THE EFFECTS OF BANK CAPITAL ON CREDIT SUPPLY IN RESPONSE TO CHANGES IN LEVELS OF LIQUIDITY: EVIDENCE FROM US COMMERCIAL BANKS FROM 2003 TO 2010

By

Dohan Kim

THESIS

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ABSTRACT

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This paper examines whether the effect of a change of bank capital ratios on lending differs depending on the level of liquidity. Using the balanced 1,050 U.S. commercial banks quarterly data from 2003 Q1 to 2010 Q4, this paper finds that the effect of bank capital on credit growth, where it is defined as a quarterly growth rate of loans and unused commitments, relates positively to the level of bank liquid assets. It also shows that the positive effect of bank capital increase on credit growth is significant only after banks retain enough liquid assets. This interaction effect did not change during the recent financial crisis period, and were more prominent for large banks. The results suggest three important policy implications. First, any policy actions to sustain bank lending, for example capital injections and liquidity support, are complementary and should be implemented harmoniously to be more effective. Second, if only capital injection is implemented, this would be more effective for banks with high liquid assets in the light of boosting credit supply. At last, international regulatory efforts to induce banks to hold more liquid assets and capital would be a right direction since banks with more liquid assets and capital would be able to supply more credit thanks to their increased capability of absorbing negative economic shocks.

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I. Introduction

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

After the recent financial crisis, the importance of financial stability of the banking systems has been issued to regulators, academics and policymakers. Especially, with the Basel Committee on Banking Supervision (BCBS) at the center, regulators and policymakers have highlighted the importance of sufficient capital buffers and sound liquidity risk management for the stability of the banking systems. As a result, Basel III, which requires enhanced quality and quantity of capital as well as sufficient amount of stable funding based on the liquidity of bank’s assets, has been recently endorsed internationally. The idea is also based on the belief that banks holding sufficient capital, liquid assets, and stable funding structure would maintain their intermediation capacity better in response to external negative economic shocks.

One of the main objectives of reforms to strengthen global capital and liquidity rules, as emphasized by the Basel Committee, is to build the foundation for sustainable economic growth with a strong and resilient banking system (BCBS, 2011). That is to say, it is to prevent losses caused by spilling over from negative shocks in the financial sector to the real economy. In this context, a number of researches have examined the effects of financial shocks on real economic activity and the procyclical features of risk-based capital ratios, which may worsen financial shocks further by inducing banks to reduce the supply of credit when needed the most.

Above all, however, understanding a relationship between bank capital and lending is a

[1] Federal Reserve Board, Press Release June 7, 2012
http://www.federalreserve.gov/newsevents/press/bcreg/20120607a.htm

key to 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 research questions to verify the linkage between financial sector and real activity. For example, bank capital plays a key role in a framework for the macro-financial linkage developed by Bayoumi and Malander (2008). In their framework, a relationship between the bank capital ratio and lending standards is the first link. Banks tighten their lending standards in response to a negative shock on the capital ratio, causing a decrease in the credit volume. They find that a reduction of the bank capital ratio by one percentage point results in 2.5% decrease of change in credit to GDP ratio, and finally causes 1.5% reduction in the level of GDP. Furthermore, it is also important 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, the channel through which monetary policy and shocks to bank capital affect bank lending. Thus, it is hard to comprehend the effect of monetary policy on real economy without verifying the relationship between bank capital and lending

Figure 1 shows that a growth rate of bank lending has dropped significantly during 2008 and 2010, which is considered the most severe crisis period. A shortage of capital was spotted as one of key factors that limit banks' ability to make loans. For this reason, many studies that examine the effect of changes in bank capital on lending have emerged recently. (see Berrospide and Edge, 2010; Gambacorta and Marques-Ibanez, 2011; Carlson *et al.*, 2011; Brei *et al.*, 2013). On the other hand, some papers have focused on other factors that caused a slowdown of bank lending during the recent financial crisis. For instance, 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 caused a decline in bank lending during the recent crisis. Similarly, Ivashina and Scharfstein (2010) show that a drop in the supply of bank lending was greater for banks with less access to deposit financing and more exposed to credit-line drawdowns.

The idea of this paper is based on the conclusions of a number of related literatures that highlight the importance of other bank-specific characteristics on bank lending (Berrospide and Edge, 2010; Gambacorta and Marques-Ibanez, 2011). In fact, researches to date have focused on a linear relationship between bank capital ratios and bank lending or examined whether there was a structural change in response to external shocks. To my best knowledge, there are no studies that examine the interaction effect of bank capital and liquidity on lending. In this regard, this paper examines whether the effect of bank capital on lending changes depending on the level of bank liquidity using the balanced 1,050 U.S. commercial banks quarterly data from 2003 Q1 to 2010 Q4.

The main results are as follows. The effect of bank capital on credit[2], which is defined as net loans on the balance sheet plus unused commitments off the balance sheet, relates positively to the level of bank liquidity. The results suggest that the effect of bank capital increases leads to bank lending increases only after banks retain enough liquid assets. This interaction effect did not change during the crisis period, and more prominent for large banks. The results suggest three important policy implications. First, any policy actions such as capital injections and liquidity support to sustain bank lending are complementary and should be implemented harmoniously to be more effective. Second, if only capital injection is implemented, this would be more effective for banks with high liquid assets in terms of only supporting credit supply. Third, recent international regulatory reform efforts that emphasize the importance of sufficient capital and liquidity management are supported. BCBS (2011) underlines the importance of liquidity management because banks failing to manage their liquidity well have suffered despite of adequate capital levels during the recent financial crisis. The results imply that banks with high amount of capital and liquid assets would cut

[2] In this paper, the term "credit" is defined as net loans on the balance sheet plus unused commitments off the balance sheet while "loan" is defined as net loans.

credit supply less in response to external shocks than banks with lack of capital and liquid assets although newly imposed liquidity regulation may change banks' behavior in an unexpected way.

This paper makes two contributions to the literature. First, it shows that the interaction effect of bank capital and liquidity on credit supply is significant, which may imply that the relationship between bank capital and lending is complicated rather than a linear. Researches to date have focused on the linear relationship between bank capital and lending. Second, it shows that a role of unused commitments should be considered when 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, which is defined as net loans on the balance sheet plus unused commitments off the balance sheet, is maybe the more appropriate measure for bank lending. This view is consistent with Cornett *et al.* (2011) and Ivashina and Scharfstein (2010).

The paper is organized as follows. Section 2 reviews the literature. In section 3, our hypotheses are discussed. Section 4 briefly describes the data used. Section 5 describes the empirical methodology and variables. Section 6 presents regression results and Section 7 addresses robustness issues. At last, Section 8 concludes and discusses policy implications.

II. Literature review

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

There are two strands of the literature that examine the effect of bank capital on lending. This is because there is an issue about how to judge whether banks are well-capitalized. One may look at the actual capital ratio compared to some absolute numbers such as the minimum regulatory requirements, 8%, and 10%, which are the levels viewed as well-capitalized banks by capital adequacy guidelines (e.g., see Bernanke and Lown, 1990; Gambacorta and Mistrulli, 2004; Carlson *et al.*, 2011; Das and Sy, 2012; Brei *et al*., 2013; Kapan and Minoiu, 2013). However, some researchers prefer to use the gap between the estimated target capital ratio and the actual capital ratio to evaluate whether banks are well-capitalized (e.g., see 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 one potential problem with the analysis using the target capital ratio is that any models used to estimate the target capital ratio can be misspecified. If the model is poor, any results of using the estimated target capital ratio are easily biased. On the other hand, Carlson *et al*. (2011) point out that analysis using the target capital ratio can explain why some banks adjust lending policies to move toward higher capital ratios even if the capital ratios look high enough.

It is arguable which approach is better to examine the effect of bank capital ratio on bank lending. Although there is a general agreement that banks manage their capital ratios actively to reach the implicit target capital ratios and many researchers use the concept of the bank target capital ratio as one of the determinants of the actual capital ratio, this study uses only the actual capital ratio for two reasons. First, I estimated the target capital ratio by using a partial adjustment model, which is used in a large number of literature (e.g., see 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 it was found that the target capital ratio was too volatile for the low adjustment speed, 10~20 percent on a quarterly basis. This result increases concerns about the bias of the estimated target capital ratio. Second, the main interest is the relationship between lending and the actual capital ratio that is observable rather implicit and unobservable target capital ratio. Besides, policies based on observable values are preferred. Therefore, in this study, only actual capital ratios are employed.

The effect of bank capital on lending

There have been many empirical studies that examined the effect of bank capital on lending, and most of them found positive effects of capital on lending albeit various degrees of the effects. In the early literature, Bernanke and Lown (1991) estimate that the effect of one percentage increase in bank capital on bank lending is about a 2~3 percentage point increase per year in loan growth. Although they conclude that the relationship between bank capital and lending is modest in size and the capital shortage is not a major factor in the lending slowdown, the estimates are somewhat larger than those of other related studies. Berrospide and Edge (2010) explain that larger estimates by Bernanke and Lown (1991) may be caused by the fact that their model does not include other bank-specific control variables. Thus, the coefficient on the 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 140 U.S. Bank Holding Companies (BHCs) quarterly data from 1992 Q1 to 2008 Q3, they estimate around 0.7~1.2 percentage points increase in loan growth in response to one percentage point increase in bank capital ratio, on a yearly basis. They also employ the VAR model along with the fixed effect regressions, and find relatively modest effects of bank capital on loan growth. Interestingly, they also find that the modest effects are stable over time by performing rolling-window panel regressions. Nonlinear effects and interaction effects with the output gap are also examined, but they report that none of these terms are statistically significant.

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

While above mentioned studies use the U.S. data, Gambacorta and Mistrulli (2004) and Francis and Osborne (2010) focus on Italian banks and U.K. banks, respectively. Using the Italian banks' quarterly data over the period 1992-2001, Gambacorta and Mistrulli (2004) find that the effect of excess capital on lending is significantly positive and the impacts of monetary policy and output shocks on bank lending are different based on the level of bank capitalization. Francis and Osborne (2012) find that banks raise their target capital ratios when capital requirements are increased, and vice versa. Thus, banks increase their actual capital ratios in response to tightened capital requirements by adjusting their portfolios toward less risky assets to reduce the gap between the internal target capital ratios and the actual capital ratios, suggesting that bank lending depends positively on the gap between the actual and target ratios. A partial adjustment model is used with quarterly data for U.K. individual banks from 1996 to 2007.

The effect of capital ratio on loan growth estimated by Carlson *et al.* (2011) is small compared to what the previous literature has found. They find that the effect of a one percentage point increase in capital ratio on loan growth is about 0.05~0.2 percentage point increase on an annual based on the annual U.S. banks data from 2001 to 2009. However, this positive relationship is not found prior to the recent financial crisis and become significant only in 2008 and 2009. Thus, they suggest that capital matters more for loan growth during the crisis period. The result corresponds to what Gambacorta and Marques-Ibanez (2011) and Cornett *et al.* (2011) have found although it was not the focus of their researches.

Other relevant literature

Since the Basel Committee adopted the international bank regulatory framework, called the Basel Accord, in 1988, which sets the minimum capital requirement that banks should maintain, many studies that examine the effects of this regulation on bank risk-taking behavior, lending, and overall soundness and safety of individual banks as well as the banking system have emerged. Specifically, many researchers have examined whether capital requirements boost bank capital ratios and restrain bank risk-taking. These studies are closely related to the main question of this study.

VanHoose (2008) surveys previous academic researches in this subject, and concludes that there is not strong evidence that toughening capital requirements has contributed significantly to an increase of the bank capital ratios. This is consistent with Jackson *et al.* (1999) that explore prior studies over the 1980s and 1990s investigating whether banks increase capital ratios in response to regulatory capital requirements. They find that it is hard to conclude that capital requirements induce banks to hold higher capital ratios than they otherwise would although there is a broad consensus that low capitalized banks tend to increase their capital ratios rapidly more than do well capitalized banks. Gropp and Heider (2009) also find that capital regulation is only a second-order determinant of banks' capital structure using 200 largest publicly traded banks from 16 countries consisting of the U.S. and 15 EU countries from 1991 to 2004.

However, Jacques and Nigro (1997) find that risk-based capital regulation results in an increase of capital ratios and a decrease of risk in banks' portfolio by examining 2,570 Federal Deposit Insurance Corporation (FDIC) insured commercial banks from 1990 to 1991 using a three-stage least squares (3SLS) model. Berger *et al.* (2008) examining annual panel data for 666 publicly traded U.S. BHCs from 1992 to 2006 show that BHCs actively manage their capital ratios toward the target capital ratios that are set substantially above the minimum capital requirements. Especially, they show that low capitalized banks adjust their capital ratios toward the target ratios much faster than do well capitalized banks by allowing adjustment speeds to vary based on BHC-specific characteristics in their partial adjustment models. Thus, studies are somewhat mixed.

More importantly, there are a number of researches that examine whether capital regulations contribute to credit shocks. Jackson *et al.* (1999) conclude that banks respond to tightened capital regulations in the least costly way, so banks may reduce lending in response to external shocks on capital because issuing new equity is costly and constrained during economic downturns. VanHoose (2007) also argues that the theoretical literature yields a general agreement that short-run effects of capital regulation lead to a decline in the loan supply. Furfine (2001) also suggests that capital regulation played a role in the credit crunch of the 1990s by affecting the optimal portfolio allocation of banks. The results imply that if banks manage their capital ratios actively by adjusting their portfolio composition, there would be a strong relationship between bank capital and lending.

III. Hypotheses

Most of the literature cited above focus on the linear relationship between the bank capital ratio and lending or examine whether there is a structural change in response to external shocks. The latter studies use models that allow an interaction term of the bank capital ratio and the crisis dummy to see if well-capitalized banks supply more lending than do low-capitalized banks during the crisis period.

On the other hand, Brei *et al.* (2013) incorporate a quadratic term of the capital ratio in their equations to capture non-linear effects of a change of the capital ratio on lending. They find that the effect of the capital ratio increase is positive on bank lending and this positive effect decreases in marginal terms in a normal time while increasing in crisis. Importantly, they suggest that the effect of banks' capitalization on loan growth turns positive in crisis only after the bank capital ratio exceeds a threshold, so a recapitalization should be sufficient enough to be effective. Carlson *et al.* (2011) also find the nonlinear effect of the capital ratio on loan growth. They show that the impact of the capital ratio on loan growth is greater when the capital ratio is relatively low and closer to the regulatory minimum requirement.

In this context, this study starts from the idea that the effect of a change of the capital ratio may differ depending on other bank-specific characteristics as it differs depending on the level of the capital ratio itself. In this paper, among various types of bank-specific characteristics, liquidity level is examined.

Figure 2 shows a negative relationship between liquid assets and loans. It is reasonable to think that banks having a high proportion of loans on the balance sheets are likely to have a low level of liquid assets such as cash and securities. According to Acharya *et al.* (2010), banks hold liquid assets for various reasons even if liquid assets usually have lower returns than illiquid assets like loans. Generally speaking, banks want to hold liquid assets sufficiently for the precautionary motive to survive the crisis. Banks that face a shortage of liquid assets experience a difficulty in raising external finance, thus suffer from fire-sale discounts especially during the distressed periods. However, as illiquid assets are attractive in terms of profits, banks may set a certain preferred level of the liquidity ratio based on the tradeoff relationship between the low and high level of liquidity. Acharya *et al.* (2010) argue that bank liquidity is countercyclical, so banks tend to have lower liquidity during economic boom periods and higher liquidity during the crisis. Cornett *et al.* (2011) also find that banks build up liquidity buffers in response to the increased risk during the crisis. Thus, banks' efforts to increase liquidity buffers during the recent financial crisis result in a decline of credit supply. In this context, one can expect that whether banks would expand supply of credit may depend of the level of bank liquidity. That is to say, the effect of the capital ratio on bank credit supply may differ depending on the level of the liquidity ratio. To understand possible responses of banks to the increased capital ratios, some elementary balance sheet arithmetic is used below.

Suppose that there are two banks, A and B. Bank A is of assets 100, liquid assets 50, loans 50, debt 90, and equity 10. Bank B is of assets 100, liquid assets 10, loans 90, debt 90, and equity 10. Now suppose that there is a positive capital shock, so capital increase by 1 in both banks. If banks want to stay at the same level of leverage, they would like to increase debt by 9. In fact, it does not matter if banks keep the leverage level since the focus of this paper is on the asset composition side. Anyway, assets of both banks increase by 10. Our interest is which a bank would increase loans more. Other things are being equal, it is expected that bank A with more liquid assets would be able to supply more credit than bank B, so the effect of the capital increase on lending is greater for bank A. Banks like bank B are likely to invest more in liquid assets rather supplying loans until they hold sufficient liquid assets although a certain sufficient level may depend on other bank-specific characteristics. This view is consistent with Kashyap and Stein (2000) arguing that less liquid banks are likely to reduce loans in order to maintain their liquid assets holdings above the dangerously low level. Therefore, the main hypothesis is as follow.

(*Hypotheses*) The effects of the capital ratio and liquidity ratio changes are positive on bank lending and these effects positively depend on the level of each ratio. In other words, there is a positive interaction effect between the capital ratio and liquidity ratio, so the effect of additional capital (liquid assets) on the supply of credit is greater for banks with more liquid assets (capital).

The expectation for positive effects of the capital and liquidity ratios on lending is also based on the following ideas. Liquidity can be defined by a funding perspective and an operating perspective or both perspectives together.[3] While the definitions of NCR and NSFR[4], which are suggested by the BCBS recently, incorporate both funding and operating perspectives, the liquidity ratio used in this paper represents the liquidity level of the operating side only. Meanwhile, capital ratio may represent the liquidity level of the funding side. From an operating perspective, banks with assets that have short maturities and marketable are considered in a good liquidity status. In contrast, banks with liabilities that have long maturities and not demandable easily by creditors and investors are viewed as having good liquidity from a funding perspective. Thus, it is expected that banks with a high level of the capital ratio have a greater ability to supply more credit than banks with a low level of the capital ratio based on their more stable liability structures. For such a reason, banks having more liquid assets are able to supply more credit as they already have sufficient liquid assets. These expectations are consistent with empirical results of the previous studies (e.g., see Kashyap and Stein, 2000; Berrospide and Edge, 2010; Cornett *et al.*, 2011; Brei *et al.*, 2013).

IV. Data

This study uses U.S. commercial bank data obtained from the FDIC Statistics on Depository Institutions (SDI), which provide detailed financial reports of FDIC-insured

[3] 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 while the latter describes how easily money can be raised by selling assets.

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

institutions in standardized formats. In the dataset, 9,328 institutions at 2003 Q1 and 7,667 institutions at 2010 Q4 are reported, but this study only covers banks having a bank charter class "N". A classification code is assigned by the FDIC based on the institution's charter type, charter agent, federal reserve membership status and its primary federal regulator. The classification code "N" means national charter and fed member commercial banks that are supervised by the office of the comptroller of the currency (OCC). Banks that are assigned to the code "N" account for 63.2% in terms of asset size, so focusing on this type of banks is reasonable. Applying this criterion leaves us 2,065 banks at 2003 Q1 and 1,383 banks at 2010 Q4. A detailed explanation about the bank classification is summarized in the table 1.

The sample for this study is on a quarterly frequency and consists of a balanced panel of U.S. commercial banks that have operated continuously from 2003 Q1 to 2010 Q4. There are two reasons the period between 2003 and 2010 is chosen. First, it covers two different economic periods in U.S.; the economic boom period (2003 Q1 to 2007 Q2) and the recent crisis period (2007 Q3 to 2010 Q4). To see if there is a structural change during the crisis, only one period of economic boom and crisis is covered. The years before 2003 are excluded because there was a "dot-com crush" from 2000 to 2002. Second, according to Papanikolaou and Wolff (2010), there have been no considerable regulatory changes in the U.S. during the examined period, which could have changed the banks' behavior. For instance, U.S. banks and BHCs still report their regulatory capital ratios under the Basel I, which was adopted in 1988 and took full effect in 1992[5], and General Accepted Accounting Principles (GAAP) accounting conventions. A balanced panel is used since the study is intended to examine the behavior of normal banks although using a balanced panel is subject to a survivorship bias. Banks under extreme conditions may behave differently, so it may lead us to unexpected conclusions.

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

Some adjustments are applied to mitigate the influence of missing or outlier values and possible mergers and acquisitions. First of all, banks that have violated the regulatory capital requirements during the examined period are excluded because banks that are considered as undercapitalized face a variety of mandatory and discretionary supervisory actions such as restrictions on asset growth and dividend payments. Thus, observations are dropped if total risk-based capital ratio is less than 8% or tier 1 risk-based capital ratio is less than 4% or leverage ratio is less than 4%. Meanwhile, banks that reported total-risk based capital ratio more than 40% are also excluded as it is considered abnormally high. In terms of the liquidity, observations are dropped if the liquidity ratio is less than 0%. Banks that grow more than 50% or less than -50% quarterly in assets, loans and credit are also excluded to reduce a possibility of mergers and acquisitions. At last, banks having a risk-weighted assets to total assets ratio over 100% are not included. As a result, 1,050 U.S. commercial banks are left in the final sample. A description of the dataset is summarized in the table 2.

In the case of macroeconomic data, real GDP data are obtained from U.S. Bureau of Economic Analysis (BEA) and 3-month federal funds effective rates are obtained from Federal Reserve Bank (FRB).

V. Econometric model and variables

Econometric model specification

The main interest is to examine whether the relationship between bank capital and lending depends on the level of the liquidity. To test this hypothesis, a bank capital ratio variable is interacted with a bank liquidity ratio variable, thus allowing a coefficient on the bank capital ratio variable to fluctuate as the liquidity ratio changes. To this end, the econometric model used by Brei *et al.* (2013) is employed with some adjustments. First of all, a quadratic term of capital ratio is not included, instead the interaction term of the capital ratio and the liquidity ratio is included to examine the main hypothesis. In addition, some variables that are not considered by Brei *et al*. (2013) are included. Therefore, the empirical model is given by the following equation.

$$L_{i,t} = \alpha_i + \beta_0 L_{i,t-1} + \beta_1 CAP_{i,t-1} + \beta_2 LIQ_{i,t-1} + \beta_3 CAP * LIQ_{i,t-1} + \gamma \mathbf{X}_{i,t-1}$$

$$+\delta_1 \Delta GDP_{t-1} + \delta_2 \Delta MP_{t-1} + \sum_{s=2}^{4} \varphi_s \mathrm{Q}_s + \varepsilon_{i,t} \qquad (1)$$

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

In this econometric model, each coefficient captures the short-term impact on lending in response to a change in the variable. In contrast, the long-term impact is expressed by dividing each coefficient by (1-β_0). For example, $\Delta L_{i,t}/\Delta \mathbf{X}_{i,t-1} = \gamma/(1-\beta_0)$ is the long-term impact 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 in period t of bank i. Following most of literature, for example, Kashyap and Stein (1995), Gambacorta and Mistrulli (2004), Berrospide and Edge (2010), Drehmann and Gambacorta (2011), Brei *et al.* (2013), and Kapan and Minoiu (2013), the growth rate of the dependent variable is used instead of the variable in levels to mitigate spurious correlation.

As explanatory variables, bank-specific characteristic variables and macroeconomic control variables are included. Bank-specific variables used by Brei *et al.* (2013) are all included except 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, additional bank-specific characteristic variables that are considered as important control variables affecting bank lending by the previous literature are used. For example, the ratio of unused commitments

($COMMIT_{i,t-1}$) is included as it is pointed out by Cornett *et al.* (2011), unused commitments are important explanatory variable affecting 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 a bank asset quality indicator. Bank specific characteristics except the capital ratio and the 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, 4% for tier1 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 funds effective rate (ΔMP_{t-1}) are included to account for macroeconomic conditions and loan demand effects. When these macroeconomic control variables are not included, yearly time fixed dummies are used instead. At last, α_i represents bank-level fixed effects that capture unobserved bank characteristics and 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 a possible endogeneity bias.

This study focuses only on fixed effects panel methodology while Brei *et al.* (2013) employ a dynamic system Generalized Method of Moments (GMM) panel methodology developed by Blundell and Bond (1998) to ensure efficiency and consistency. Brei *et al.* (2013) and Gambacorta and Mistrulli (2004) argue that this methodology ensures efficiency and consistency as long as the models do not suffer from serial correlation of order two and valid instruments are used.

However, Roodman (2006) recommends that fixed effects estimators may work better than system GMM when time dimension T is large because dynamic panel bias becomes insignificant while the number of instruments tends to explode as time dimension T increases. Furthermore, Judson and Owen (1999) suggest that fixed effects estimators perform well or even better when the time dimension of the 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. Since the time dimension of the dataset is 30 for the most regressions and the minimum is 22, this study just sticks to the bank fixed effects panel model. In fact, the fixed effects methodology is also used commonly in a number of the literature (e.g., see Berrospide and Edge, 2010; Francis and Osborne, 2010; Cornett *et al.*, 2011).

Meanwhile, fixed effects are chosen over random effects based on the Hausman test results albeit not reported. Choosing fixed effects over random effects is also reasonable because bank effects are likely to be time invariant during the examined period, which is considered not long enough time to change each bank's inherent characteristics. As argued by Brei *et al.* (2013), the fact that the sample of banks is not randomly chosen from the population of banks also supports the choice of fixed effects estimations.

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

Variables and expected signs

Loan growth **(L_t)**: To examine whether an increase in bank capital ratio leads to an increase in bank lending, 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, drawdowns of unused commitments 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 opened before the crisis are useful for borrowers because they can use unused commitments when banks are reluctant to lend. Thus, an increase in loans caused by drawdowns of unused commitments is likely to affect banks' lending behavior as well as a relationship between bank capital and lending. This study follows Cornett *et al.* (2011) approach to deal with these changes from off balance sheet to on balance sheet by adding the credit growth variable as a dependent variable.

Capital **(CAP_{t-1})**: There are various capital ratios, but only regulatory capital ratios are considered for this study. The minimum capital requirements are set on three types of capital ratio measurement; total risk-based capital ratio, tier 1 risk-based capital ratio, and leverage ratio. Total risk-based capital ratio is defined core capital (tier 1) plus supplementary capital (tier 2) over risk-weighted assets and should be at least 8% to be regarded as adequately capitalized banks. Tier 1 risk-based capital ratio includes only core capital in the numerator and divided by risk-weighted assets and should be at least 4%. Leverage ratio is defined as core capital (tier 1) over total average assets rather than risk-weighted assets. All three types of regulatory capital ratios are considered in the regressions and coefficients on these regulatory capital ratios are expected to be positive. Coefficients on the interaction term with crisis dummy are also expected to be positive because well-capitalized banks are better able to 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 hypotheses chapter, liquidity can be defined in various ways, but the definition of liquidity is limited to the operating side in this paper. In other words, liquidity in this paper means how sufficient liquid assets banks hold in their asset side of balance sheets. Then, what assets are treated as liquid assets? Generally speaking, cash and securities are treated as liquid assets, but researchers adjust definitions based on the availability of specific information and their judgment. For example, Berrospide and Edge (2010) and Das and N.R. Sy (2012) use a securities over assets ratio as a proxy for liquidity ratio while Drehmann and Gambacorta (2011) and Gambacorta and Mistrulli (2004) include cash and securities in the liquid assets. Brei *et al.* (2013) treat cash, trading securities and interbank lending with maturity less than 3 months as liquid assets.

However, it seems that the definitions used by Shim (2013) are reasonable the most. Shim (2013) defines cash and balances due from depository institutions, securities, federal funds and trading account assets less pledged securities as liquid assets. It is rational to think that only assets that are pledgeable and available for sales are considered as liquid assets, so this paper follows this definition. Coefficients on the liquidity ratio are expected to be positive for the reasons discussed earlier in the hypotheses section and these positive effects on bank lending would be greater during the crisis period, which is the time when banks desperately need liquid assets.

Interaction term ($CAP*LIQ_{t-1}$): To verify the coefficients on this interaction term is the main interest of this study. As discussed previously in the hypotheses section, the expected sign on this term is positive. The effects of additional capital (liquid assets) on bank lending would be 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 its average across all banks in the sample respectively in order to obtain the meaningful coefficients. This means that the coefficients on capital ratios are interpreted as the effects on the banks with the average liquidity ratio while the coefficients on liquidity ratio mean the effects on the banks having minimum regulatory capital ratios (i.e., 8% for total risk-based capital ratio, 4% for tier1 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, larger banks have incentives to take more risk by the high expectation of government’s bailout to prevent systemic risk, thus may supply more credit. However, larger banks can diversify their portfolio by investing various types of securities and involve in various activities while smaller banks tend to focus on the traditional lending activity. Looked at in this perspective, the size effect could be negative.

Funding structure ($MFUND_{t-1}$): Broadly speaking, liabilities consist of deposits and non-deposits. 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 is because banks may rely more on market funding, which is usually considered cheaper and easier to accumulate during the economic boom period, to expand their balance sheets. On the other hand, as Brei *et al.* (2013), Ivashina and Scharfstein (2010), Cornett *et al.* (2011), and Gambacorta and Marques-Ibanez (2011) argue, it is expected that banks that rely more on market funding cut more lending during the crisis because they are more vulnerable to external shocks. In other words, banks having better access to deposit financing cut lending less than banks relying 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 the unused commitments to total assets, is an important determinant of bank lending behavior. Interestingly, the expected sign is different by the type of the dependent variable. The expected sign is positive for the growth rate of loans while negative for the growth rate of credit because drawdowns of unused commitments increase loans but do not affect the amount of credit. These effects are expected to be greater during the crisis. Banks that are exposed to a higher level of unused commitments would supply more loans unwillingly as the increased credit-line drawdowns during the crisis transfer assets from off-balance sheets to on-balance sheets. As a result, those banks reduce the supply of new credit more than other banks.

Profitability (*ROA_{t-1}*): The profitability is measured as the ratio of net income after taxes and extraordinary items to total assets. Banks with a higher profitability are likely to have strong balance sheets because the profitability relates to the quality and quantity of capital ratios. On the other hand, the higher profitability may imply a greater risk in assets, so more loans. In either view, a positive relationship between the profitability and bank lending is expected.

Loan quality (*NPL_{t-1}*): The ratio of noncurrent loans to total loans reflects the quality of banks' loan portfolio. The higher the level, the worse the quality becomes. Banks would cut lending more as the loan quality gets worse. 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 funds effective rate (ΔMP_{t-1}) are used. The expected sign on the growth rate of real GDP is positive due to the inherent procyclicality of bank lending and increased loan demands. On the other hand, the effect of interest rate changes on bank lending is expected to be negative since an increase of market rates lead to decreased loan demands.

Crisis dummy (*$CRISIS_t$*): To examine whether there was a structural change in response to external economic shocks, the crisis dummy is interacted with bank-specific characteristics variables. The crisis dummy is an indicator variable that takes the value of 1 for the crisis period and 0 elsewhere. It is hard to define the crisis period. It is commonly defined as beginning at 2007 Q3, but arguable when it has ended or would end.

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

VI. Estimation results

Linear regression results

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

First of all, the estimated coefficients of capital ratio and liquidity ratio are positive and statistically significant. The effects of additional capital and liquid assets on loan growth rate are positive as expected. Thus, it supports the view that banks with high level of capital ratio and liquidity have a greater ability to supply credit than banks with low level of capital ratio and liquidity based on their strong balance sheets. In terms of magnitude of coefficients, the results in Eqs (1) and (2) suggest that a 1 percentage point increase in the capital ratio boosts annualized loan growth by about 0.6~0.7 percentage point. Interestingly, the effect of capital ratio on credit is very small and statistically less significant. The result may imply that banks are less constrained by the regulatory capital ratio when they expand their credit by supplying credit-lines to their customers. This is because risk-weights for off-balance sheet activities are lower than on-balance sheet activities.

All the additional variables ($COMMIT_{t-1}$, ROA_{t-1}, NPL_{t-1}) are turned out to be statistically significant with expected signs. Thus, it supports that those variables are important determinants of bank lending. In all regressions, expected signs for coefficients on other control variables are obtained. The size effect is turned out to be negative. This may imply that small banks focus on traditional lending activity, so supply relatively more lending than do large banks. Market funding effect is positive albeit not significant in Eqs (3)-(4). It suggests that U.S. commercial banks have relied on market funding during the examined period to boost their lending even if the effect is relatively modest. Meanwhile, the results show the importance of the role of the unused commitment ratio on loan growth. As discussed earlier, the effect of unused commitment changes is positive on loan growth but negative on credit growth. The magnitude of coefficients is great and statistically very significant. This means that lending by banks that are exposed more to credit-line risk would increase by credit-line drawdowns. Then, those banks would reduce the supply of new loans or credit-line in response to the increased takedown demands. Therefore, the effects of unused commitment on loan growth and credit growth are opposite. The coefficients on profitability (ROA_{t-1}) and loan quality (NPL_{t-1}) also have expected signs and are statistically significant and consistent in all regressions. While the increased profitability has a positive impact on loan growth, low quality of loans deteriorates banks' ability to supply loans.

At last, macroeconomic variables are used when yearly time dummies are not included, and the results are not affected significantly by this. A half percentage point increase in the 3-month federal funds effective rate change, which is a proxy for monetary policy, is associated with about 0.2 percentage point decrease of loan growth and 0.12 percentage point decrease of credit growth in the following quarter. The effect is strongly significant and negative as expected. In later, it is found that the coefficient on this variable is positive (see table 9), albeit not statistically significant, for large banks. This result is in line with Kashyap and Stein (1995), showing that small banks response more sensitively than large banks to the monetary policy.

On the other hand, none of the coefficients on the growth rate of real GDP variable are significant, nor deviates from zero. Interestingly, in later regressions done by bank size (see table 9), the coefficients on the GDP growth for large banks are positive and statistically significant while not significant for medium and small banks. It may suggest that large banks are more procyclical than medium and small banks to the business cycle. Large banks supply more credit during the economic boom and cut credit supply more during the crisis than do medium and small banks. Since the level of capital ratios of large banks is much lower than those of medium and small banks, this is consistent with the result of Gambacorta and Mistrulli (2004), suggesting that well-capitalized banks supply credit less procyclically to GDP shocks.

Table 6 reports the linear regression results with crisis interactions. All the bank-specific characteristic variables are interacted with crisis dummy. As discussed before in the econometric model and variables section, two types of crisis dummies are used. The first one defines the crisis as the period between 2007 Q3 and 2009 Q2, and used in Eqs (1)-(2). The second one covers the period from 2007 Q3 to 2010 Q4, and used in Eqs (3)-(4). Overall, the results are not significantly different, but the second definition of the crisis dummy seems to capture the crisis period better in the light of the previous literature. Well-capitalized banks and more liquid banks supply more lending than do low-capitalized 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). Regression results in Eqs (3)-(4) are more pronounced than regression results in Eqs (1)-(2). The impacts of capital ratio and liquid assets on loan and credit growth are greater during the crisis, so they matter more for banks to supply credit in response to external economic shocks.

Interaction effect of bank capital and liquidity ratio

Table 7 reports the interaction effects of capital ratios and liquid assets on loan growth and credit growth for all types of regulatory capital ratios. In regression models with an interaction term, the coefficients for capital ratios and liquidity ratio reflect conditional impacts of these variables on loan growth and credit growth. Since liquidity ratio is normalized to its mean value, the coefficients on capital ratios are interpreted as the effect of capital ratios on loan and credit growth for banks with the average liquidity ratio. In the same way, the coefficients on liquidity ratio mean the effect of liquidity ratio on loan and credit growth for banks with the minimum regulatory capital requirements since capital ratios are normalized to their minimum regulatory requirements (8% for total risk-based ratio, 4% for tier 1 risk-based ratio and leverage ratio).

The results in the table 7 are different depending on the type of the dependent variable. Although positive interaction effects of capital ratio and liquid assets on loan growth are found in Eqs (1)-(3), the coefficients are small and statistically not significant. However, the coefficients on the interaction terms in Eqs (4)-(6), where credit growth is used as dependent variables, are turned out to be positive and statistically significant. One standard deviation increase of liquidity ratio from its mean boosts the effects of capital ratio on credit growth by about 0.04~0.06 percentage points although the coefficient on the interaction term for leverage ratio is not statistically significant. When considering the effects of capital ratio on credit growth is about 0.05~0.07 percentage points, this impact is meaningful. On the other hand, this interaction effects are not worthwhile for the effects of liquidity ratio on credit growth in the light of relatively small volatile 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.

In table 8, crisis dummy is interacted with all the bank-specific characteristic variables including the interaction term in order to examine there was a structural change in response to the external shock. The coefficients on the interaction term increase a little bit, but not significantly different from the results in table 7. Furthermore, the coefficients on the interaction term with crisis dummy are not statistically significant. Thus, it is concluded that the interaction effects of capital ratio and liquidity ratio did not change during the crisis period.

Regression results by bank size are presented in the table 9. Large banks are those banks with assets greater than $10 billion, medium banks are those banks with assets between $1 billion and $10 billion, and small banks are those banks with assets less than $1 billion at 2003 Q1. As a result, 56 banks, 540 banks, and 454 banks are classified into large banks, medium banks, and small banks, respectively. Interestingly, the previous results hold only for large banks. In the case of large banks, the interaction effects of capital ratios and liquidity ratio are much greater than the results of Eqs (4)-(6) in the table 7. One standard deviation increase of liquidity ratio from its mean increases the effects of capital ratios on credit growth by more than 0.1 percentage points. This also suggests that the effects of capital ratios on credit growth could be almost none or even negative at the very low level of liquidity ratio. Furthermore, negative signs for the coefficients on liquidity ratio suggest that the effect of liquidity ratio on credit growth becomes positive only after capital ratios exceed certain level. This is well depicted in the figure 5.

The fact that the interaction effects are significant only for large banks may imply that large banks manage their capital ratios and liquidity ratio more actively and simultaneously. This is inferred from the context that large banks tend to maintain the lower levels of capital ratios and liquidity ratio than do medium and small banks. It could make large banks more sensitive to changes in capital ratios and liquidity ratio.

VII. Robustness

About the estimation period, including the Troubled Asset Relief Program (TARP) implementation period could be one potential problem distorting the results. TARP was one of the major programs implemented by the Treasury in response to the recent financial crisis in order to stabilize the financial system. The beginning of the program was on October 28, 2008, when the Treasury decided to inject capital into nine largest banks under the Capital Purchase Program (CPP) (Black and Hazelwood, 2012).

According to Black and Hazelwood (2012) and Berrospide and Edge (2010), one of the objectives of the CPP was to boost bank lending by injecting capital through purchases of preferred stock with warrants. As a result, capital ratios of U.S. banks increased significantly after 2008 Q4. Figure 6 shows how significantly regulatory capital ratios for the examined banks have increased after TARP capital injections. For this reason, Berrospide and Edge (2010) cut the estimation period before 2008 Q4, which is the beginning of TARP capital injections, in order to prevent it from distorting the regression results. Black and Hazelwood (2012) argue that recipient banks of TARP funds were encouraged to increase loans. Using an event-study methodology and loan-level regressions, they find that the effect of TARP on bank risk-taking is positive for large banks while negative for small banks. Therefore, the period excluding the period after TARP capital injections are examined in order to test whether the main results are robust.

The results are reported in the table 10. The interaction effects remain at the similar level for the sample including all the banks. In the case of regression results for large banks, the coefficients on the interaction terms increase except it for total risk-based ratio. Therefore, it is concluded that the effect of capital ratio on credit growth is positively associated with the level of liquidity ratio even after excluding the period after TARP capital injections.

VIII. Conclusions and policy implications

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

More importantly, this paper examines whether the effect of a change of bank capital ratios on lending differs depending on the level of liquidity. This paper finds that the effect of bank capital on credit growth relates positively to the level of bank liquid assets. It also shows that the positive effect of bank capital increase on credit growth is significant only after banks retain enough liquid assets. This interaction effect did not change during the recent financial crisis period, and were more prominent for large banks.

The results suggest three important policy implications. First, any policy actions to sustain bank lending, for example capital injections and liquidity support, are complementary and should be implemented harmoniously to be more effective. Second, if only capital injection is implemented, this would be more effective for banks with high liquid assets in the light of boosting credit supply. At last, recent international regulatory reform efforts to induce banks to hold more liquid assets and capital are supported. The results imply that banks with more liquid assets and capital would be able to supply more credit thanks to their increased capability of absorbing negative economic shocks.

This paper makes two contributions to the literature. First, it shows that the interaction effect of bank capital and liquidity on credit supply is significant, which may imply that the relationship between bank capital and lending is complicated rather than a linear. Researches to date have focused on the linear relationship between bank capital and lending. Second, it shows that a role of unused commitments should be considered when 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, which is defined as net loans on the balance sheet plus unused commitments off the balance sheet, is maybe the more appropriate measure for bank lending.

BIBLIOGRAPHY

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 (2013): 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 (2010): 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.

Kashyap, Anil K., and Jeremy C. Stein. “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).

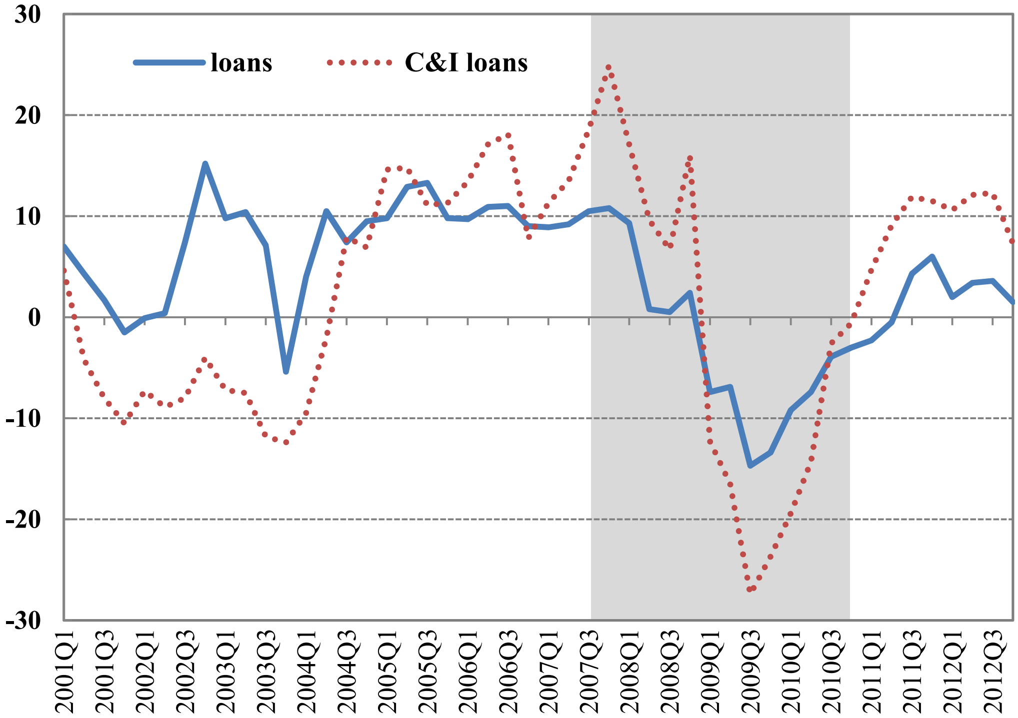
VanHoose, David. “Bank Capital Regulation, Economic Stability, and Monetary Policy: What Does the Academic Literature Tell Us?,” *Atlantic Economic Journal* 36 (2008): 1-14.

VanHoose, David. "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.

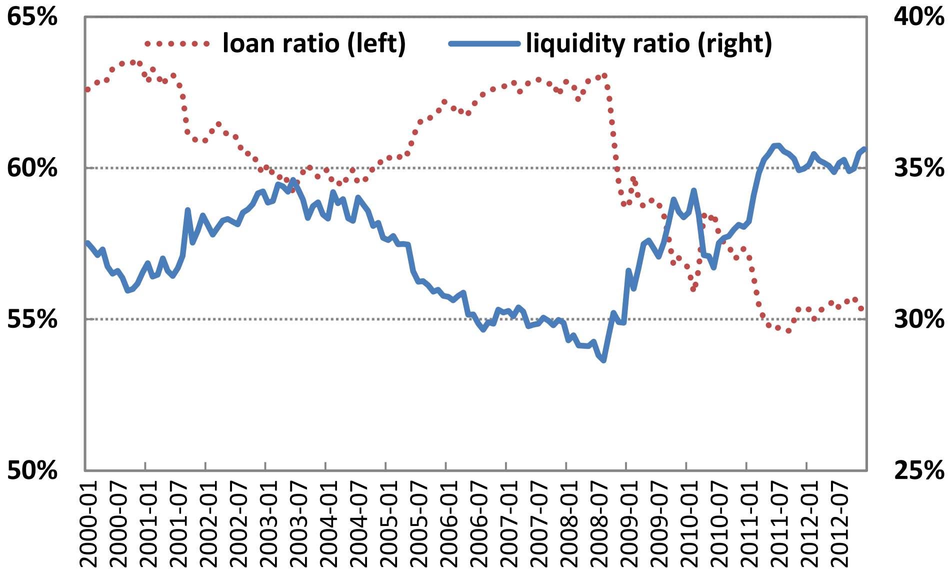
Figure 1. Growth rates of loans and Commercial and Industrial loans



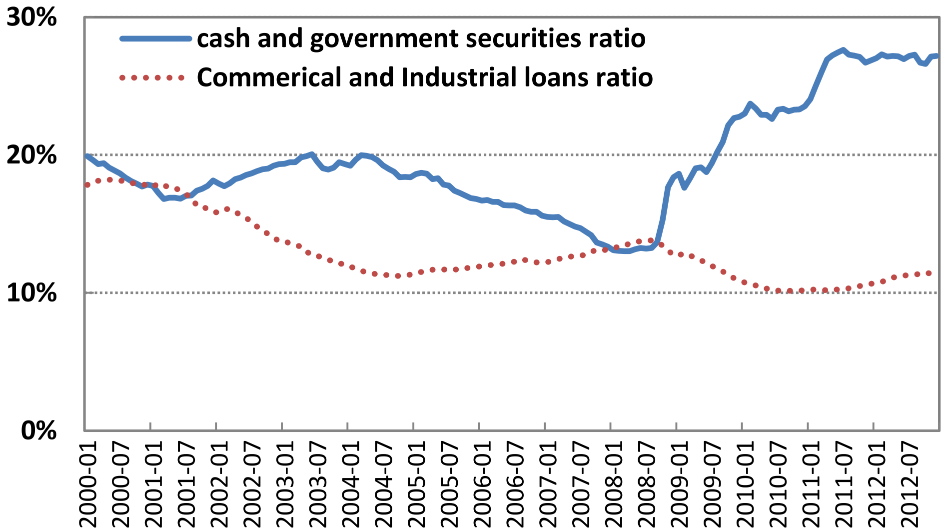
Source: Federal Reserve Bank H.8.
Note: Annual growth rates, seasonally adjusted. A shaded area is from 2007q3 to 2010q4.

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

(a)

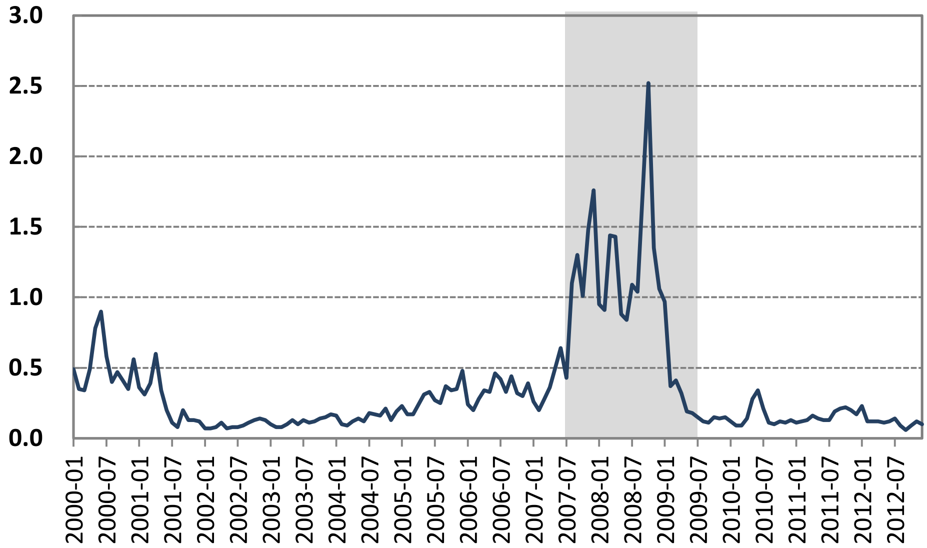


(b)



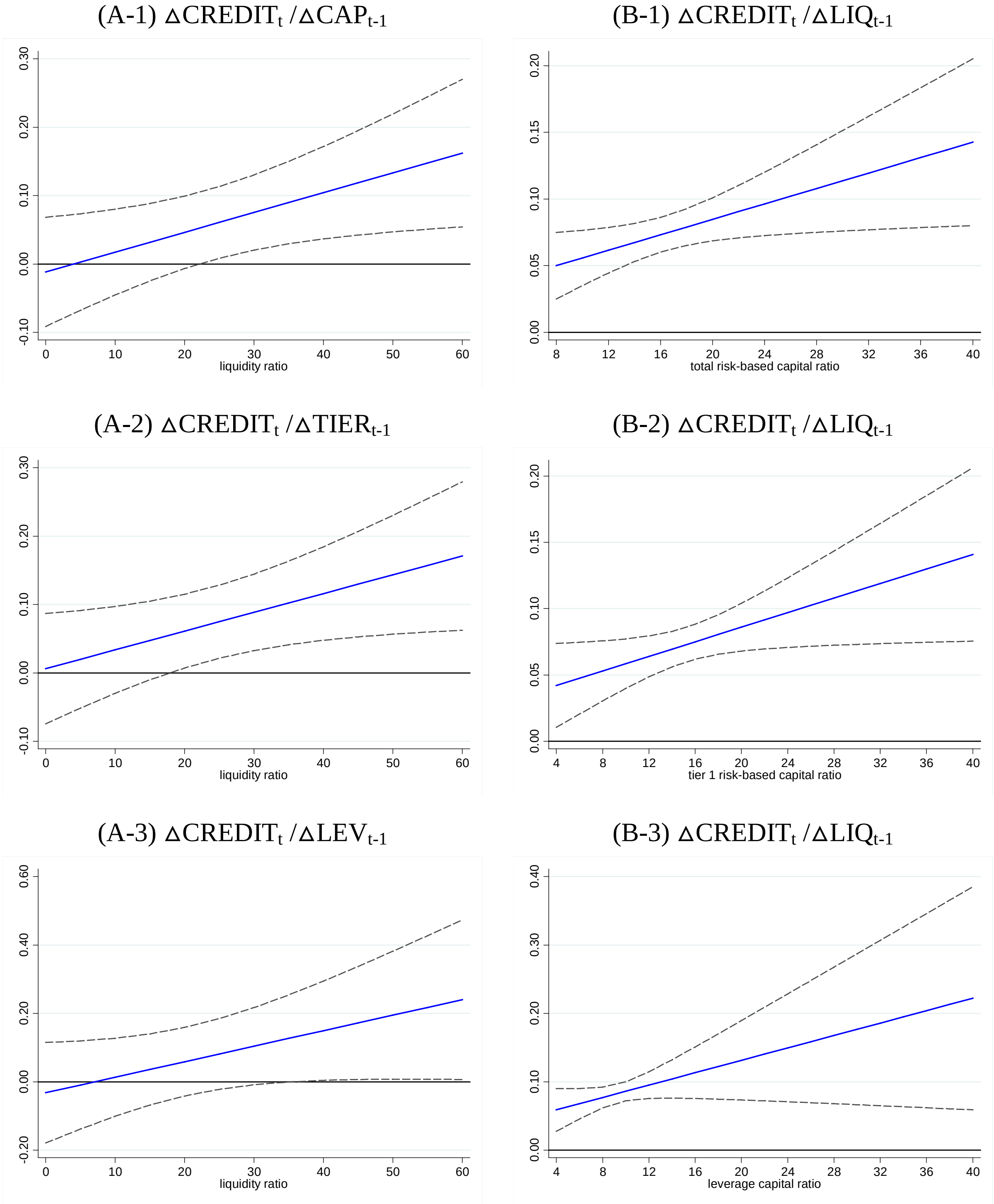
Source: Federal Reserve Bank H.8. Assets and liabilities of commercial banks in the United States.
Note: Liquidity ratio = (cash + securities + interbank loans + fed funds and reverse RPs with banks) / total assets

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.

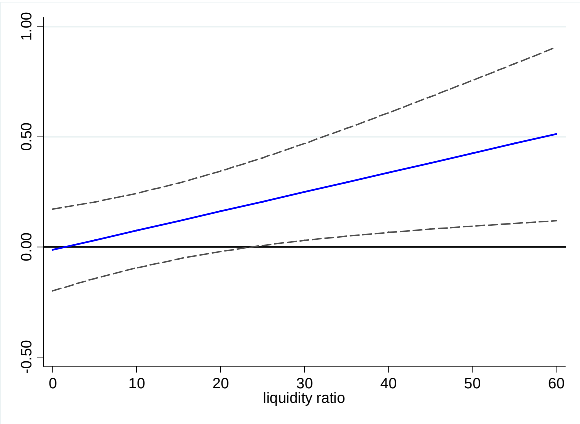
Figure 4. The effects of capital ratio and liquidity ratio on credit growth for all banks



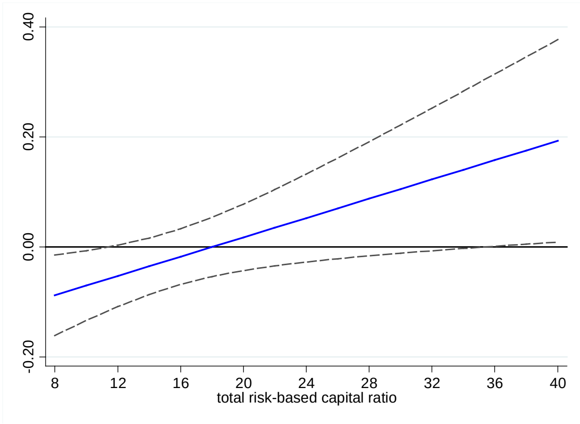
Note: The figures illustrate the results of Eqs (4)-(6) in the table 7. The change in the growth rate of credit for a 1 percentage point increase in the regulatory capital ratio (left column). The change in the growth rate of credit for a 1 percentage point increase in the liquidity ratio (right column). 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

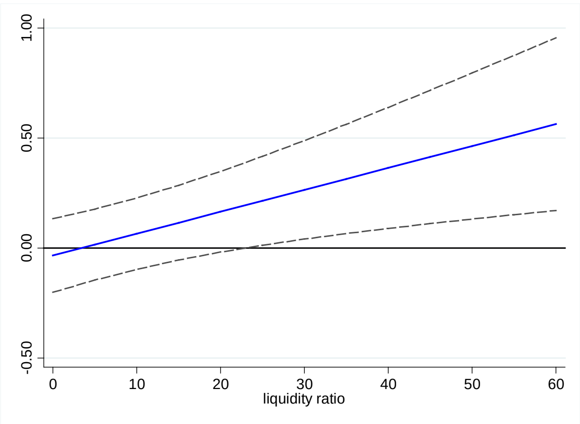
(A-1) $\triangle CREDIT_t / \triangle CAP_{t-1}$



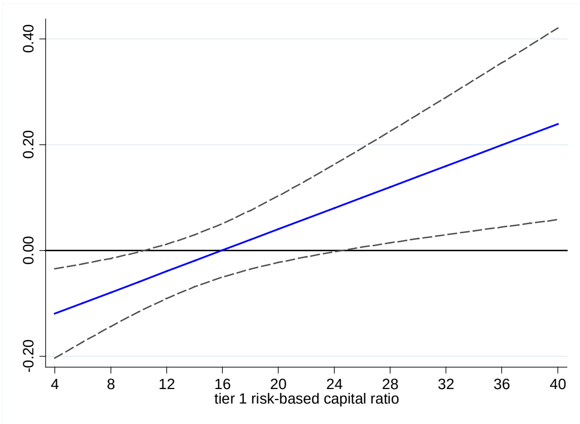
(B-1) $\triangle CREDIT_t / \triangle LIQ_{t-1}$



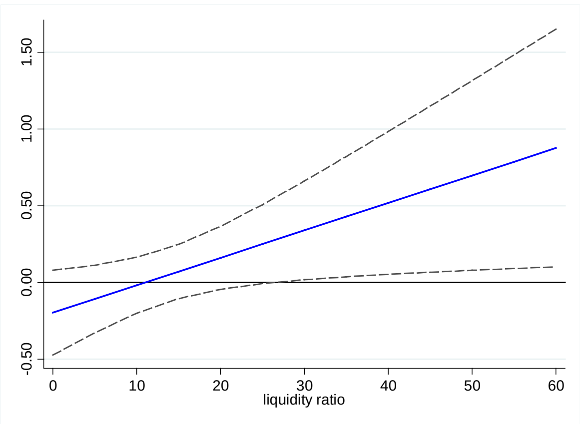
(A-2) $\triangle CREDIT_t / \triangle TIER_{t-1}$



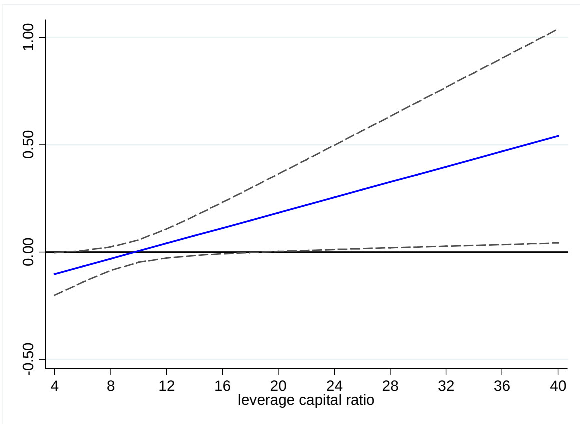
(B-2) $\triangle CREDIT_t / \triangle LIQ_{t-1}$



(A-3) $\triangle CREDIT_t / \triangle LEV_{t-1}$

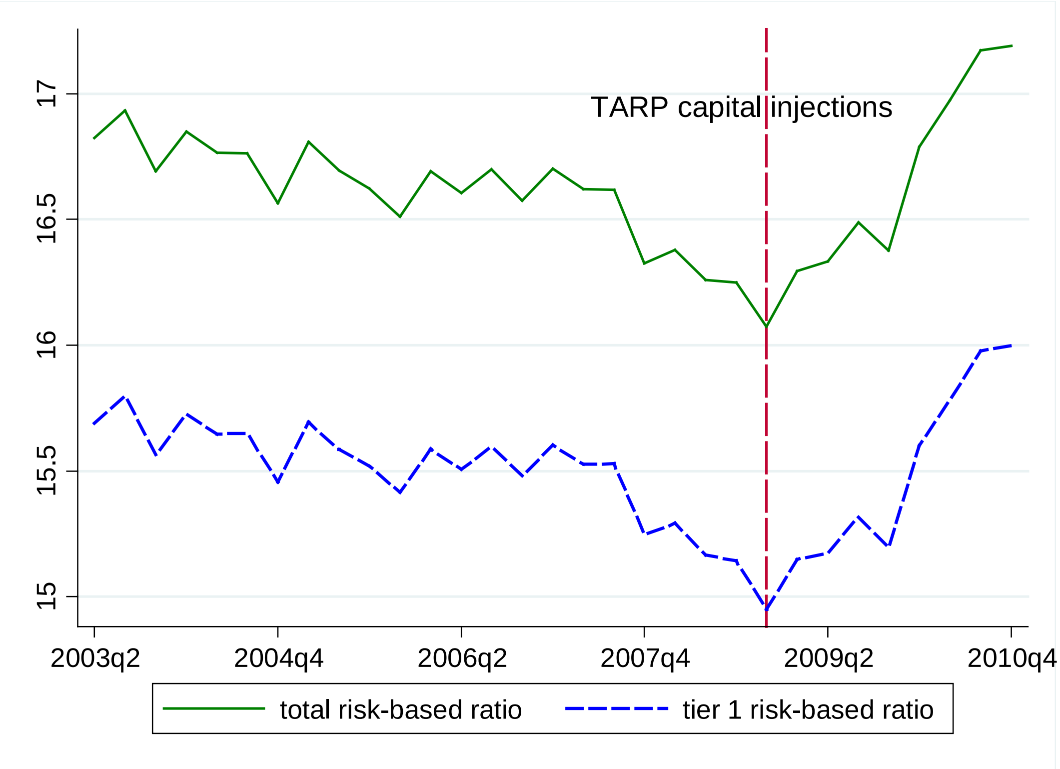


(B-3) $\triangle CREDIT_t / \triangle LIQ_{t-1}$



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: Federal Deposit Insurance Corporation Statistics on Depository Institutions (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%

Source: FDIC SDI.
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		
ΔGDP_{t-1}	Quarterly growth rate of real GDP (%)	BEA
ΔMP_{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)
$CAP_{t-1}\times CRISIS$	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)
$LIQ_{t-1}\times CRISIS$	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)
$SIZE_{t-1}\times CRISIS$	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)
$MFUND_{t-1}\times CRISIS$	-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)
$COMMIT_{t-1}\times CRISIS$	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)
$ROA_{t-1}\times CRISIS$	-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)
$NPL_{t-1}\times CRISIS$	-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 banks	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 banks	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.