Dissertation Proposal

Easy Monetary Policy and Tight Capital Requirement: An Empirical Study of Bank Lending Behavior

---

Zefan Wang
University of Delaware
March 1, 2018

Contents

Abstract

The paper studies the effects of the substantially heightened risk-based capital requirements (Basel III and the Stress Tests) on bank lending in the U.S.. The effectiveness of monetary policy is examined as well. The study uses the quarterly bank level data from the FDIC ranging from 2002 - 2017. The unbalanced dataset covers around 6,000 - 9,000 depository institutions, with a total of 500,000 observations across 64 quarters. The data is divided into sub-samples to compare the effects pre and post the introduction of the heightened requirements in 2009. Banks are divided into control and trial groups based on their subjected regulatory pressure. The analysis uses the standard dynamic lending models based on Kashyap & Stein (1995), Gambacorta & Mistrulli (2004), Berrospide & Edge (2010), Gambacorta & Shin (2016) and Borio & Gambacorta (2017). Dynamic panel regressions such as system GMM and GMM with nonlinear moment conditions, and lags of explantory variables are used to mitigate the endogeneity issues according to Anderson & Hsiao (1981), Arellano & Bond (1991), Ahn & Schmidt (1995) and Blundell & Bond (1998).

Brief Introduction

Economic growth in the U.S. has been slow since the Great Recession. Bank lending growth has been low at the same time. Regulators engaged in several stimulative policies but the recovery is still in a slow process. Multiple reasons such as the saving glut, low interest rates, liquidity shortage, uncertainty on risks and the hallucinations of "this time is different" could contribute to the banking crisis and the following credit crunch, which amplifies the recession into a deep and prolonged one. (Mizen, 2008; Rosengren, 2008; Brunnermeier, 2009; Cecchetti, 2009; Reinhart & Rogoff, 2009; Illes et al., 2015). Some believe that the banking system needs stricter regulations while others think more regulations could lead to a slower economy with a less stable banking system.

This paper will revisit the topic of the risk-based capital requirements in affecting bank lending under the current settings of the U.S.. The risk-based capital standard (Basel III) has been substantially heightened since the Great Recession. Basel III introduced a new standard of Common Equity Tier 1 Capital (CET1) of an unprecedented 4.5%, or 7% if including an additional 2.5% conservation buffer as a way to improve capital quality and quantity. The U.S. Federal Reserve Board determined that it will implement Basel III by 2019 on all sizes of banks, except for BHCs with assets of less than $500 million. In addition, the stress tests implemented in the U.S. require the largest BHCs to meet higher risk-based capital requirements under different economic scenarios as well. Thus, using recent data to analyze the effects of the substantially heightened capital requirements would provide new insights into the subject. The paper will take a step further to study two components of CET1, specifically common stockholders' equity and retained earnings of banks. This study will also explore the effectiveness of monetary policy with a substantially heightened capital requirements.

The empirical analysis uses the quarterly bank-level data from the FDIC ranging from 2002 - 2017. The data on CET1 is only available after 2015 for all banks. A proxy for CET1 thus will be constructed to compare the effects across periods. The data will be divided into 3 sub-samples. The first sub-sample covers from 2002 - 2009, which can be used to measure the effects prior to the introduction of the heightened capital requirements. The second sub-sample covers from 2009 - 2015, when the stress test is implemented and the Basel III is being phased in. The last sub-sample ranges from 2015 - 2017 under which the data for CET1 is available. Banks will be divided into groups based on their regulatory pressure. Dynamic panel regressions will be used to address the endogeneity issues. The purpose of this research is to study the effects of the substantially heightened higher-quality capital requirements on bank lending, retained earnings and common stockholders' equity across sub-sample periods and bank groups. The effectiveness of monetary policy will be examined as well.

1 Introduction

The outbreak of the financial crisis put financial intermediaries under the spotlight of public attention. Lax supervision of the financial system was criticized for being one of the major causes of the recession. In addition, the fear of failure of systemically important financial institutions required public resources to bail out troubled banks for their risk taking activities. Regulators around the globe subsequently issued a series of heightened standards including the heavily debated increases in the risk-based capital requirements to enhance supervision and to internalize the costs to banks themselves.

On the other hand, the banking industry has been asking for less regulations for years. They argue that layers of regulations have become overwhelming for business, and they could lend more if the capital levels were different. Other observers also worry about banks' future and the slow growth seen in the U.S. economy. They are concerned that the heightened capital requirements might lead to a slower economy resulting in a less stable banking system (Congdon & Hanke, 2017; Gramm & Solon, 2016; Sarin & Summers, 2016).

Moreover, increasing attention has been paid to the interplay between prudential supervision and monetary policy. Monetary policy and prudential supervision can work at cross-purposes. Monetary policy could affect systemic risk, and prudential regulation could affect economic growth (Yellen, 2011).

The connection relies on the validity of the credit view of money. The traditional money view does not give a special role to loans, neither does it differentiate the loan rate from the common interest rate. It assumes that money pumped into banking would be automatically multiplied and transfered to the econonmy. However, the credit view argues a more significant role is played by banks. Asset allocations decided by banks are critical for conducting monetary policy (Bernanke, 1988; Bernanke & Gertler, 1995).

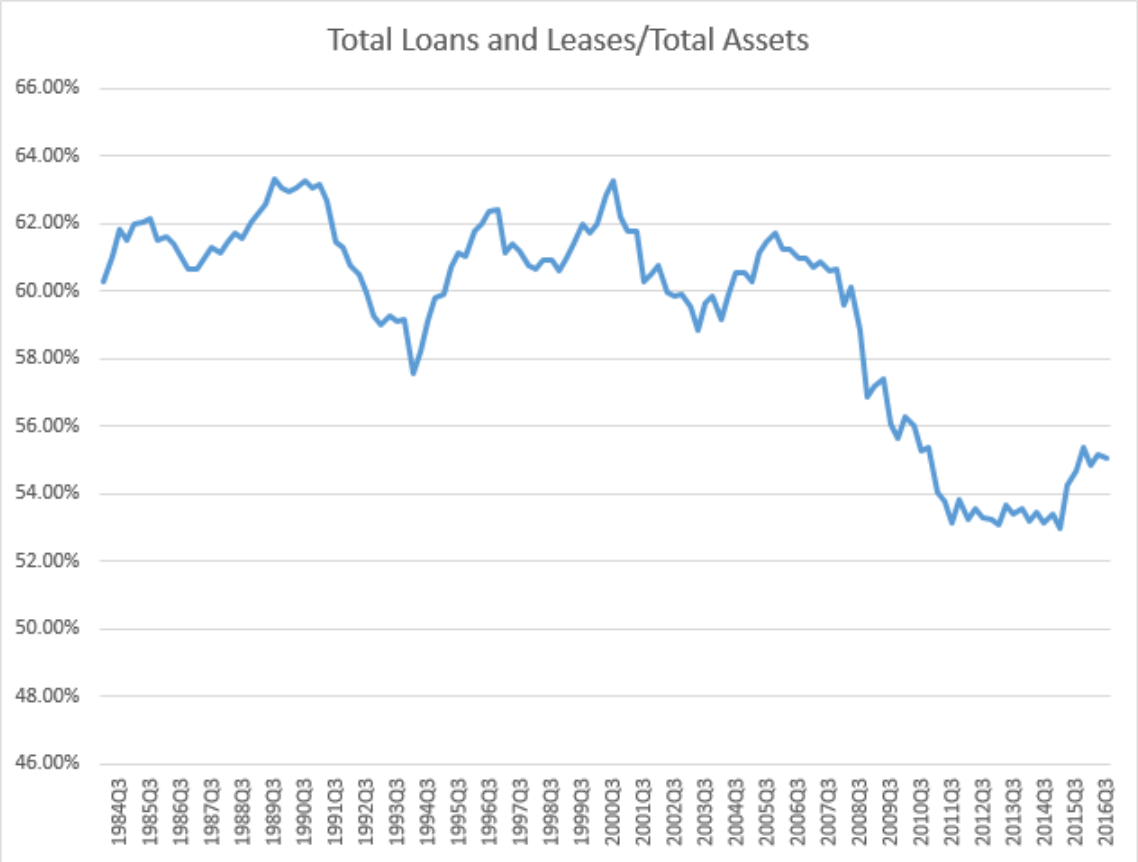
Subjected to a substantially heightened capital standard which brings the relationship between bank lending and capital to a new high level, banks might restrain lending during bad times or recoveries due to a capital shortage and constraints, even if monetary easing is conducted. They might also find making loans unattractive compared with alternative ways of allocating assets, such as investing. Hence the effectiveness of monetary policy to stimulate recoveries might be weakened with heightened capital requirements.

In contrast, monetary tightening which drains reserves out of banking might be more effective with heighted capital constraints. For example, under-capitalized banks might incur higher costs on alternative funds which leads them to cut back loans further. Monetary tightening might also reduce banks' profitability, which prevents capital accumulation in the long term, thus reduces bank lending. That is to say, monetary policy might be asymmetric (Chami & Cosimano, 2010; Kishan & Opiela, 2006; Van den Heuvel et al., 2002). The Fed might have an easier time to conduct monetary tightening than easing. As suggested by Bliss & Kaufman (2002), the standard textbook model in which banks are only subjected to the reserve requirement is incomplete. An additional capital constraint should be incorporated

to analyze the effects of monetary policy.

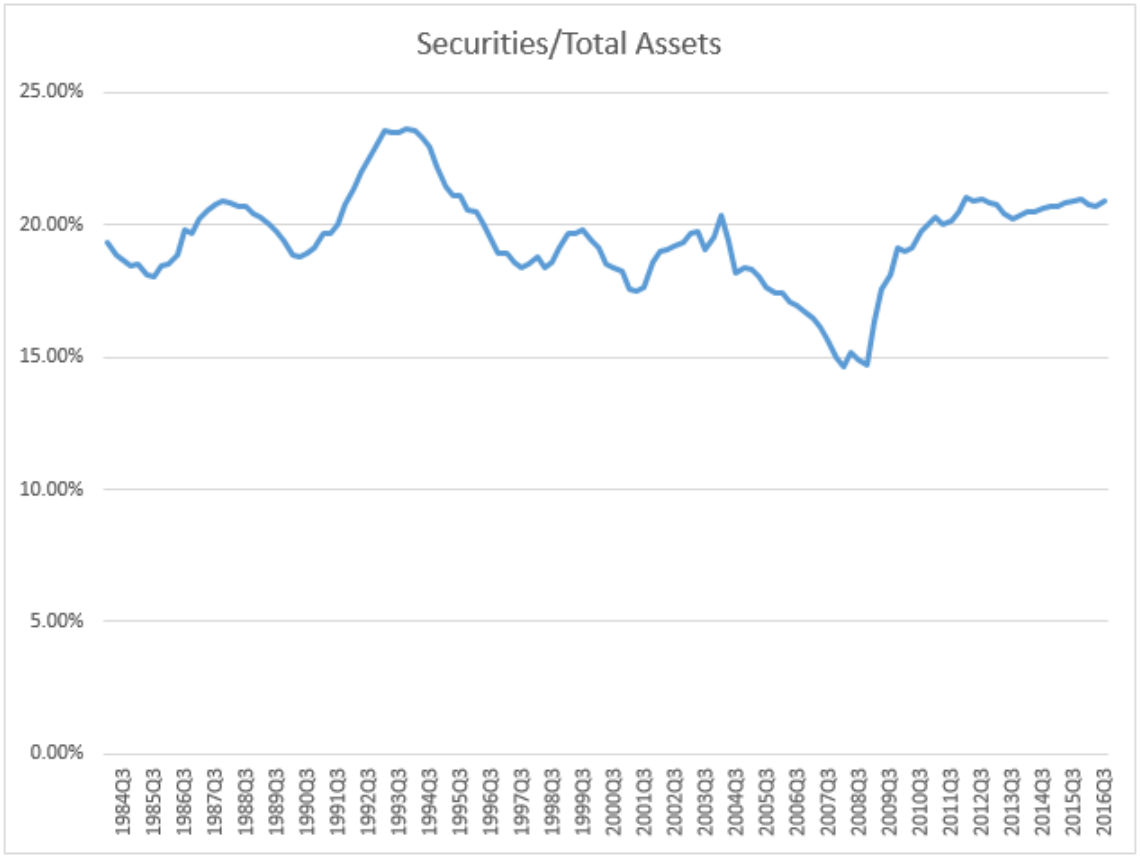
Motivated by the debates presented above, this paper tries to examine the effects of risk-based capital requirements and monetary policy on U.S. bank lending in recent years. Aggregate data shows that banks reduced assets allocated to loan making but increased security holdings since the Great Recession. Excess reserves have been built up dramatically since then.

Total Loan and Leases Ratio



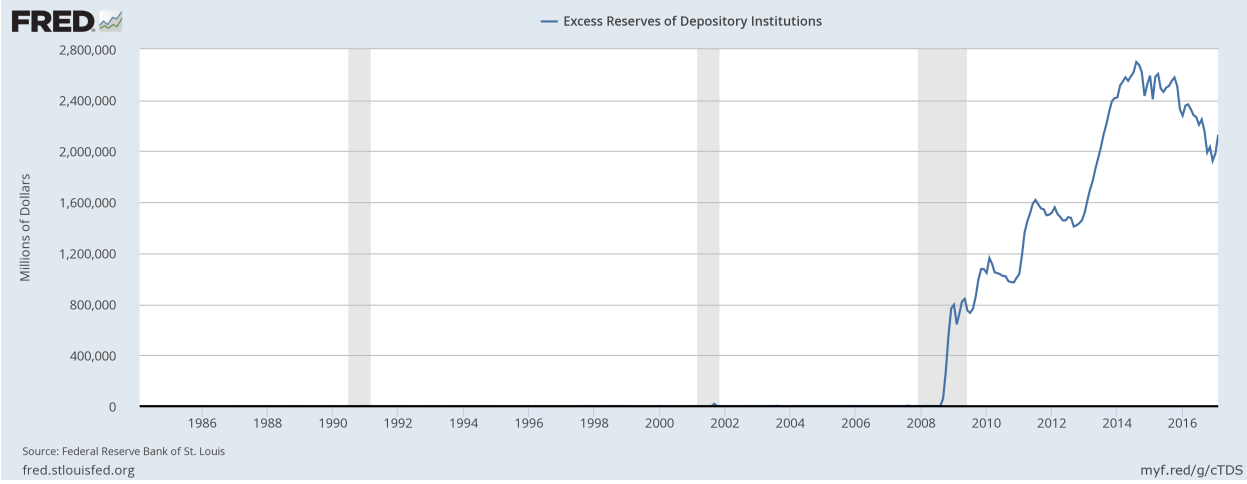
Aggregate quarterly data from the FDIC

Securities Ratio



Aggregate quarterly data from the FDIC

Excess Reserve



This paper is built on both the credit crunch literature and the bank lending channel literature. It contributes to the existing literature in three ways:

First, previous literature on the Basel capital requirements have not reached a conclusion on their effects on lending. However, the risk-based capital standard has become more restrictive now than before. Basel III sets the requirement for higher-quality capital CET1 at 7% including the conservation buffer, and even higher if including a counter-cyclical buffer and for globally systemically important banks. One might expect that the risk-based capital standard would become more relevant now than ever. The stress tests implemented in the U.S. also enhance the effects of risk-based capital requirements on lending for large BHCs. On the other hand, regulators has been giving banks plenty of time to prepare for the implementation of Basel III, which could mitigate the effects to some extent. Thus, studying the phase-in periods using recent data might provide new insights into the subject.

Second, different from the previous literature, this paper will consider two essential components of CET1 — retained earnings and common stockholders' equity [1]. Banks can meet the required capital ratios by either cutting loans (decrease denominator) or increase certain types of capital (increase numerator). In the case of CET1, banks could raise either common stockholders' equity or retained earnings by cutting dividends. Banks are known for being reluctant to cut dividends. Cutting dividends could convey a bad signal to the public. Dividends also serve as income to investors. On the other hand, banks are reluctant to issue common stocks due to information asymmetry or lemon premium during a crisis, and it is a dilution of earnings (Myers & Majluf, 1984; Hyun & Rhee, 2011). However, what happened in the U.S. was that the 19 largest BHCs under the Supervisory Capital Assessment Program (SCAP) [2] had to raise their capital to a satisfactory level within 6 months in 2009. The following Comprehensive Capital Analysis and Review (CCAR) [3] allows the Fed to object the largest banks' plans of stock repurchase and dividend payout. According to the Fed, "The 19 institutions paid out 15 percent of net income in common dividends in 2011 compared with a payout of 38 percent of net income in 2006. They also raised more in common equity than they repurchased in 2011" (Board of Governors of the Federal Reserve System, 2012). Smaller community banks are not subject to the stress tests, but they will be subject to the Basel III capital requirement by 2019. They might have to rely on retained earnings to gradually build up CET1, because they have limited access to public funding. The combined regulatory pressure from both the stress tests and Basel III could affect banks' retain earnings beyond the effects from profitability by altering their dividend payout policy. The regulatory push on banks of all sizes to manage their capital deliberately would justify the need to study the dynamics between retained earnings and common stockholders' equity.

Third, the previous literature put insufficient emphasis on the connection between monetary policy and capital requirements. This paper will emphasize the interactions be-

[1] CET1 includes mainly common stocks, retained earnings and related items. It does not include preferred stocks, the detailed definition will be given in the data and model section.

[2] SCAP is the precursor of the current stress tests.

[3] CCAR is a part of the stress tests that takes into consideration banks' capital plan.

tween them since one cannot study one of them without taking into consideration of the other.

The empirical analysis mainly uses the quarterly bank-level data from the FDIC ranging from 2002 - 2017. The data will be divided into 3 sub-samples covering pre and post the implementation of higher-quality capital requirements in the U.S.. Because data on CET1 is only available for all the FDIC insured banks starting from 2015, a proxy for CET1 will be constructed. Banks will be divided into groups based on their subjected regulatory pressure. The analysis will use dynamic panel regressions such as system GMM to control endogeneity. The analysis uses the standard dynamic lending models based on Kashyap & Stein (1995), Gambacorta & Mistrulli (2004), Berrospide & Edge (2010), Gambacorta & Shin (2016) and Borio & Gambacorta (2017). The analysis takes advantage of a large amount of information that can be extracted from a panel data.

Section 2 will briefly introduce the background of the Basel chronologically, ending with some background on the U.S. stress tests. Section 3 will review the related literature. Section 4 will describe data, methods and models.

2 Background of the Risk-Based Capital Standards

This section will briefly introduce the background of the Basel capital standard chronologically, with some observations on the U.S. stress tests. The Basel capital requirement was simple and straightforward when it was first introduced in 1988, but it has become more complicated and heightened since then.

2.1 Basel I

The risk-based capital standard was initially introduced in 1988 (Basel I). It was constructed by the Basel Committee on Banking Supervision (BCBS) which comprised representatives of central banks and supervisory authorities of the G10 countries. The standard aimed to improve the soundness of internationally active banks and establish competitive equality across countries by issuing a common capital standard with some discretion within each country. The focus of Basel I was to address credit risks inherent in banks. Two tiers of capitals were introduced. Tier 1 (core capital) consists of equity capital and disclosed reserves (post-tax retained earnings). Other reserves or debts that can be used to absorb losses for an on-going basis are counted into tier 2 capital. It classified banks' assets into broad categories and assigned 5 possible weights to each category. The risk-based capital ratios can be calculated as capital divided by risk-weighted assets. The standard ratio was set at 8% for total capital to risk-weighted assets and 4% for tier 1 capital to risk-weighted assets (Basel Committee on Banking Supervision, 1988).

The standard was straightforward. The intention was to improve banks' capitalization that supports the risk-taking behavior by raising capital (the numerator, see the importance of banks' capitalization to their lending (Shin, 2016; Berger & Bouwman, 2013)). However, bank capital deteriorates during recessions. The side effects come when banks choose to cut loans (the denominator) instead as capital requirements become binding. Some studies suggest that banks are more likely to reduce loans than to issue equities during recessions (Myers & Majluf, 1984; Hyun & Rhee, 2011). Banks' reluctance to extend lending might result in a leftward shift in the credit supply curve, which might have negative effects on the real economy beyond demand effects during recessions. A spate of literature thus emerged around 1990 [4] in the U.S. to study the regulatory-induced credit crunch, or put another way the capital crunch (Bernanke & Lown, 1991; Berger & Udell, 1994; Furlong, 1992; Hancock & Wilcox, 1994; Peek & Rosengren, 1996). The literature will be reviewed in section 3.

2.2 Basel II

The first consultative paper for Basel II was released in 1999, and formalized in 2004. The new standard aimed to improve the soundness of internationally active banks by

[4] A time when a recession coincided with the introduction of Basel I.

providing a more risk-sensitive capital standard. It recognized the importance of other forms of risks such as operational risks. It gave banks more discretion when evaluating risks which could depend on the characteristics of borrowers. It also meant to address issues such as regulatory arbitrage in which banks could artificially boost their capital ratios, for example, securitisation through a "special purpose vehicle" (Jackson et al., 1999).

The Basel II introduced the concept of 3 pillars – minimum capital requirements, supervisory review and market discipline. Pillar 1 minimum capital requirements retained the previous risk-based capital requirements of an 8% minimum ratio. It allowed banks to choose between a standardized approach specified by supervisors and an internal-ratings based approach. The standardized approach was essentially the Basel I requirement, but weighted assets based on external ratings given from rating agencies. The internal-ratings based approach allowed banks to build models under supervisory reviews to calculate capital requirements based on factors such as the probability of default. Pillar 2 and pillar 3 were to enhance supervisory examination and market transparency (Basel Committee on Banking Supervision, 2004).

A flood of literature appeared around the beginning of 2000 to study the potential effects of Basel II. The main argument was that Basel II was procyclical and would increase the cyclicality of business cycles. By measuring risks based on factors such as the probability of default of borrowers which certainly would increase during recessions, banks would be subjected to tighter capital requirements when a recession occurs. This might lead to a more severe retrenchment in credit supply (Kashyap & Stein, 2004; Gordy & Howells, 2006; Andersen, 2011).

2.3 Basel III

The consultative paper for Basel III was introduced at the end of 2009, and formalized in 2010. Basel III aims to improve the resilience of the banking sector by addressing lessons from the financial crisis. It improves several aspects of Basel II and heightens the risk-based capital requirements qualitatively and quantitatively. It means to be a standard applicable to all sizes of banks, but more stringent for systemically important banks.

One purpose of Basel III is to improve capital quality and quantity. As stated in the consultative paper, banks could hold as little as 2% common equity to risk-based assets before regulatory adjustments but still display a strong Tier 1 ratios under Basel II. However, it was retained earnings, which are a part of banks' common equity bases, that absorbed credit loses and writedowns during the Great Recession (Basel Committee on Banking Supervision, 2009). Basel III thus introduce a new minimum requirement of 4.5% on common equity tier 1 capital to enhance the quality and quantity of essential bank capital. It also raises the requirement for the tier 1 capital ratio from 4% to 6%. The requirement for the total capital ratio stays at 8%. In addition, Basel III introduces a capital conservation buffer of 2.5% CET1 that can be drawn down during times of stress, hence raising the CET1 requirement to 7%. The quantitative impact study released by the Basel Committee showed that a group

of 94 internationally active and well diversified big banks in aggregate had a shortfall of €577 billion to reach the 7% CET1 requirement by the end of 2009, and a shortfall of €25 billion for the other 169 banks in the study (Basel Committee on Banking Supervision, 2010b). Moreover, a countercyclical buffer which ranges from 0% to 2% will be added to address the procyclicality in Basel II. An additional loss absorbing requirement will also be imposed on globally systemically important banks (Basel Committee on Banking Supervision, 2011a).

These buffers aim to push banks to build up capital in good times thus dampening the procyclicality of capital requirements. Other aspects of Basel III include a leverage ratio and a liquidity coverage ratio (Basel Committee on Banking Supervision, 2010a). The U.S. Fed determined that Basel III will be implemented in the U.S. on all banks except for BHCs with assets less than $500 million in 2013. The implementation date for a 4.5% minimum of CET1 is 2015; for 7% of CET1 including 2.5% of conservation buffer is 2019 (Board of Governors of the Federal Reserve System, 2013).

As summarized above, the Basel capital standard has become more stringent over the years. One might expect that the capital standard is more relevant in affecting a bank's lending decision than before. On the other hand, regulators have been giving banks extended time to prepare for the full implementation. Thus, using recent data to study the phase-in periods might provide insights into the subject.

2.4 The U.S. Stress Tests

The U.S. Fed designed the stress tests during the financial crisis. The precursor of the current Dodd-Frank Act Stress Test (DFAST) is the Supervisory Capital Assessment Program (SCAP) which started in 2009. SCAP included the 19 largest U.S. BHCs. It performed stress tests on these banks under different scenarios, and required them to meet a satisfactory level of capital within 6 months. If these banks cannot raise the amount of capital needed, the U.S. treasury will be a backstop for them. The bank-specific test results were disclosed. The unprecedented move meant to gain public confidence at the time. The program was successful, because banks that under the program ended up raising enough capital by themselves. SCAP was closed later, but experience was learned and used in the current stress tests (Board of Governors of the Federal Reserve System, 2009).

In 2011, the Comprehensive Capital Analysis and Review (CCAR) was implemented. It incorporates banks' future capital plans into scenario tests and allow the Fed to object to banks' plans of stock repurchase and dividend payout due to quantitative or qualitative concerns. The first participants were the previous 19 largest BHCs under SCAP. CCAR later extended coverage to BHCs that have over $50 billion of consolidated assets (Board of Governors of the Federal Reserve System, 2017a).

The Dood-Frank Act Stress Test (DFAST) was formally implemented in 2013. It included the 19 largest BHCs and extended to other banks with over $50 billion assets later. It tests banks' capital ratio under different scenarios assuming banks do not repurchase

stocks and keep their previous dividend payout plan. The focus was on the Tier 1 common ratio (T1C) which is a US measure of essential common equity capital [5]. The requirement was around 4.5% - 5%. The results of DFAST also serves as an input for the CCAR. Both the DFAST and the CCAR comprise the current stress tests (Board of Governors of the Federal Reserve System, 2017b).

In addition to largest BHCs, banks with assets over $10 billion but under $50 billion are required to perform company-run stress tests based on supervisory scenarios, but they are not subject to the stress tests. Smaller community banks are not subject to any form of stress tests. The current stress tests and SCAP successfully push the largest banks to raise high-quality capital over time and cut dividend payout compared with their pre-crisis level. According to the Federal Reserve, "The common equity capital ratio – which compares high-quality capital to risk-weighted assets – of the 34 bank holding companies in the 2017 CCAR has more than doubled from 5.5% in the first quarter of 2009 to 12.5% in the first quarter of 2017. This reflects an increase of more than $750 billion in common equity capital to a total of $1.25 trillion during the same period" (Board of Governors of the Federal Reserve System, 2017c).

[5]The Fed later switched to use CET1 as Basel III was gradually phased-in in the U.S..

3 Literature Review

This section will review two strands of literature. 1. Literature associated with regulatory-induced lending slowdowns – the credit crunch literature. 2. Literature on the effectiveness of monetary policy and its relationship with capital requirements – the bank lending channel literature.

3.1 Credit Crunch

The literature on regulatory-induced credit crunches has a relatively long history of debate. However, it has not reached a conclusion despite many theoretic and empirical works that have been done in the field. The literature has extended into various branches over time. Studies in the literature generally try to answer several questions. 1. Do capital requirements improve banks' capitalization? And how do capitalization and capital requirements affect banks' lending and investing behavior? 2. Do capital requirements enhance procyclicality in the banking industry? 3. How does the effectiveness of monetary policy change when capital requirements are binding (VanHoose, 2008)? The third question closely relates to the credit view of money which states that part of monetary policy works though bank credit. Related literature will be reviewed in the next subsection.

First, how does one define a bank credit crunch? Bernanke & Lown (1991) defined it as a significant leftward shift in the credit supply curve holding constant both the safe real interest rate and the quality of potential borrowers. By comparing loan growth rates across recessions, they argued that the unusually slow growth rate seen in 1990 suggested an additional role played by supply factors other than demand factors seen in a normal recession. Berger & Udell (1994) defined it as a decrease in loan growth compared with normal times rather than recessions. Clair & Tucker (1993) viewed credit crunches as localized events that occur at different times in different parts of a country. They examined closely the contraction of bank credit that began in Texas in 1986. In sum, the general concept of a credit crunch is that it is a reduction in credit supply beyond a normal demand reduction seen in business cycles.

The first spate of this strand of literature emerged around the beginning of 1990, when a recession coincided with the introduction of Basel I, to study the observed credit crunch in the U.S.. Some believe it was a regulatory-induced incident while others think it was more likely to be a demand-driven business cycle.

Bernanke & Lown (1991) examined the credit crunch using state-level data from 1989-1991. They believed that "the credit crunch" might be better called "the capital crunch", because it was due to loan writedowns and credit losses during the recession, which reduced banks' capital. The drop in capital ratios then caused banks to sell assets and reduce lending in order to comply with the regulatory standard. They thus examined the relationship between loan growth and the capital-to-asset ratio across states. They also

conducted a case study on banks in New England where loan growth slowed the most. Their results showed that loan growth was positively related to the capital-to-asset ratio. Banks with lower capital levels had slower loan growth. They concluded that the capital crunch contributed to the slowdown in lending. However, because the magnitude was not extremely large [6], they believed that demand factors played the major role in the lending slowdown.

Furlong (1992) studied the same issue using bank-level data from 1985-1991 and found that loan growth was positively related to the capital-to-asset ratio. The study showed that the capital standard indeed tightened in the early 1990s compared with the 1980s. The sensitivity of loan growth to banks' capital positions increased during the credit crunch as well. The effects were found to be more pronounced for large banks than smaller banks. The author believed that it could be due to the reason that capital regulation tends to be binding more often for larger banks.

By exclusively focusing on banks in New England and the liability side of those banks' balance sheets, Peek & Rosengren (1992) were able to isolate supply factors from demand factors to some extent. They found a strong positive relationship between a bank's capital shock and the growth rate of its deposits. They concluded that a capital crunch happened in New England, but they could not test further if the capital crunch caused a credit crunch because the data was insufficient at the time.

Peek & Rosengren (1993) again examined the credit crunch on FDIC insured banks in New England from another perspective. By including a dummy variable for banks under formal regulatory action, they differentiated the effects of regulatory enforcement actions on banks' lending from banks' voluntary retrenchment. They found that banks facing formal regulatory actions shrank at a significantly faster rate than those without. A large share of reduced lending was concentrated in loan categories that depend on local banks. They thus concluded that the capital crunch had resulted in a credit crunch in New England.

U.S. banks were also subjected to a tier 1 leverage ratio requirement at the time, which is a ratio of tier 1 equity capital to unweighted assets. Baer & McElravey (1992) studied the effects of the risk-based capital ratio together with the leverage ratio on assets growth of U.S. bank holding companies from 1989-1991. They argued that the leverage ratio requirement was more binding than the risk-based capital requirements. Their results showed that differences in the equity ratio could explain 45 percent of the variation in asset growth rates while the risk-based capital requirements could explain only 12 percent of the variation in growth rates.

Hancock & Wilcox (1994) further investigated whether banks have increased their holdings of securities at the expense of business loans in response to shortfalls of capital. Their results showed that banks contracted their portfolios in response to shortfalls relative to either an unweighted 4.75 percent leverage ratio or a risk-weighted 8 percent capital standard. Contrary to widely held perceptions, their result showed that banks with less

[6] Bernanke & Lown (1991) found that the capital ratio explained approximately 2-3 percentage points of the decline in lending.

capital than required by the risk-weighted standard appeared to have shifted away from assets with low risk weights (securities and single-family mortgages) and to have shifted toward assets with higher risk weights (commercial real estate and business loans) without further elaboration. When they included both shortfall variables in a regression, shortfalls relative to the unweighted capital standard significantly affected bank credit, while shortfalls of capital relative to the risk-weighted standard did not.

Berger & Udell (1994) tested different credit crunch hypotheses including the risk-based capital standard, the leverage ratio, loan examinations, voluntary risk retrenchment, and two demand side hypotheses – macro-demand and secular decline. They took advantage of a large amount of bank level data from 1979-1992. They used 1979-1989 as control periods in the regression. They found that the risk-based capital hypothesis was the worst of all the alternative explanations of the bank credit reallocation in the 1990s. The results for the risk-based capital hypothesis were inconsistent to the predictions. Other credit crunch hypotheses provided only limited support for a supply side "credit crunch". The demand factors however proved to be relatively strong.

On the other hand, Lown & Wenninger (1994) aruged that supply-side banking problems contributed to the lending slowdown to some extent. In their cross-sectional regressions, they regressed the loan growth rate on the capital ratio, the growth rate of employment, and the loan loss reserve ratio using state-level data. Their results showed that only employment and loan losses were significant in determining loan growth for 1988 and 1989. However, capital was significant when it was included in the regressions by itself and when employment was also included for 1990 and 1991. When loan losses were included, the siginificance of capital weakens. They believed that it could be that the loan-loss ratio likely reflects more accurately the current market value of the banking system's portfolio in each state, which reduces capital's significance when the loan loss reserve ratio is included in the regressions. They concluded that roughly 15% to 40% of the lending slowdown from 1989 - 1990 could be explained by supply-side factors in the banking industry.

Lown & Peristiani (1996) reexamined the issue by studying the effects of bank capital on consumer loan rates from 1988-1992. They found that large, low-capitalized banks deliberately curtailed consumer credit by raising interest rates on consumer loans. The result implied that banking behavior was consistent with the credit crunch hypothesis. Their result on non-performing loans also suggested that the credit slowdown was caused by numerous factors, each could have played a significant role at one point in time.

Isolating effects of supply factors from demand factors was always an obstacle. However, Peek & Rosengren (1996) were able to conduct a cleaner natural experiment that differentiates effects of risk-based capital requirements from demand factors. By studying the branches of Japanese banks that operated in the U.S., they found that binding risk-based capital requirements associated with the Japanese stock market decline resulted in a decrease in lending by Japanese banks in the United States that was both economically and statistically significant from 1988-1995. Their result showed that a 1-percentage-point decline in the parent's risk-based capital ratio resulted in a statistically significant decline

in total loans at U.S. branches of nearly 4 percent of assets annually, which translates into roughly a 6-percent decline in total loans.

Several newer studies focused on the behavior of different sizes of banks. Hancock & Wilcox (1998) examined economic activity and bank loans using state-level data from 1989-1992. They found that small banks shrank their loan portfolios considerably more than large banks did in response to declines in capital. They argued that large banks tended to increase loans more when small banks were under increased capital pressure than vice versa. They believed that one reason could be that large businesses may have taken out loans from large banks to fund trade credit for their small business customers. Or it could be that large banks may be able to handle all the borrowing demands of many small businesses. However, a small bank may not be able to fund the borrowings of even one large firm. They also found that real economic activity was reduced more by capital declines and loan declines at small banks than at large banks. They argued that it could be that the customers of large banks have alternative sources of credit while small banks' customers may not be able as quickly to arrange for credit through other small banks. They concluded that small banks were making "high powered loans" in that dollar-for-dollar loan declines in their loans had larger impacts on economic activity than loan declines at large banks did.

Berrospide & Edge (2010) studied large BHCs in the U.S. from 1990-2008 for post Basel periods. Their results showed that bank capitalization only had modest long-run effects on lending while demand factors and perceived risks of banks were the main drivers using both panel regressions and VARs.

Kashyap et al. (2010) studied the impacts of introducing substantially heightened Basel III capital requirements on large financial institutions. Their results showed that the frictions associated with raising new external equity finance are likely to be greater than the ongoing costs of holding equity on the balance sheet, implying that the new requirements should be phased in gradually. If phased in abruptly, the new requirements have negative effects on lending activities. In addition, they argued that capital requirements have only modest long-run, steady-state impacts on loan rates, in the range of 25 to 45 basis points for a ten percentage-point increase in the capital requirements.

The topic of a credit crunch has also been widely studied internationally. Although the results might not be applicable to the U.S., I will breifly mention several studies here. Woo (2003) and Watanabe (2007) gave evidence that the regulatory-driven capital crunch caused the credit crunch in Japan in 1990s using panel regressions.

Kok & Schepens (2013) studied effects of banks' deviations from their optimal capital ratios on banks' balance sheet activities for a group of large European banks from 2004-2011. They found asymmetries in banks' reactions to deviations from optimal capital levels. Overcapitalized banks preferred to reshuffle risk-weighted assets or increase asset holdings when deviating from their optimal Tier 1 risk-based ratio, whereas they would rather increase equity levels or reshuffle risk-weighted assets without changing asset holdings when being below target. When looking at the equity ratio, under-capitalized banks deleveraged and

lowered loan growth during the financial crisis, whereas banks tended to adjust equity levels, for example, through changes in retained earnings in the pre-crisis periods.

Bridges et al. (2014) estimated the effects of changes in capital requirements on banks' capital ratios and lending using data for bank groups in the United Kingdom from 1990 to 2011. Capital requirements were set individually on banks in the U.K. for the past two decades. They found that changes in capital requirements typically lead to a positive change in actual capital ratios. Capital requirements affected lending with heterogeneous responses in different sectors of the economy. Banks cut (in descending order based on point estimates) loan growth for commercial real estate, other corporate and household secured lending. The response of unsecured household lending was smaller and insignificant over the first year. Loan growth mostly recovered within three years. Their results confirmed that regulatory requirements affected capital ratios permanently and credit supply temporarily.

Mustika et al. (2015) examined the credit crunch from 2006-2008 in Indonesia following Berger & Udell (1994). They studied banks' behavior of reducing lending and increasing riskless security holdings under regulatory burden and tightening monetary policy. They concluded that the 'Risk-Based Capital Credit Crunch Hypothesis' performed the worst of all the alternative explanations of the bank credit reallocation of 2006-2008 while the "Macro demand-side hypothesis" best explained the credit crunch. More extensive literature reviews on credit crunch can be found in VanHoose (2007), VanHoose (2008) and Borio & Zhu (2012).

To summarize the above findings, some believe that it is demand factors rather than the risk-based capital requirements that affect bank lending. However, other think that risk-based capital ratio did explain bank lending in some degree beyond the demand effects. Moreover, banks of different sizes and extents of capital insufficiency might react differently to the requirements. The debate also justifies the need to study the subject further since the risk-based capital requirements has been significantly heightened after the Great Recession.

3.2 Bank Lending Channel

Another issue this paper will examine is the effectiveness of monetary policy in affecting bank lending with heightened capital requirements. The assumption is that bank lending channel exists. I also believe that the heightened capital requirements would strengthen the effectiveness of monetary tightening, but weaken the effectiveness of monetary easing. This section will brief review the literature regarding the existence of bank lending channel first, then review several studies that examine the relationship between monetary policy and capital requirements.

The conventional money view of monetary policy treats loans as indistinguishable from money and assigns a common interest rate. The credit view on the other hand emphasizes that banks' decisions about how to manage their asset portfolios determine whether the policy's impact will fall primarily on open-market interest rates or on effective bank loan rates. The credit view argues that not only the LM curve but also the IS curve shifts given a

monetary policy as banks' lending affects consumption and investments. It means to be an addition to the money view (Bernanke, 1988; Bernanke & Blinder, 1988; Woodford, 2010).

Bernanke & Gertler (1995) summarized two relevant channels of the credit view – the balance sheet channel and the bank lending channel. The balance sheet channel states that borrowers' balance sheets deteriorate following a monetary tightening. The sustained weakening of balance sheets implies that the premium for external finance may rise, thus reducing demand for credits. The bank lending channel states that banks can not perfectly offset the reduction in reservable deposits after a monetary tightening by issuing other source of deposits, and thus cut lending as a result. The bank lending channel relies on the failure of the proposition made in Modigliani & Miller (1958), which states that the investment decision in the firm will be completely unaffected by the type of security used to finance the investment.

A spate of studies examined the existence of the bank lending channel. For example, Kashyap et al. (1992) examined the composition of external finance from a firm's perspective. They found that a monetary tightening reduced banks' supplies of loans and encouraged firms' issuance of commercial paper. The shift in the mix of loans and commercial paper affected investment and the real economy as well. The shift in the external finance of firms provided evidence of the existence of the bank loan channel.

Kashyap & Stein (1995) further studied balance sheet behavior across different sizes of banks from 1976-1992 in the U.S.. They argued that if the lending channel exists, the balance sheet items of small and big banks should react differently to a monetary tightening due to their access to alternative funds. Their results suggested that both lending and securities holdings of small banks were more sensitive to a contraction in monetary policy than those of big banks. A newer study from Kashyap & Stein (2000) found evidence that the impact of monetary policy on lending was stronger for small banks with less liquid balance sheets than small banks with liquid balance sheets.

While there are other literature that examined the existence of bank lending channel, the review will stop here and focus on the literature regarding the relationship between the effectiveness of monetary policy and capital requirements.

3.2.1 Monetary Policy and Capital Requirement

Traditionally, monetary policy works through reserves, and banks were only subjected to reserve requirements. It is assumed that money pumped into the banking system will be lent out to the economy. However, the capital requirement introduced an additional constraint for banks, which could amplify or weaken the bank lending channel. For example, banks with binding capital requirements might not be able to lend due to the capital constraints and choose to invest instead even when a monetary easing is conducted. On the other hand, monetary tightening is still effective by draining reserves out of banking. That is to say, monetary policy is asymmetric when banks are subjected to capital requirements

(Bliss & Kaufman, 2002).

Van den Heuvel et al. (2002) summarize that monetary policy works through banks' capital as an additional capital channel, which might amplify or weaken the bank lending channel. For example, given a monetary easing, capital requirements can block the bank lending channel by preventing banks from making loans. On the other hand, a monetary tightening can reinforce the bank lending channel for less capitalized banks because they incur a higher "lemon premium" for alternative funding. Additionally, a monetary tightening that raises deposit costs will reduce banks' profitability, which results in less capital accumulation in the long-term. It also reduces bank's incentive to make loans. Bank then would find it less valuable to hold capital, which further reinforces the reduction in lending in the presence of risk-based capital requirements (Chami & Cosimano, 2010).

Peek & Rosengren (1995) was one of first studies that addressed the effects of monetary policy on capital constrained banks. They studied bank lending in New England from 1976-1994. They argued that loans by capital-constrained banks will rise in response to a tightening of monetary policy, because decreases in bank reserves that reduce transactions deposits are exactly offset by an increase in non-transactions deposits. On the other hand, a tightening of monetary policy will reduce loans for unconstrained banks because changes in non-transactions deposits do not exactly offset changes in transactions deposits. Although the study inspires the idea of studying capital's effects on loan differentiating the capital-constrained and unconstrained banks, it contradicts the conclusions reached from other newer studies. It was later argued that several preliminary assumptions are likely to be violated in the real world. It could be that banks are not be able to offset the reduction in transactions deposits completely. And capital-unconstrained banks might have better access or lower costs to alternative funds.

Kishan & Opiela (2000) examined effects of monetary policy on US banks of different size and capitalization groups from 1980-1995. They found loans of small under-capitalized banks were the most responsive to monetary policy, while large well-capitalized banks could shield the effects of contractionary monetary policy because of their better access to alternative funds.

Kishan & Opiela (2006) further examined the cross-sectional asymmetry and policy-stance asymmetry in the bank lending channel by comparing pre- and post-Basel periods using data from 1980-1999. They argued that monetary easing and tightening should have different effectiveness with capital requirements. Banks with different capitalization should react differently to a particular stance of monetary policy as well. They found that contractionary monetary policy reduced loans of small low-capital banks relative to high-capital banks. That is to say monetary tightening is more effective in restraining loans from small low-capital banks. However, expansionary monetary policy was not able to increase loan growth of low-capital banks relative to high-capital banks in the post Basel/FDICIA periods. The results suggested the asymmetry of monetary policy with capital requirements. Their results did not hold in the pre-Basel/FDICIA periods however, indicating that regulation constraints must be of a certain level of stringency for the results to hold.

Van den Heuvel (2012) examined effects of monetary policy on output using US state-level data from 1969-1995. He found that when a state's banking sector starts out with a low capital-asset ratio, its subsequent output growth is more sensitive to changes in the Federal funds rate. The result was consistent with the existence of a "bank capital channel".

Bijapur (2010) examined the effectiveness of monetary policy in boosting GDP growth and credit (TED spread) during credit crunch periods using a VAR from 1972-2009. He concluded that impacts of policy rate cuts on GDP growth and credit became weaker during credit crunch periods. That is to say, monetary stimulus could be less effective during credit crunch periods. They believed that the reason could be due to both a "credit crunch" effect and a "recession" effect, but they did not investigate further.

Orzechowski (2016) studied the long-run relationship among monetary policy, bank capital, and lending using annual data on U.S. commercial banks from 1966-2013. The empirical analysis used an autoregressive model to examine loan activity between high and low-bank-capital states. The results showed that commercial loans at high capital banks had a stronger negative relationship to changes in the federal funds rates than low capital banks. Real estate loans showed a slightly stronger negative correlation with the federal funds rate for high capital banks than banks with low capital levels. The author argued that it could be that high capital banks have greater flexibility to rearrange their balance sheet items to support loan growth while low capital banks are constrained by capital requirements. He concluded that monetary policy may have asymmetric effect on different capitalized banks. However, the study did not differentiate between monetary easing and tightening across the long time period. The study could have offered more evidence if different monetary states are considered.

Gambacorta & Mistrulli (2004) examined the response of lending to monetary policy and output shocks in Italy from 1992-2001. They found well-capitalized banks could better shield their lending from monetary policy shocks and GDP shocks. In another study, Gambacorta & Shin (2016) examined loan growth of a group of large banks in the G-10 countries and several other countries from 1994-2012. They found that loan growth was positively related to capital levels. Banks with higher capital levels had faster loan growth. They also found that a monetary tightening had smaller effects for banks with higher capitalization. They argued that banks with higher capital ratios incur a lower cost in borrowing through debt, thus could supply more credit than lower capitalized banks.

Cecchetti & Li (2008) and Angeloni & Faia (2013) provided suggestions on the optimal monetary policy and prudential regulation when they are affected by each other. More extensive literature reviews can be found in Borio & Zhu (2012) and the Basel Committee on Banking Supervision (2011b).

As summarized above, the evidence on the effectiveness of monetary in affecting bank lending with capital requirements is insufficient, especially when different bank status and monetary policy state are considered. For example, under a monetary easing, a well-capitalized bank could lend more because they are not subjected to the capital constraints.

However, a under-capitalized bank could not lend much because they are constrained by the capital requirements. In this case, monetary easing is more effective for well-capitalized banks than under-capitalized banks. On the other hand, what might happen if a monetary tightening is conducted? Well-capitalized banks can still lend if they have lower cost and better access to alternative funding. Under-capitalized banks would cut lending as desired by policy maker. In this case, monetary tightening is more effective for under-capitalized banks than well-capitalized banks. This paper will study the sub-samples pre and post the introduction of the heightened capital requirements. This could provide more evidence of the effectiveness of monetary easing when capital requirements is substantially heightened and banks are subjected to different regulatory pressure.

4 Data and Model

4.1 Objectives

The empirical research will try to answer following questions:

1. How do the substantially heightened risk-based capital requirements affect bank lending before and after its introduction?

2. How is the effectiveness of monetary policy in affecting bank lending across sub-sample periods?

3. How do banks which are subjected to different regulatory pressure (either Basel III or the stress tests, both or none) react differently to the heightened capital requirements during the phase-in periods? And how is the effectiveness of monetary policy in affecting lending of different bank groups during the periods?

4. How do the substantially heightened capital requirements affect banks' common stock equity and retained earnings?

4.2 Data

Definition of Regulatory Capital (Board of Governors of the Federal Reserve System (2014), footnote 22):

Common Equity Tier 1 (CET1):

$$\begin{aligned} CET1 = &\text{ Common Stocks and Related Surplus + Retained Earnings} \\ &\text{+ Accumulated Other Comprehensive Income} \\ &\text{+ Limited Amounts of CET1 Minority Interst} \\ &\text{- Applicable Regulatory Adjustments and Deductions} \end{aligned}$$

Tier 1 Capital (T1):

$$T1 = CET1 + \text{Additional Tier 1 Capital (non-cumulative perpetual preferred stocks)}$$

Tier 1 Common (T1C)[7]:

$$T1C = T1 - \text{Non-common Elements (non-cumulative perpetual preferred stocks)}$$

[7]CET1 is not exactly the same as T1C. T1C was the U.S. measure of high quality of capital, which was transited to CET1 around 2014-2015.

The empirical analysis uses the quarterly bank-level data from the FDIC ranging from 2002 - 2017. Data on CET1 is only available for all the banks starting from 2015. A proxy for CET1 will thus be constructed for periods before 2015. The data will be divided into 3 sub-samples to compare effects before and after the introduction of higher-quality capital requirements. The first sub-sample ranges from 2002 - 2009, which represents periods before the introduction of Basel III and the stress test. The quarterly bank level data begins in 2002. The second sub-sample ranges from 2009 - 2015, when the heightened capital requirements have been introduced and being phased in. 2009 is the year when the first round of the stress tests were performed under SCAP. The 19 largest U.S. BHCs were under SCAP in 2009. The tests gradually expanded to cover other large BHCs with assets of more than $50 billion around 2012 - 2014 [8]. The third sub-sample ranges from 2015 - 2017 when CET1 data is available.

Several potential proxies for CET1 can be constructed. CET1 mainly consists of common stocks and retained earnings. I can use the sum of common stockholders' equity and retained earnings over risk-weighted assets as a proxy. Another proxy could be Tier 1 capital minus preferred stocks over risk-weighted assets since CET1 excludes preferred stocks. This proxy is a better approximation than the previous one by comparing data after 2015. The data has shown that the two numbers are the same or similar for most of the banks [9]

The whole data set covers around 6,000 - 9,000 depository institutions insured by the FDIC in the U.S. from 2002 - 2017, around 500,000 observations. The data is unbalanced due to the fact that some banks drop out while others enter the industry over years. The data starts with around 9,000 banks in 2002, however the number of banks declines gradually by around a average of 50 per quarter to around 6,000 in 2017. The analysis will use dynamic panel regressions and focus on difference across sub-sample periods and different responses among bank groups.

4.3 Methods

The model is based on the standard dynamic lending regressions following Berrospide & Edge (2010) and Borio & Gambacorta (2017). The dependent variables in this research are growth rates of bank's loans, retained earnings, or common stockholders' equity. The factors of interest are the risk-based capital ratio and monetary policy. Lagged variables of these factors will be used to mitigate the endogeneity problem. Since the model contains lagged dependent variables in the regressors for serial adjustments, dynamic panel regression techniques such as system GMM and GMM with nonlinear moment conditions will be used to mitigate endogeneity and provide consistant estimates based on Anderson & Hsiao (1981), Arellano & Bond (1991), Ahn & Schmidt (1995) and Blundell & Bond (1998).

[8] The starting year of DFAST and CCAR to cover all banks with assets of more than $50 billion was 2014, some large BHCs were covered under CapPR during the transition.

[9] ANOVA and t-tests have shown that the proxy and CET1 are not significantly different for 2015-2017.

Two dummy variables will be introduced to differentiate banks that undergo different regulatory pressure (either Basel III or the stress tests, none or both) during the phase-in periods. This establishes bank control group and trial group. The largest BHCs [10] in the U.S. are subject to both Basel III and the stress tests. The first round of the stress tests was performed in 2009 on the 19 largest U.S. banks, and extended to cover other large BHCs with assets of over $50 billion gradually. The Federal Reserve Board releases the bank-specific results for these banks, and can object to their capital plan such as repurchasing stocks and raising dividend payout for quantitative or qualitative concerns. Medium banks with assets of over $10 billion but under $50 billion need to perform company-run stress tests under supervisory scenarios and disclose the results since 2013, but they are not subject to the supervisory stress tests. The Fed will not issue statements regarding these banks' tests. In addition, these banks need to prepare for the full implementation of Basel III in 2019 (7% of CET1 including the conservation buffer). Smaller community banks are not subject to any form of the stress tests, but they need to prepare for the implementation of Basel III. BHCs with assets of less than $500 million are subjected to neither the stress tests nor Basel III.

Macro economic conditions and bank's specific characteristics such as size and profitability of loan will be controlled. By comparing responses from different bank groups, the analysis could shed light on how the substantially heightened capital requirements and monetary policy affect bank lending, retained earnings or common stock capital during the phase-in periods. Merger and acquisition can be dealt with by using pre-merger data.

4.4 Model

The empirical specifications presented here are based on the standard dynamic lending regressions to study the effects of bank capital and monetary policy on bank loan growth, see Kashyap & Stein (1995), Gambacorta & Mistrulli (2004), Berrospide & Edge (2010), Gambacorta & Shin (2016) and Borio & Gambacorta (2017) for more details. I add dummy variables for regulatory pressure (Basel III and the Stress Tests), interaction terms and control variables.

The factors of interest are capital ratio, monetary policy and their interaction. Demand factors and other supply factors such as perceived risks by banks are controlled in the regressions. Some studies suggest that estimates might be biased if these variables are not included. The banks can be divided into groups by introducing two dummy variables for regulatory pressure. The effects across sub-sample periods can be studied by estimating within each sub-sample, or by modeling a dummy variable and test for a structural break.

[10] 34 banks with assets of over $50 billion participate in the supervisory stress tests in 2017.

A baseline specification:

$$\Delta \ln L_{i,t} = \alpha_i + \theta_t + \sum_{j=1}^{4} \beta_j \ \Delta \ln L_{i,t-j} + \eta \ CET1R_{i,t-1} + \sum_{j=1}^{4} \ \mu_j \ \Delta MP_{t-j} + \phi \ Z_{i,t-j} + \epsilon_{i,t}$$

A specification with a structural break dummy variable (D_t):

$$\Delta \ln L_{i,t} = \alpha_i + \theta_t + \sum_{j=1}^{4} \beta_j \ \Delta \ln L_{i,t-j} + \eta \ CET1R_{i,t-1} + \sum_{j=1}^{4} \ \mu_j \ \Delta MP_{t-j} + \kappa \ D_t \cdot CET1R_{i,t-1} + \sum_{j=1}^{4} \ \lambda \ D_t \cdot \Delta MP_{t-j} + \phi \ Z_{i,t-j} + \epsilon_{i,t}$$

A specification with interaction:

$$\Delta \ln L_{i,t} = \alpha_i + \theta_t + \sum_{j=1}^{4} \beta_j \ \Delta \ln L_{i,t-j} + \eta \ CET1R_{i,t-1} + \sum_{j=1}^{4} \ \mu_j \ \Delta MP_{t-j} + \sum_{j=1}^{4} \lambda_j \ CET1R_{i,t-1} \cdot \Delta MP_{t-j} + \phi \ Z_{i,t-j} + \epsilon_{i,t}$$

A specification with regulatory dummy variables:

$$\Delta \ln L_{i,t} = \alpha_i + \theta_t + \sum_{j=1}^{4} \beta_j \ \Delta \ln L_{i,t-j} + \eta \ CET1R_{i,t-1} + \sum_{j=1}^{4} \ \mu_j \ \Delta MP_{t-j} + \zeta \ StressTest_{i,t} \cdot CET1R_{i,t-1} + \sum_{j=1}^{4} \kappa_j \ StressTest_{i,t} \cdot \Delta MP_{t-j} + \gamma \ BaselIII_{i,t} \cdot CET1R_{i,t-1} + \sum_{j=1}^{4} \delta_j \ BaselIII_{i,t} \cdot \Delta MP_{t-j} + \sum_{j=1}^{4} \lambda_j \ CET1R_{i,t-1} \cdot \Delta MP_{t-j} + \phi \ Z_{i,t-j} + \epsilon_{i,t}$$

L_{it}: Level of bank's total loans and leases. The model includes the lags of loan growth rate $\Delta \ln L_{i,t-j}$ for serial adjustments. Specific types of loan such as industry and commercial loan and auto loan can also be used as dependent variables. The quarterly bank level data comes from the FDIC.

BaselIII: A dummy variable which equals to 1 if the bank is subjected to Basel III after 2013. It equals to 0 for the sub-sample periods before 2013. A bank is assumed to be

subjected to Basel III if it has over $500 million of assets, or its BHC has over $500 million of assets. Data on BHCs is from the Federal Reserve Bank of Chicago.

StressTest: A dummy variable which equals to 1 for the largest BHCs that are subject to the stress tests after 2009. It equals to 0 for the sub-sample periods before 2009. This variable is 1 for all the largest banks whose BHCs participate in the CCAR, DFAST, or SCAP since 2009. This variable is 1 for all the medium banks whose assets are above $10 billion, or BHCs with assets of over $10 billion starting in 2013.

CET1R: A ratio of higher-quality capital over risk-weighted assets. A ratio of the proxy of CET1 (Tier 1 capital less preferred stock equity) to risk-weighted assets is used. The quarterly bank level data comes from the FDIC.

MP: A proxy of monetary policy. Following Bernanke & Blinder (1992), I use the federal funds rate ranging from 2002 - 2017. The data comes from the FRED.

D: A dummy variable for structural break on 2009. This is 0 before 2009, and 1 otherwise.

Z control variables:

Demand Factors: As several studies argued, demand factors played a major role in the credit crunch (Bernanke & Lown, 1991; Berger & Udell, 1994). I include several demand control variables: four lags of real GDP growth rate, four lags of the inflation rate (CPI), four lags of unemployment rate and four lags of the growth rate of state level personal income. The quarterly national data such as real GDP, inflation and unemployment rate are from the FRED. Real and nominal GDP are available until the second quarter of 2017. The state level personal income is from the U.S. Bureau of Economic Analysis.

Perceived Risk by Banks: As argued in several studies, the reduced supply of credit might be caused by voluntary credit retrenchment from banks because of high risks during recessions (Berger & Udell, 1994; Peek & Rosengren, 1993). High uncertainty also affects the transmission of monetary policy to lending. Thus leaving out this factor might cause the results to be biased (Baum et al., 2013). One proxy for perceived risks by banks is net charge-offs. I follow Berrospide & Edge (2010) and add one lag of the net charge-offs to total assets ratio as a control variable. However, net charge-offs alone might not be able to capture the whole picture of the rising of credit risks. Therefore, I also add one lag of the ratio of non-performing loans (assets past due 30 - 89 days, 90 + days, and nonaccrual) to total assets following Berger & Udell (1994). Some also argue that the CP-Bill spread can reflect risks, but others believe it is more likely to reflect the stance of monetary policy (Bernanke & Blinder, 1992).

Bank Specific Variables: A lag of bank size measured by the log of bank's total assets is included. One lag of liquidity ratio measured by the ratio of the sum of cash and securities to total assets is included. One lag of bank's cost of funding measured by the ratio of total interest expense on deposits to average earning assets is included.

Profitability on lending: Some argue that banks' profitability also played a major role in affecting loan growth during a credit crunch (Sharpe, 1995). Borio & Gambacorta (2017) also found that the effectiveness of monetary policy is reduced during a low-interest-rate environment. The impact of low rates on the profitability of banks lending helped to explain the subdued lending in the period from 2010-2014 for large international banks. The reason is that deposit rates usually follow short-term rates while lending rates follow long-term rates. Thus a monetary easing that lowers federal funds rate will reduce deposit rates faster than lending rates, which increases the spread for lending activities during normal times. However, when interest rate is already low, a lower federal funds rate will not be able to lower deposit rates further, while lending rates that follow long-term rates will come down eventually, which reduces the spread for lending activities. Lowered profitability also makes it harder to accumulate capital. A proxy for this variable is hard to find, as data is missing on lending rates. And even if there is data on loan rates, it might not accurately reflect the true price of a loan because loans usually involve collateral. However, data on interest income from loans and leases is available. Thus, one lag of the ratio of interest income from domestic office loans to total assets is included in the regressions. It also helps to see if the substantially heightened capital requirements affect banks' retained earnings beyond the effects from profitability.

Intermediation costs: banks' intermediation costs could also be one of the supply-side factors causing a credit crunch. Jaremski & Sapci (2017) argue that banks' intermediation costs (non-interest expenses) are counter-cyclical because of housing prices. House prices decrease during recessions, which would increase banks' costs of monitoring, screening and litigation which could cause a credit crunch in the economy. Using quarterly data for large U.S. commercial bank hold companies from 1993-2012, they show that house prices are the main driving source of the counter-cyclicality of banks' intermediation costs using both panel regressions and VARs. However, they do not further demonstrate if the intermediation costs or house prices have caused a slowed loan growth in their study. Due to the reason that higher non-interest expense could divert banks' resource from lending, one lag of the ratio of non-interest expense to average assets is included.

Other control variables such as a time trend and seasonal dummies will also be included.

4.5 Common Stockholders' Equity and Retained Earnings

As mentioned in the introduction, both common stockholders' equity and retained earnings are essential components of CET1 or T1C. The substantially heightened capital requirements push banks to either cut lending or raise high quality capital. Although the requirements are stringent, banks have been given a long time to prepare for the implementation. The risk-based capital requirements might not affect banks' lending significantly if banks can raise enough essential capital moving toward the deadline. The previous section investigates this question. This section further explores the question by examining the how

would common stockholders' equity and retained earnings be affected by the heightened capital requirements.

In general, companies are reluctant to cut dividends. It could convey a bad signal to the public. Dividends are also an income source to investors. On the other hand, companies are also reluctant to issue common stocks due to information asymmetry problems/higher lemon premiums during a crisis. It is also a dilution of earnings. However, the regulatory pressure has pushed US banks to manage their capital plan diligently since the financial crisis. The Fed can also object to banks' plan of stock repurchase or increasing dividend payout if the results are unsatisfactory (both stress tests and Basel III). According to the Fed, "The 19 institutions paid out 15 percent of net income in common dividends in 2011 compared with a payout of 38 percent of net income in 2006. They also raised more in common equity than they repurchased in 2011" (Board of Governors of the Federal Reserve System, 2012). By 2017, the largest 34 BHCs has raised the common equity ratio from 5.5% in 2009 to 12.5%, a increase of more than $750 billion (Board of Governors of the Federal Reserve System, 2017c). Smaller banks are not subject to the stress tests, but they need to prepare for the implementation of Basel III by 2019. They might rely on accumulating retained earnings from profits over time, because they might not have the same access to public funding as large banks.

Most of the literature focused on how bank's assets (Loans and Securities) react to their capital level. Few studies examined the source of capital. Gambacorta & Shin (2016) investigated the effects of the equity-to-total assets ratio on banks' cost of debt financing, annual loan growth and equity growth for 105 large international banking institutions from the G10 countries from 1994-2012. They found that a 1 percentage point increase in the equity-to-total assets ratio is associated with a 4 basis point reduction in the cost of debt financing and with a 0.6 percentage point increase in loan growth. They suggested the importance of greater retention of earnings and hence higher bank capital would have facilitated the transmission of accommodative monetary policy. However, they did not further examine how retained earnings would be affected by the leverage ratio.

Kok & Schepens (2013) studied how deviations from banks' capital targets affect both the numerator (Tier 1 capital or retained earnings) and denominator (risk-weighted asset) of the capital ratio, and loan growth for large European banks from 2004-2011. Their results suggested that the effects of Tier 1 ratio on retained earnings are not significant. They believe that it could be that retained earnings are at least in the short term largely determined by exogenous macroeconomic and financial factors and are not a sufficiently reliable tool to change Tier 1 ratios when they are off target.

In sum, there is not sufficient amount of evidence from the literature on how heightened capital requirements affect common stockholders' equity and retained earnings. This study would provide more evidence on the subject. The empirical specifications presented here follow the above specification for bank lending. I use the growth rate of common stockholders' equity and retained earnings (undivided profit) instead of loan growth as the dependent variables in this section.

The specifications below follow the baseline specification of lending but use undivided profit and common stockholders' equity as dependent variables.

$$\Delta\%RE_{i,t} = \alpha_i + \theta_t + \sum_{j=1}^{4} \beta_j \, \Delta\%RE_{i,t-j} + \eta \, CET1R_{i,t-1} + \sum_{j=1}^{4} \mu_j \, \Delta MP_{t-j} + \phi \, Z_{i,t-j} + \epsilon_{i,t}$$

$$\Delta \ln CS_{i,t} = \alpha_i + \theta_t + \sum_{j=1}^{4} \beta_j \, \Delta \ln CS_{i,t-j} + \eta \, CET1R_{i,t-1} + \sum_{j=1}^{4} \mu_j \, \Delta MP_{t-j} + \phi \, Z_{i,t-j} + \epsilon_{i,t}$$

References

Ahn, S. C., & Schmidt, P. (1995). Efficient estimation of models for dynamic panel data. *Journal of econometrics*, *68*(1), 5–27.

Andersen, H. (2011). Procyclical implications of basel ii: can the cyclicality of capital requirements be contained? *Journal of Financial Stability*, *7*(3), 138–154.

Anderson, T. W., & Hsiao, C. (1981). Estimation of dynamic models with error components. *Journal of the American statistical Association*, *76*(375), 598–606.

Angeloni, I., & Faia, E. (2013). Capital regulation and monetary policy with fragile banks. *Journal of Monetary Economics*, *60*(3), 311–324.

Arellano, M., & Bond, S. (1991). Some tests of specification for panel data: Monte carlo evidence and an application to employment equations. *The review of economic studies*, *58*(2), 277–297.

Baer, H. L., & McElravey, J. (1992). *Capital adequacy and the growth of us banks* (Tech. Rep.). Federal Reserve Bank of Chicago.

Basel Committee on Banking Supervision. (1988). *International convergence of capital measurement and capital standards*. Bank for International Settlements Basel.

Basel Committee on Banking Supervision. (2004). *International convergence of capital measurement and capital standards: A revised framework*. Bank for International Settlements Basel.

Basel Committee on Banking Supervision. (2009). *Strengthening the resilience of the banking sector*. Bank for International Settlements Basel.

Basel Committee on Banking Supervision. (2010a). *A global regulatory framework for more resilient banks and banking systems*. Bank for International Settlements Basel.

Basel Committee on Banking Supervision. (2010b). *Results of the comprehensive quantitative impact study*. Bank for International Settlements Basel.

Basel Committee on Banking Supervision. (2011a). *Global systemically important banks: Assessment methodology and the additional loss absorbency requirement*. Bank for International Settlements Basel.

Basel Committee on Banking Supervision. (2011b). *The transmission channels between the financial and real sectors: A critical survey of the literature*. Bank for International Settlements Basel.

Baum, C., Caglayan, M., & Ozkan, N. (2013). The role of uncertainty in the transmission of monetary policy effects on bank lending. *The Manchester School*, *81*(2), 202–225.

Berger, A. N., & Bouwman, C. H. (2013). How does capital affect bank performance during financial crises? *Journal of Financial Economics*, *109*(1), 146–176.

Berger, A. N., & Udell, G. F. (1994). Did risk-based capital allocate bank credit and cause a" credit crunch" in the united states? *Journal of Money, credit and Banking*, *26*(3), 585–628.

Bernanke, B. S. (1988). Monetary policy transmission: through money or credit? *Business Review*, *11*, 3–11.

Bernanke, B. S., & Blinder, A. S. (1988). *Credit, money, and aggregate demand.* National Bureau of Economic Research Cambridge, Mass., USA.

Bernanke, B. S., & Blinder, A. S. (1992). The federal funds rate and the channels of monetary transmission. *The American Economic Review*, 901–921.

Bernanke, B. S., & Gertler, M. (1995). *Inside the black box: the credit channel of monetary policy transmission* (Tech. Rep.). National bureau of economic research.

Bernanke, B. S., & Lown, C. S. (1991). The credit crunch. *Brookings papers on economic activity*, *1991*(2), 205–247.

Berrospide, J. M., & Edge, R. M. (2010). The effects of bank capital on lending: What do we know, and what does it mean?

Bijapur, M. (2010). Does monetary policy lose effectiveness during a credit crunch? *Economics Letters*, *106*(1), 42–44.

Bliss, R. R., & Kaufman, G. G. (2002). Bank procyclicality, credit crunches, and asymmetric monetary policy effects: a unifying model.

Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of econometrics*, *87*(1), 115–143.

Board of Governors of the Federal Reserve System. (2009). *The supervisory capital assessment program: Overview of results.* Board of Governors of the Federal Reserve System.

Board of Governors of the Federal Reserve System. (2012). *Federal reserve announces summary results of latest round of bank stress tests.* Board of Governors of the Federal Reserve System.

Board of Governors of the Federal Reserve System. (2013). *Federal reserve board approves final rule to help ensure banks maintain strong capital positions.* Board of Governors of the Federal Reserve System.

Board of Governors of the Federal Reserve System. (2014). *Comprehensive capital analysis and review 2014: Assessment framework and results.* Board of Governors of the Federal Reserve System.

Board of Governors of the Federal Reserve System. (2017a). *Comprehensive capital analysis and review 2017: Assessment framework and results*. Board of Governors of the Federal Reserve System.

Board of Governors of the Federal Reserve System. (2017b). *Dodd-frank act stress test 2017: Supervisory stress test methodology and results*. Board of Governors of the Federal Reserve System.

Board of Governors of the Federal Reserve System. (2017c). *Federal reserve releases results of comprehensive capital analysis and review*. Board of Governors of the Federal Reserve System.

Borio, C., & Gambacorta, L. (2017). Monetary policy and bank lending in a low interest rate environment: diminishing effectiveness? *Journal of Macroeconomics*.

Borio, C., & Zhu, H. (2012). Capital regulation, risk-taking and monetary policy: a missing link in the transmission mechanism? *Journal of Financial Stability*, *8*(4), 236–251.

Bridges, J., Gregory, D., Nielsen, M., Pezzini, S., Radia, A., & Spaltro, M. (2014). The impact of capital requirements on bank lending.

Brunnermeier, M. K. (2009). Deciphering the liquidity and credit crunch 2007–2008. *The Journal of economic perspectives*, *23*(1), 77–100.

Cecchetti, S. G. (2009). Crisis and responses: the federal reserve in the early stages of the financial crisis. *The Journal of Economic Perspectives*, *23*(1), 51–75.

Cecchetti, S. G., & Li, L. (2008). Do capital adequacy requirements matter for monetary policy? *Economic Inquiry*, *46*(4), 643–659.

Chami, R., & Cosimano, T. F. (2010). Monetary policy with a touch of basel. *Journal of Economics and Business*, *62*(3), 161–175.

Clair, R. T., & Tucker, P. (1993). Six causes of the credit crunch. *Economic Review-Federal Reserve Bank of Dallas*, 1.

Congdon, T., & Hanke, S. H. (2017, Mar 14). More bank capital could kill the economy. *The Wall Street Journal*. Retrieved from `https://www.wsj.com/articles/more-bank-capital-could-kill-the-economy-1489446254`

Furlong, F. T. (1992). Capital regulation and bank lending. *Economic Review-Federal Reserve Bank of San Francisco*(3), 23.

Gambacorta, L., & Mistrulli, P. E. (2004). Does bank capital affect lending behavior? *Journal of Financial intermediation*, *13*(4), 436–457.

Gambacorta, L., & Shin, H. S. (2016). Why bank capital matters for monetary policy. *Journal of Financial Intermediation*.

Gordy, M. B., & Howells, B. (2006). Procyclicality in basel ii: Can we treat the disease without killing the patient? *Journal of Financial Intermediation*, *15*(3), 395–417.

Gramm, P., & Solon, M. (2016, Apr 15). The great recession blame game. *The Wall Street Journal*. Retrieved from `https://www.wsj.com/articles/the-great-recession-blame-game-1460758184`

Hancock, D., & Wilcox, J. A. (1994). Bank capital and the credit crunch: The roles of risk-weighted and unweighted capital regulations. *Real Estate Economics*, *22*(1), 59–94.

Hancock, D., & Wilcox, J. A. (1998). The credit crunch and the availability of credit to small business. *Journal of Banking & Finance*, *22*(6), 983–1014.

Hyun, J.-S., & Rhee, B.-K. (2011). Bank capital regulation and credit supply. *Journal of Banking & Finance*, *35*(2), 323–330.

Illes, A., Lombardi, M. J., & Mizen, P. (2015). Why did bank lending rates diverge from policy rates after the financial crisis?

Jackson, P., Furfine, C., Groeneveld, H., Hancock, D., Jones, D., Perraudin, W., ... Yoneyama, M. (1999). *Capital requirements and bank behaviour: the impact of the basle accord* (No. 1). Bank for International Settlements Basel.

Jaremski, M., & Sapci, A. (2017). Understanding the cyclical nature of financial intermediation costs. *Southern Economic Journal*.

Kashyap, A. K., & Stein, J. C. (1995). The impact of monetary policy on bank balance sheets. In *Carnegie-rochester conference series on public policy* (Vol. 42, pp. 151–195).

Kashyap, A. K., & Stein, J. C. (2000). What do a million observations on banks say about the transmission of monetary policy? *American Economic Review*, 407–428.

Kashyap, A. K., & Stein, J. C. (2004). Cyclical implications of the basel ii capital standards. *Economic Perspectives-Federal Reserve Bank Of Chicago*, *28*(1), 18–33.

Kashyap, A. K., Stein, J. C., & Hanson, S. (2010). An analysis of the impact of substantially heightenedcapital requirements on large financial institutions. *Booth School of Business, University of Chicago, mimeo*, *2*.

Kashyap, A. K., Stein, J. C., & Wilcox, D. W. (1992). *Monetary policy and credit conditions: Evidence from the composition of external finance* (Tech. Rep.). National bureau of economic research.

Kishan, R. P., & Opiela, T. P. (2000). Bank size, bank capital, and the bank lending channel. *Journal of Money, Credit and Banking*, 121–141.

Kishan, R. P., & Opiela, T. P. (2006). Bank capital and loan asymmetry in the transmission of monetary policy. *Journal of Banking & Finance*, *30*(1), 259–285.

Kok, C., & Schepens, G. (2013). Bank reactions after capital shortfalls.

Lown, C., & Peristiani, S. (1996). The behavior of consumer loan rates during the 1990 credit slowdown. *Journal of Banking & Finance*, *20*(10), 1673–1694.

Lown, C., & Wenninger, J. (1994). The role of the banking system in the credit slowdown. *Studies on causes and consequences of the 1989-92 credit slowdown*, 69–112.

Mizen, P. (2008). The credit crunch of 2007-2008: a discussion of the background, market reactions, and policy responses. *Federal Reserve Bank of St. Louis Review*, *90*(5), 531–567.

Modigliani, F., & Miller, M. H. (1958). The cost of capital, corporation finance and the theory of investment. *The American economic review*, 261–297.

Mustika, G., Suryatinc, E., Hall, M. J., & Simper, R. (2015). Did bank indonesia cause the credit crunch of 2006–2008? *Review of Quantitative Finance and Accounting*, *44*(2), 269–298.

Myers, S. C., & Majluf, N. S. (1984). Corporate financing and investment decisions when firms have information that investors do not have. *Journal of financial economics*, *13*(2), 187–221.

Orzechowski, P. E. (2016). Bank capital, loan activity, and monetary policy: evidence from the fdics historical statistics on banking. *Journal of Economics and Finance*, 1–16.

Peek, J., & Rosengren, E. (1992). The capital crunch: Neither a borrower nor a lender be. *Journal of Money, Credit and Banking*, *27*(3), 625–638.

Peek, J., & Rosengren, E. (1993). Bank regulation and the credit crunch. *Journal of Banking & Finance*, *19*(3), 679–692.

Peek, J., & Rosengren, E. S. (1995). Bank lending and the transmission of monetary policy. In *Conference series-federal reserve bank of boston* (Vol. 39, pp. 47–68).

Peek, J., & Rosengren, E. S. (1996). The international transmission of financial shocks: The case of japan.

Reinhart, C. M., & Rogoff, K. S. (2009). *This time is different: Eight centuries of financial folly*. princeton university press.

Rosengren, E. S. (2008). Implications of a credit crunch. *Speech to the Business and Industry Association of New Hampshire*.

Sarin, N., & Summers, L. H. (2016). Understanding bank risk through market measures. *Brookings Papers on Economic Activity*, *2016*(2), 57–127.

Sharpe, S. A. (1995). *Bank capitalization, regulation, and the credit crunch: a critical review of the research findings*. Federal Reserve Board.

Shin, H. S. (2016). Bank capital and monetary policy transmission. In *panel remarks at the" ecb and its watchers xvii" conference, frankfurt* (Vol. 7).

Van den Heuvel, S. J. (2012). Banking conditions and the effects of monetary policy: evidence from us states. *The BE Journal of Macroeconomics*, *12*(2), 1–31.

Van den Heuvel, S. J., et al. (2002). Does bank capital matter for monetary transmission? *Economic Policy Review*, *8*(1), 259–265.

VanHoose, D. D. (2007). Theories of bank behavior under capital regulation. *Journal of Banking & Finance*, *31*(12), 3680–3697.

VanHoose, D. D. (2008). Bank capital regulation, economic stability, and monetary policy: what does the academic literature tell us? *Atlantic Economic Journal*, *36*(1), 1–14.

Watanabe, W. (2007). Prudential regulation and the credit crunch: Evidence from japan. *Journal of Money, Credit and Banking*, *39*(2-3), 639–665.

Woo, D. (2003). In search of" capital crunch": Supply factors behind the credit slowdown in japan. *Journal of Money, Credit, and Banking*, *35*(6), 1019–1038.

Woodford, M. (2010). Financial intermediation and macroeconomic analysis. *The Journal of Economic Perspectives*, *24*(4), 21–44.

Yellen, J. L. (2011). Macroprudential supervision and monetary policy in the post-crisis world. *Business Economics*, *46*(1), 3–12.