t-1}$×CRISIS	0.009	0.010	0.008	0.010	0.010	0.009
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
COMMIT$_{t-1}$	0.277***	0.277***	0.271***	-0.135***	-0.134***	-0.135***
	(0.028)	(0.028)	(0.027)	(0.022)	(0.022)	(0.022)
COMMIT$_{t-1}$×CRISIS	0.011**	0.011**	0.011**	-0.010**	-0.009**	-0.010**
	(0.006)	(0.006)	(0.005)	(0.004)	(0.004)	(0.004)
ROA$_{t-1}$	0.069	0.068	0.082	0.209**	0.207**	0.192**
	(0.086)	(0.086)	(0.090)	(0.093)	(0.093)	(0.094)
ROA$_{t-1}$×CRISIS	0.147	0.139	0.175*	0.247**	0.238**	0.281**
	(0.103)	(0.102)	(0.105)	(0.113)	(0.113)	(0.112)
NPL$_{t-1}$	-0.490***	-0.488***	-0.483***	-0.638***	-0.638***	-0.639***
	(0.053)	(0.053)	(0.053)	(0.055)	(0.055)	(0.055)
NPL$_{t-1}$×CRISIS	0.087	0.087	0.087	0.028	0.028	0.033
	(0.058)	(0.058)	(0.059)	(0.062)	(0.062)	(0.063)
ΔGDP$_{t-1}$	0.016	0.018	0.010	0.028	0.030	0.028
	(0.036)	(0.036)	(0.038)	(0.041)	(0.041)	(0.043)
ΔMP$_{t-1}$	-0.203**	-0.203**	-0.160**	-0.095	-0.098	-0.078
	(0.079)	(0.079)	(0.079)	(0.083)	(0.083)	(0.082)
CRISIS	0.017	-0.165	0.077	-0.117	-0.350	-0.026
	(0.214)	(0.267)	(0.242)	(0.217)	(0.270)	(0.252)
Constant	-0.312	-0.757**	0.429	0.275	0.041	0.358
	(0.293)	(0.378)	(0.375)	(0.313)	(0.411)	(0.425)
Bank dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	31,500	31,500	31,500	31,500	31,500	31,500
Number of bank	1,050	1,050	1,050	1,050	1,050	1,050
Adjusted R-squared	0.156	0.156	0.153	0.119	0.120	0.118

Note: This table reports fixed effects regression results with crisis dummy interactions, where crisis dummy takes the value of 1 for the period from 2007q3 to 2010q4 and 0 elsewhere. The sample period goes from 2003q1 to 2010q4. For the capital ratio variable (CAP$_{t-1}$), all three types of regulatory capital ratios are used, respectively. Capital ratios are normalized to their minimum regulatory requirements. All other bank-specific characteristic variables are normalized to their mean values. All the regressions include quarterly dummies to control for seasonal influences. Robust standard errors, clustered at the bank-level, are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 9. Interaction effect of capital and liquidity by bank size

	Large banks			Medium banks			Small banks		
Definition of CAP	Total risk-based ratio	Tier 1 risk-based ratio	Leverage ratio	Total risk-based ratio	Tier 1 risk-based ratio	Leverage ratio	Total risk-based ratio	Tier 1 risk-based ratio	Leverage ratio
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$CREDIT_{t-1}$	0.104***	0.103***	0.104***	0.052***	0.052***	0.051***	0.066***	0.066***	0.062***
	(0.035)	(0.035)	(0.035)	(0.018)	(0.018)	(0.018)	(0.023)	(0.023)	(0.023)
CAP_{t-1}	0.186	0.193	0.209	-0.011	0.005	-0.057	0.101**	0.118**	0.214**
	(0.116)	(0.117)	(0.141)	(0.037)	(0.038)	(0.068)	(0.050)	(0.051)	(0.095)
LIQ_{t-1}	-0.088*	-0.119**	-0.102*	0.062***	0.056***	0.050**	0.056**	0.052	0.100***
	(0.044)	(0.051)	(0.060)	(0.016)	(0.020)	(0.024)	(0.025)	(0.032)	(0.029)
$CAP_{t-1}\times LIQ_{t-1}$	0.009**	0.010**	0.018*	0.003	0.002	0.006	0.002	0.002	-0.001
	(0.004)	(0.004)	(0.010)	(0.002)	(0.002)	(0.005)	(0.002)	(0.002)	(0.004)
$SIZE_{t-1}$	-4.220***	-4.229***	-4.172***	-4.884***	-4.860***	-4.913***	-4.727***	-4.675***	-4.616***
	(0.695)	(0.713)	(0.699)	(0.347)	(0.348)	(0.328)	(0.544)	(0.546)	(0.551)
$MFUND_{t-1}$	0.017	0.018	0.016	-0.005	-0.004	-0.006	0.015	0.016	0.022
	(0.045)	(0.045)	(0.045)	(0.016)	(0.016)	(0.016)	(0.030)	(0.030)	(0.030)
$COMMIT_{t-1}$	-0.067*	-0.066*	-0.071**	-0.154***	-0.153***	-0.151***	-0.171***	-0.170***	-0.173***
	(0.034)	(0.035)	(0.034)	(0.031)	(0.031)	(0.031)	(0.039)	(0.039)	(0.039)
ROA_{t-1}	0.322***	0.319***	0.332***	0.377***	0.372***	0.395***	0.257*	0.251*	0.252*
	(0.093)	(0.092)	(0.098)	(0.129)	(0.129)	(0.129)	(0.131)	(0.131)	(0.131)
NPL_{t-1}	-0.673***	-0.668***	-0.644***	-0.633***	-0.635***	-0.631***	-0.610***	-0.609***	-0.605***
	(0.126)	(0.127)	(0.144)	(0.055)	(0.055)	(0.055)	(0.056)	(0.056)	(0.056)
ΔGDP_{t-1}	0.321**	0.324**	0.317**	-0.032	-0.031	-0.039	0.026	0.028	0.035
	(0.140)	(0.140)	(0.138)	(0.054)	(0.054)	(0.055)	(0.067)	(0.067)	(0.068)
ΔMP_{t-1}	0.369	0.364	0.370	-0.258***	-0.259***	-0.266***	-0.271**	-0.268**	-0.244**
	(0.271)	(0.269)	(0.272)	(0.090)	(0.090)	(0.090)	(0.111)	(0.110)	(0.108)
Constant	15.720***	15.212***	15.840***	3.387***	3.239***	3.712***	-5.666***	-6.120***	-5.869***
	(2.801)	(3.114)	(2.714)	(0.390)	(0.492)	(0.437)	(0.545)	(0.617)	(0.596)
Bank dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,680	1,680	1,680	16,200	16,200	16,200	13,620	13,620	13,620
Number of banks	56	56	56	540	540	540	454	454	454
Adjusted R-squared	0.217	0.217	0.216	0.136	0.136	0.136	0.096	0.096	0.095

Note: Large banks are banks with assets greater than $10 billion, medium banks are banks with assets between $1 billion and $10 billion, and small banks are banks with assets less than $1 billion at 2003q1. The sample period goes from 2003q1 to 2010q4. The dependent variable is the quarterly growth rate of credit. Capital ratios are normalized to their minimum regulatory requirements. All other bank-specific characteristic variables are normalized to their mean values. All the regressions include quarterly dummies to control for seasonal influences. Robust standard errors, clustered at the bank-level, are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 10. Robustness checks

	All banks			Large banks		
Definition of CAP	Total risk-based ratio	Tier 1 risk-based ratio	Leverage ratio	Total risk-based ratio	Tier 1 risk-based ratio	Leverage ratio
	(1)	(2)	(3)	(4)	(5)	(6)
$CREDIT_{t-1}$	0.058***	0.058***	0.055***	0.060	0.061	0.058
	(0.015)	(0.015)	(0.015)	(0.044)	(0.043)	(0.043)
CAP_{t-1}	0.094*	0.108**	0.094	0.028	0.011	-0.008
	(0.050)	(0.051)	(0.093)	(0.167)	(0.169)	(0.248)
LIQ_{t-1}	0.077***	0.067***	0.086***	-0.010	-0.059	-0.068
	(0.016)	(0.020)	(0.021)	(0.049)	(0.061)	(0.069)
$CAP_{t-1} \times LIQ_{t-1}$	0.003*	0.003*	0.005	0.007	0.012**	0.026*
	(0.002)	(0.002)	(0.003)	(0.005)	(0.005)	(0.014)
$SIZE_{t-1}$	-6.355***	-6.292***	-6.421***	-7.632***	-7.785***	-7.346***
	(0.690)	(0.693)	(0.687)	(1.277)	(1.326)	(1.252)
$MFUND_{t-1}$	-0.002	-0.002	-0.000	0.056	0.055	0.059
	(0.022)	(0.022)	(0.023)	(0.061)	(0.061)	(0.064)
$COMMIT_{t-1}$	-0.204***	-0.204***	-0.205***	-0.094**	-0.096**	-0.093**
	(0.028)	(0.028)	(0.028)	(0.042)	(0.041)	(0.043)
ROA_{t-1}	0.213**	0.208*	0.220**	1.079**	1.102**	1.075**
	(0.108)	(0.107)	(0.111)	(0.477)	(0.475)	(0.450)
NPL_{t-1}	-0.696***	-0.696***	-0.684***	-1.348***	-1.343***	-1.332***
	(0.052)	(0.052)	(0.050)	(0.287)	(0.291)	(0.288)
Constant	-1.431***	-1.852***	-1.103**	26.130***	26.672***	25.430***
	(0.393)	(0.533)	(0.507)	(4.458)	(4.931)	(4.384)
Bank dummies	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Quarter dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	23,100	23,100	23,100	1,232	1,232	1,232
Number of banks	1,050	1,050	1,050	56	56	56
Adjusted R-squared	0.083	0.083	0.081	0.100	0.101	0.102

Note: This table reports fixed effects regression results excluding the period after TARP capital injections. Thus, the sample period goes from 2003q1 to 2008q4. The dependent variable is the quarterly growth rate of credit. For the capital ratio variable (CAP_{t-1}), all three types of regulatory capital ratios are used, respectively. Capital ratios are normalized to their minimum regulatory requirements. All other bank-specific characteristic variables are normalized to their mean values. All the regressions include quarterly dummies to control for seasonal influences. Robust standard errors, clustered at the bank-level, are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.