ON- AND OFF-BALANCE SHEET CREDIT RISK AND CAPITAL IN U.S. BANKS: EVIDENCE OF UNBALANCED PANEL DATA

A Dissertation

presented to

the Faculty of the Graduate School

at the University of Missouri-Columbia

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Philosophy

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by

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MAY 2009

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ACKNOWLEDGEMENTS

I would like to start out by expressing my appreciation to my dissertation advisor, Dr. Ronald Ratti, for his guidance, help, support, and patience throughout this research. I am also pleased to thank my committee members, Dr. Douglas J. Miller, Dr. Shawn Ni, and Dr. Paul Brockman for their comments and advice. As for Dr. Douglas J. Miller, I greatly appreciate his assistance and valuable suggestions on econometrics. In addition, I would like to thank Lynne Riddell of the Department of Economics for her kind help over the years throughout my graduate study. Furthermore, I sincerely enjoy the camaraderie and conversations with Shiou-Yen Chu (Vivien), Shali Lou, and Sarah Ali.

My gratitude extends to Piyanan Nuankhieo for being a good friend and for her help and support during my study in Columbia. Many thanks also go out to Nisamanee Sombatruang, who is my best friend, for lasting friendship and for encouraging me with her best wishes. I am also grateful to Vireka Suntapunt for her help and guidance especially on accounting issue.

Most importantly, I could have not made it all the way without the love and support of my family. I would like to express my deepest appreciation to my parents, Preecha and Povongtip Poramapojn, to whom I owe everything, for their sacrifice, dedicated efforts, patience, and continuing encouragement. They are always a source of love, strength, and inspiration. Thank you for everything and for raising me to be the person I am today. Additionally, I am grateful to my brother, Pathiwich Poramapojn, for his love and support. This dissertation is dedicated to my family.

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ABSTRACT

This study presents the relationship between capital and on- and off-balance sheet credit risk and the effectiveness of capital standards in the United States. The selected banks are commercial banks and bank holding companies in the United States that involve in securitization from the third quarter of 2001 to the first quarter of 2008. Three simultaneous equations are estimated by using three-stage least squares (3SLS) to account for three endogenous variables, which are capital, on-balance sheet credit risk, and off-balance sheet credit risk.

The results of the main model indicate that banks with securitization only simultaneously determine change in capital and off-balance sheet credit risk and they have a positive relationship, that change in off-balance sheet credit risk exogenously determines change in on-balance sheet credit risk and they have a positive relationship, and that change in capital and change in on-balance sheet credit risk have no significant relationship.

Next, regarding the effectiveness of capital standards, the results show that U.S. capital standards are partially effective during the sample period. Capital standards are effective in that regulatory pressure induces undercapitalized banks to increase book value capital ratio, which is the ratio of equity capital to total assets, and to adjust capital faster than adequately capitalized banks. However, capital standards are ineffective in

that with regulatory pressure, undercapitalized banks take more off-balance sheet credit risk and decrease in risk-based capital ratios. Moreover, regulatory pressure has no significant impact on change in on-balance sheet credit risk. Therefore, during the sample period, U.S. capital standards are not stringent enough to achieve banking safety and soundness.

CHAPTER 1

INTRODUCTION

Subprime mortgage crisis starting in 2007 has impacted not only on banking industry but also on the whole economy. Since then, banks have incurred large amount of loan loss provision and significantly reduced profits. Furthermore, some banks failed because of inadequate capital to cover huge losses. One of its causes is securitization, which is financial innovation that has been introduced in the 1970s in the United States and rapidly grown since then especially in the early 2000s for one related to subprime mortgages. Although securitization related to subprime loans is the main concern in this crisis, securitization is also for other types of loans. The consequence of subprime loans spreads to other types of loans, affects the overall lending activity and leads to the credit crunch. The subprime crisis also indicates the importance of bank capital adequacy in the event of unexpected losses and raises concern about the safety and soundness of banking system.

Securitization has changed the way banks do business. Traditional banking activity is that banks loan borrowers with tight lending standards, keep loans on their balance sheets and thus still retain credit risk. Credit risk is the risk that borrowers are default or unable to repay interest and principal as specified in contracts. In contrast to loans, securitization enables banks to remove loans from balance sheets and transfer credit risk associated with those loans. Therefore, two types of items are of interest, on-balance sheet and off-balance sheet. On-balance sheet item is represented by loans since banks indicate loan on the asset side of their balance sheets. However, off-balance sheet

item is represented by securitization because banks do not record any transaction involved in securitization once they sell and remove loans from their balance sheets. Banks only disclose the detail of securitization in notes to financial statements.

Since banks are vulnerable to losses from credit risk inherent to loans, banks have to hold adequate capital in order to absorb unexpected credit losses. Therefore, for bank safety and soundness, bank regulators establish the minimum capital requirement so that the amount of capital should be associated with the level of risk inherent to bank assets. The purpose of minimum capital requirement is to absorb unexpected losses, which have not yet occurred.

1. Capital and Credit Risk

Basel Accord by the Bank for International Settlements (BIS) introduces risk-based capital requirement and is widely adopted by central banks around the world as a bank supervisory guideline. Bank regulators in the United States are the Federal Reserve System, the Office of the Comptroller of the Currency, the Federal Deposit Insurance Corporation, and the Office of Thrift Supervision. These bank regulators have followed Basel Accord or Basel I risk-based capital standards since 1991. Prompt Corrective Action (PCA) under the Federal Deposit Insurance Corporation Improvement Act (FDICIA) of 1991 provides the thresholds of capital requirement. Banks with capital adequacy ratios above the thresholds are adequately capitalized. In contrast, banks with capital adequacy ratios below the thresholds are undercapitalized and subject to restrictions and further investigation by bank regulators.

In the United States, there are three capital adequacy ratios that bank regulators consider. The first ratio is total risk-based capital ratio, which is the ratio of total capital to risk-weighted assets (RWA). Total capital is the sum of tier 1 and tier 2 capital. Generally, tier 1 or core capital is composed of common stock and retained earnings while tier 2 capital is the sum of loan loss allowance (with no more than 1.25% of RWA) and subordinated debt. Moreover, tier 1 capital is at least 50% of total capital. Regarding RWA, different types of assets have different weights depending on credit risks associated with them. The weights are 0%, 20%, 50%, and 100%. RWA includes not only on-balance sheet assets but also off-balance sheet items. Banks have to calculate credit equivalent amount of off-balance sheet items and then apply the percentage risk categories in the same manner as on-balance sheet assets. The minimum total risk-based capital ratio is 8%. Next, the second ratio is tier 1 risk-based capital ratio, which is the ratio of tier 1 capital to RWA and the minimum requirement, is 4%. Finally, tier 1 leverage ratio is the ratio of tier 1 capital to average total assets and the minimum requirement is 4%. Banks are adequately capitalized if their risk-based capital ratios achieve the minimum requirement.

The drawbacks of Basel I are that it considers only credit risk and that banks can have capital arbitrage, meaning that banks take more risk without increasing capital or reduce capital requirement without reducing risk and still achieve minimum capital requirement or take the same amount of risk with less capital. The other drawback is that the same type of loan with different quality has the same weight when calculating risk-weighted assets. Therefore, the limitations of Basel I Accord lead to the implementation of Basel II, which incorporates market risk and operational risk in addition to credit risk.

In the United States, bank regulators require only the very large banks with complex transactions and the ability to build their own internal risk-based approach to comply with Basel II. It will be effective in 2008; however, other banks still conform to the current Basel I risk-based capital standards.

Capital is on the liability or right-hand side of balance sheet, which is the opposite side of loans. Capital or shareholders' equity is the first to absorb unexpected losses from risk and uncertainty before depositors; therefore, banks with more capital have greater cushion against unexpected losses and are less likely to fail.

To improve risk-based capital ratio, banks can either increase capital (the numerator) or decrease risk-weighted assets (the denominator). Capital can be increased by retained earnings through profit, the issuance of common or preferred stocks, and a reduction in dividend payout. Furthermore, RWA can be decreased by reducing assets or moving from high risk-weighted assets to low risk-weighted assets.

2. Loans (On-Balance Sheet Item)

Loans are the major assets and the most important revenue-generating source of banks. Loans appear on the asset or left-hand side of balance sheet. Banks have to comply with Generally Accepted Accounting Principles (GAAP) to prepare financial statements. GAAP is accounting standards in the United States and issued by Financial Accounting Standard Board (FASB). Loan quality is deteriorated by credit risk and according to GAAP banks have to present value of loans to reflect loan quality in balance sheets at the end of each period by using loan loss allowance as a contra account of total loans to show net realizable value. Walter (1991) addresses that since bank managers

have private information about their loan portfolio, outsiders or financial statement users can get valuable information about loan quality and credit risk from loan loss reserve (or loan loss allowance).

Banks have to follow FASB Statement No. 5 to estimate losses for groups of loan with similar risk characteristics and FASB Statement No. 114 to estimate losses for individual loan. FASB Statements No. 5 and 114 require that loan loss allowance is recognized when losses are probable and reasonably estimated based on past events and current economic information. In other words, loan loss allowance is set to cover *expected* losses from credit risk.

At the end of each period, banks have to consider expected losses from their loans. To record these transactions, banks debit loan loss provision account and credit loan loss allowance account by the same amount. The difference between loan loss provision and loan loss allowance is that loan loss provision is an expense shown in income statement and indicates the change in loan loss allowance during each period whereas loan loss allowance is shown in balance sheet and indicates probable losses from their originated loans as of the end of each period. Since loan loss provision is an expense, an increase in loan loss provision reduces profit, retained earnings, and thus, bank capital, which is on the liability or right-hand side of balance sheet. Because loan loss allowance is a contra account of total loans, an increase in loan loss allowance does not decrease the original amount of total loans but does reduce net loan amount, which is on the asset or left-hand side of balance sheet. All in all, both net loan amount and capital are decreased by the same amount to make balance sheets to be balanced. Appendix 1 shows the detail of loan accounting.

Basel Capital Accord defines two types of loan loss provision or allowance, specific and general. First, specific or non-discretionary provision is ex-post identified losses and is determined by nonperforming loans, past due payments, and loan write-offs. Specific loan loss provision is losses against particular loans. Second, general or discretionary provision is ex-ante expected losses, which are not yet occurred but reasonably estimated. General provision is possible future losses and not against specific loans. Moreover, it is under bank managers' judgment; thus, vulnerable to be used for accounting manipulation.

As discussed earlier, total capital consists of tier 1 and tier 2 capital. Both specific and general provisions are expenses; therefore, they reduce banks' profits, retained earnings and tier 1 capital. However, only general provision is included in tier 2 capital with the limit of 1.25% of risk-weighted assets. In contrast, specific provision reflects occurred losses and is not included in tier 2 capital. Laeven and Majnoni (2003) explain that regulatory capital absorbs *unexpected* losses while loan loss reserve (or allowance) absorbs *expected* loss. Furthermore, they address that "since bank solvency regulation is intended to address the consequences of future credit losses, whether of expected or unexpected nature, only "general" provisions matter in the discussion of minimum bank capital requirement." Therefore, the issue of loan loss provision and allowance refers to only general provision.

Besides, the amount of loan loss allowance and provision is subjective and affects bank capital. According to Wall and Koch (2000), the issue of loan loss accounting is debatable between the Securities and Exchange Commission (SEC) and bank regulators. On the one hand, the SEC requires banks to conform to GAAP so that financial

statements accurately present financial information in a given period and investors can compare financial performance of banking industry to those of other industries. Generally, loan loss allowance under GAAP is lower than bank regulators' perspective because it is estimated based on past and current information.

On the other hand, bank regulators prefer banks to set higher loan loss allowance and thus, banks have lower profit and capital. According risk-based capital standards, loan loss allowance decreases tier 1 capital but increases tier 2 capital; therefore, higher loan loss allowance leads to greater capital or buffer against unexpected losses. However, loan loss allowance is limited to 1.25% of risk-weighted assets (RWA) when included in tier 2 capital. If it reaches the limited amount, an increase in Tier 2 capital is less than a decrease in tier 1 capital, leading to a decrease in total capital. In this case, banks are urged to replenish capital so that capital is high enough to absorb unexpected losses during future financial crisis and reduces the probability of bank failure. The rationale is that during economic upturns, banks generally relax lending practices and easily approve loan; hence, loan growth increases and some groups of borrowers tend to have low credit quality. Therefore, banks should set aside high loan loss allowance during economic upturns to account for higher credit risk inherent to those low quality loans. Later, when economic downturns occur, those borrowers are likely to default and banks have to recognize bad loans. At first, bad loans are offset with loan loss allowance, which is already realized during economic upturns. This leads to a decrease in tier 2 capital. Next, for the excess amount of bad loans, banks have to write off those bad loans as an expense, leading to a decrease in profit and tier 1 capital. Thus, in the event of default, these losses significantly reduce capital. However, high loan loss allowance and

provision during economic upturns allow banks to have adequate capital to absorb unexpected losses during economic downturns. Therefore, high capital can reduce bank failure. Put another way, loan loss allowance under bank regulators' view is more conservative and forward-looking than under SEC or accountants' view.

However, SEC views this practice as earnings management or income smoothing, meaning that banks show smooth profit in income statements throughout periods of economic expansion and contraction. Since banks generally have high profit during economic expansion, banks are able to incur greater amount of loan loss allowance and provision, leading to a large reduction in profit. Nevertheless, during economic contraction banks have low profit and because banks have already recognized a large amount of loan loss allowance, banks only realize a small amount of loan loss allowance and provision in this period. This leads to only a small reduction in profit. All in all, although SEC and bank regulators have different opinions in accounting for loan loss allowance, they issued a joint interagency letter in 1999 stating that publicly traded banks provide financial statements in accordance with GAAP.

Regarding the loan credit risk measurement, loan loss allowance represents *expected* losses arising from credit risk of bank loans and thus, *unexpected* losses are left for capital to cover. Banks should have capital associated with credit risk. Banks with high credit risk should have capital higher than banks with low credit risk. In sum, there exists a relationship between capital and credit risk, which is represented by loan loss allowance and provision.

3. Securitization (Off-Balance Sheet Item)

To begin with, before the securitization, banks traditionally use money from depositors to loan to borrowers and earn profit from the difference between interest revenue from borrowers and interest expense paid to depositors. This business model is called originate-to-hold model because banks still keep loans on balance sheets. However, loans are illiquid assets since it takes long time for borrowers to pay off all loans if banks hold them until maturity. Therefore, banks are difficult to provide new loans and also have to carefully manage liquidity because banks can fund more loans only when they have more deposits. Nevertheless, securitization enables banks to originate more loans with low funding cost and manage risks such as credit risk and interest rate risk. However, the main focus of this paper is credit risk associated with loans. Banks with securitization are moving toward originate-to-distribute model.

Securitization is the process that transfers illiquid assets or loans into liquid assets or securities. Securitization process starts when each bank transfers on-balance sheet loans to its Special Purpose Vehicle (SPV), which is also called Special Investment Vehicle (SIV), Special Purpose Enterprise (SPE) or trust. A Special Purpose Vehicle (SPV) is an entity legally separated from bank and bank generally sponsors or provides liquidity to its SPV when necessary. Additionally, bank's financial statements do not include financial information of the Special Purpose Vehicle (SPV). Therefore, once banks sell loans to their SPVs, banks can remove loans from balance sheets but transactions of SPVs are not on bank books and this is the reason why securitization transaction is off-balance sheet item. Then, the SPV pools loans from many borrowers and packages those loans into securities to sell to investors. Securities are backed by

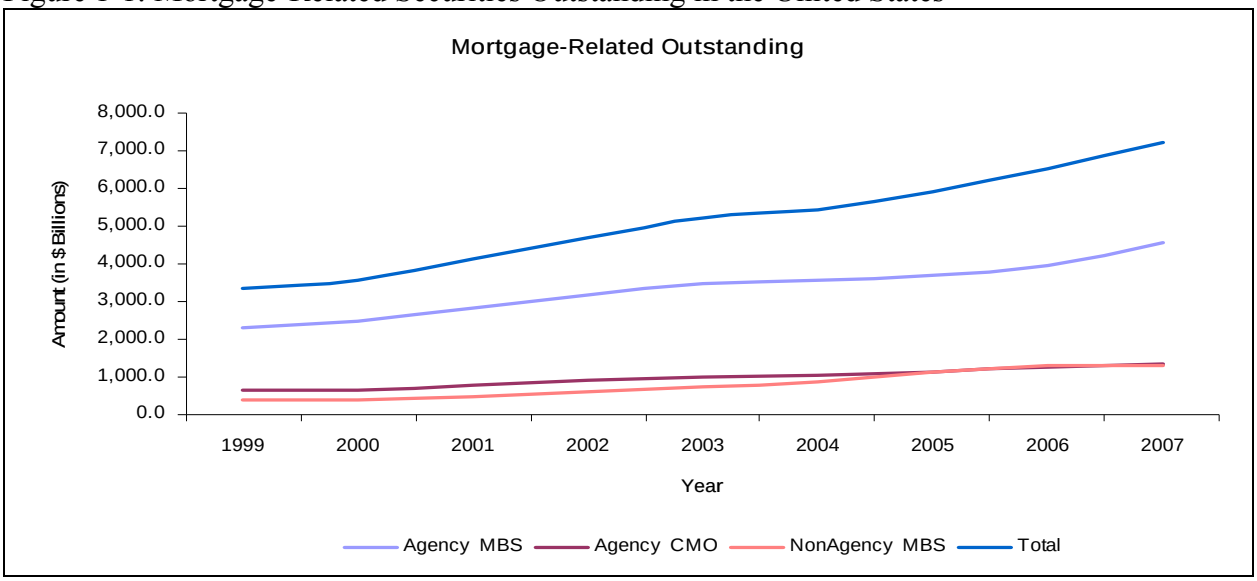
many kinds of bank assets. Mortgage-backed securities (MBS), the biggest type of loan securitization in the United States, is backed by mortgages and is a claim on the payment of principal and interest of pools of those mortgages. Next, asset-backed securities (ABS) is backed by other types of loans, such as credit card loans, auto loans, commercial and industry loans, and other consumer loans. Furthermore, ABS and MBS can be securitized into collateralized debt obligation (CDO) and collateralized mortgage obligation (CMO), respectively. In other words, CDO is security backed by pools of ABS and CMO is backed by MBS. In order to serve investors with different types of risk appetite, SPV categorizes securities into tranches with different investment grades rated by rating agencies. Subordinated tranche getting lower grade than senior tranche is the first tranche to absorb losses. Moreover, banks usually invest in those securities issued by SPVs as residual interest or credit enhancement to attract more investors.

Regarding mortgage market, banks can sell conforming mortgage loans to the Federal National Mortgage Association (Fannie Mae) and the Federal Home Loan Mortgage Corporation (Freddie Mac). Both are government sponsored enterprises (GSEs). Conforming loans have characteristics specified by those agencies and generally are prime loans. They then issue securities and guarantee the payment to investors. Securities issued by those GSEs are sometimes called agency securities. However, for non-prime mortgage loans and other types of loans, banks sell them to their SPVs. Securities issued by SPVs are called non-agency or private securities.

Figures 1-1 and 1-2 show that securitization market is in trillions of dollars and has significantly expanded since 2000. Although agency MBS/CMO is higher in value

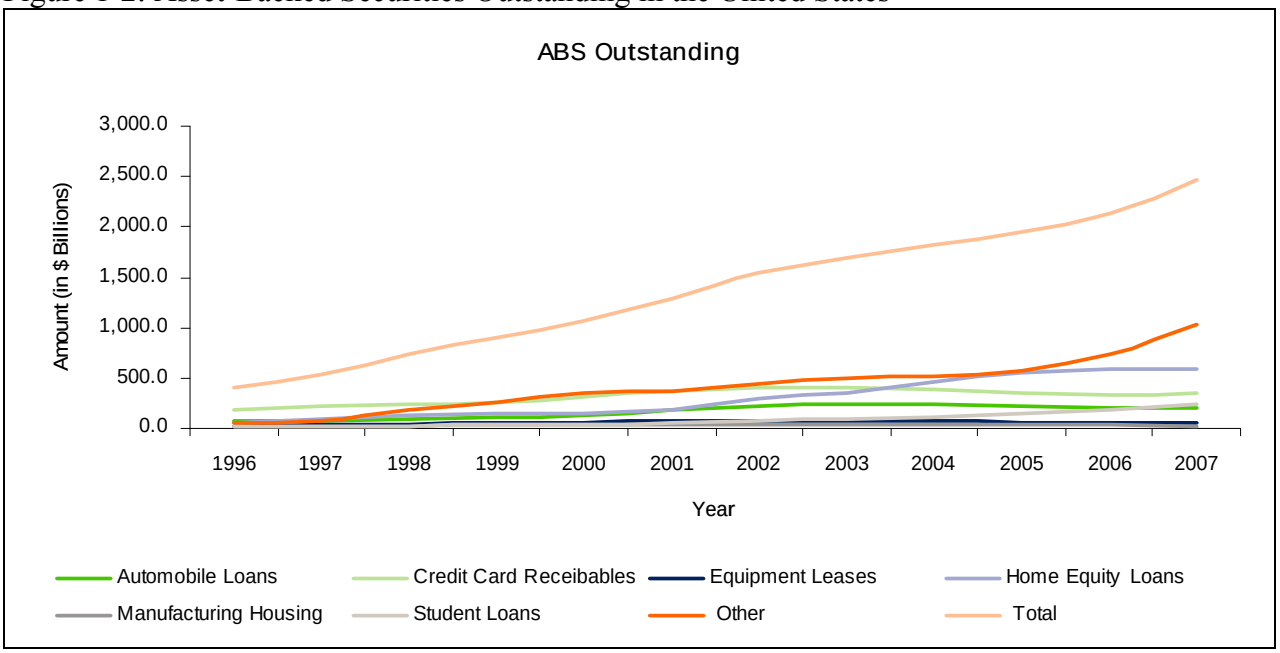
than non-agency securities, non-agency MBS/CMO together with ABS has rapidly grown since 2000.

Figure 1-1: Mortgage-Related Securities Outstanding in the United States



Source: Securities Industry and Financial Markets Association (SIFMA)

Figure 1-2: Asset-Backed Securities Outstanding in the United States



Source: Securities Industry and Financial Markets Association (SIFMA)

The SPVs issue securities to investors and gives money from investors to buy loans from banks. Banks sell loans to their SPVs and receive cash to fund new loans. Thus, if banks keep selling loans to SPVs through securitization, banks have incentive to increase more loans and are less concerned about borrower's credit quality by loosening lending standards since banks deem that they are able to securitize those loans, transfer credit risk to investors and ultimately bear no such credit risk. For example, banks loan to subprime borrowers during the early 2000s by requiring no income document or only small amount of down payment or even no down payment at all. These practices increase loan-to-value ratio of banks. Therefore, securitization is one cause of the subprime crisis. Banks transfer subprime loans to SPVs, who sell MBS and CMO backed by those low quality loans to investors.

In a normal economy, securitization works as it should be by transferring credit risk from banks to investors who are willing to take risk. However, in the event of housing bust and subprime crisis, the decline of house prices together with the rise in interest rate makes those borrowers default since they are unable to refinance or cannot afford higher interest payment. This situation makes MBS and CMO worthless and no investors want to buy them; therefore, SPVs are unable to sell securities. Besides, the consequence of subprime crisis expands to other types of securitization or ABS. Since banks sponsor and provide liquidity to SPVs, in practice banks generally get those transferred loans back on balance sheets although they do not have legal obligation to do so. Once those loans are on balance sheet, banks have to recognize credit losses from bad loans and also set loan loss allowance. These transactions decrease profit and thus eat up existing capital. In addition to repurchase loans from their SPVs, banks that purposely

warehouse loans for securitization are unable to transfer those loans to SPVs and have to hold those loans on balance sheets. Likewise, banks then realize a huge amount of loan losses and loan loss allowance, which also reduces their profit and capital. As a result, bank capital dramatically decreases and at the same time, on-balance sheet loans require banks to have more risk-based capital. Hence, banks have to find the ways to replenish a significant amount of capital to absorb credit losses. Banks that have inadequate capital could go bankrupt.

Through securitization, bank business model has changed from originate-to-hold model to originate-to-distribute model. This originate-to-distribute model means that banks generate loans in order to securitize them and receive cash flow to finance new loans and keep growing loans. Moreover, since banks still retain the relationship with their borrowers and securitization allows banks to earn ongoing service from collecting cash flows from borrowers on behalf of investors. Therefore, this originate-to-distribute model creates incentive for banks to relaxing credit standards since through securitization they do not bear any risk and still earn fee income.

The consultative document of Credit Risk Transfer of the Bank for International Settlements (2008) indicates three benefits of securitization. First, banks can transfer credit risk. Second, banks earn fee without retaining credit risk through the originate-to-distribute business model. Finally, banks earn revenue from selling loans. This working paper also discusses that during the subprime crisis some banks buy securities back from their SPVs due to reputation risk even though they do not have contractual obligation to do so. Furthermore, this crisis extends from credit problem to liquidity problem because

banks do not consider funding support to SPVs in their risk management and capital plans in the first place and the repurchases of securitized loans decrease bank liquidity.

In addition to the benefit that banks with securitization are able to transfer credit risk and receive new fund to finance loan growth, those banks are able to improve return on assets and return on equity or capital since they operate in fee-based activity. Furthermore, banks can use securitization to efficiently allocate capital. Because securitizing banks remove loans from balance sheets, a decrease in loans lead to decreased risk-weighted assets and hence, banks are able to reduce risk-based capital and free up capital for further business expansion. In other words, securitizing banks have less balance sheet and capital constraints. However, securitization also comes with disadvantages. Calomiris and Mason (2003) mention that banks generally neglect to hold sufficient capital against explicit and implicit recourse obligations from securitization. Thus, during financial distress, banks with securitization incur losses from transferred risk and significantly decrease capital.

Regarding accounting issue, Statement of Financial Accounting Standards No. 140**,** Accounting for Transfers and Servicing of Financial Assets and Extinguishments of Liabilities**,** requires that a transferor can remove financial assets from balance sheet only if the transfer is a true sale, meaning that "the transferor has surrendered control over transferred assets." Otherwise, those assets are still on balance sheet. Therefore, under true sale, once the transferor transfers asset to the transferee, the transferor has no legal right or control over transferred assets and does not provide any recourse or agreement to repurchase or redeem. In other words, sale without recourse is a true sale. Moreover, the transferee must be qualifying special-purpose entity (QSPE), which is legally isolated

from the transferor and is a bankruptcy-remote entity. This means that if the transferor goes bankrupt, the transferor's creditors cannot reach the transferred assets. Thus, banks or transferors are able to remove loans from balance sheets only when loan sales are true sales and sold to banks' SPVs or transferees that satisfy QSPE criteria. Banks also recognize gain on sale and boost profit at the time of sale. Moreover, banks do not have to consolidate financial information of their SPVs. However, sale with recourse, either explicit or implicit, is not a true sale. Explicit recourse is the recourse offering is explicitly stated in the securitization agreement while implicit recourse is the recourse that does not appear in the contract at the time of sale but later banks offer financial support to SPVs. In other words, with sales with recourse, banks cannot remove loans from balance sheets. This off-balance sheet accounting is questionable after the subprime crisis since banks recognize loan sales as true sales by selling loans without recourse but during the crisis banks buy securitized loans from SPVs back on balance sheets with no obligation to do so. This practice is implicit recourse, which is not a true sale. Therefore, both banks regulators and accounting agencies question about whether banks should recognize loan sales as true sales in the first place. Instead, if banks recognize loan sales as sales with implicit recourse, loans are still on balance sheets and banks have to set loan loss allowance for expected credit losses and thus prepare themselves adequate capital for unexpected losses. This might alleviate the consequence of the crisis. Furthermore, they are also concerned about hidden risk from securitization accounting since risk is not on balance sheets. Despite true sale, securitization may not truly transfer credit risk. The detail of loan and securitization accounting is in Appendix 1.

The Comptroller's Handbook of Asset Securitization (1997) mentions that securitization is inherent to three types of credit risk. First, credit risk from residual default exposure is losses of securitized loans that remain to originating banks after sale if borrowers default since banks have residual interests. Next, the second type of credit risk is credit quality of remaining on-balance sheet loans. If banks sell low credit risk or high quality loans, on-balance sheet loans are relatively higher credit risk or of lower quality and banks have to set high loan loss allowance, which reduces profit, retained earnings, and risk-based capital ratio. In this case, banks have to acquire more capital. However, if banks sell high credit risk loans, on-balance sheet loans are relatively lower credit risk or of higher quality. In this case, banks should have sufficient capital for the exposure to moral recourse. Finally, credit risk arises from the possibility of moral recourse. Typically, banks sell loans with no recourse so that it is a true sale and banks are able to remove loans from balance sheets. However, if underlying loans perform poorly, banks want to protect their reputation by providing financial support to their SPVs. This means that banks assume more credit risk than expected and this unexpected credit risk drives banks to have more capital. Besides, securitization is also associated with other risks. For instance, reputation risk is the risk of negative public opinion and the damage to franchise value. Although banks sell loans to SPVs, their reputation as servicers is disclosed to investors. In order to protect its reputation and value, banks buy securitized loans back without agreement to do so because damaged reputation also affects existing and future relationship with customers and investors. Next, liquidity risk is the risk that banks are unable to provide funding at unexpected times. This handbook also raises concern that banks that depend only on securitization might hold capital just enough for a "flow" of

securitized loans and therefore, might have liquidity problem when forced to bring securitized loans back on balance sheets.

In conclusion, loans, securitization, credit risk and bank capital are interrelated. First, credit risk is inherent to both loans and securitization. Second, securitization leads to loan growth since through securitization banks are able to improve liquidity by having more cash flow to fund new loans. Third, banks are required to maintain adequate capital to cushion unexpected losses from credit risk. Thus, loans and securitization, both of which are inherent to credit risk, affect bank capital. However, the difference is that loans are on-balance sheet items and banks have to hold capital appropriate to loan credit risk whereas securitization is off-balance sheet item, leading to an incentive to reduce capital. Although securitization is included in RWA, the risk weight for securitized loan is lower than the original on-balance sheet loans. Furthermore, on the one hand, banks with loan growth are exposed to higher credit risk, resulting in an increase in capital due to higher risk-weighted assets. On the other hand, banks with securitization remove loans off balance sheet and hence, banks have incentive to decrease capital. Therefore, securitization and loan growth are related and both impact on capital but in different directions. The question is whether banks with securitization tend to increase or decrease capital in response to changes in credit risk from both loans and securitization and whether bank capital is adequate to absorb unexpected losses from credit risk arising from on-balance sheet loans and off-balance sheet securitization.

4. Contributions

The purposes of this study are to examine the relationship between bank capital and credit risk and to determine the effectiveness of regulatory minimum capital requirement for commercial banks and bank holding companies in the United States. Two kinds of risks are of interest, credit risk inherent to on-balance sheet loans and credit risk associated with off-balance sheet securitization. Banks involve in securitized loans in two ways. First, banks as loan originators sell or transfer those loans to their SPVs. Second, banks purchase securities backed by those loans from SPVs as investment. However, this paper focuses on banks as sellers or transferors of loans through securitization. Contributions from this paper are as follows.

First, previous studies measure risk as the ratio of risk-weighted assets to total assets. They measure overall credit risk, both on- and off-balance sheet altogether. However, this paper separately measures on-balance sheet and off-balance sheet credit risk and examines the relationship between changes in each type of credit risk and changes in capital. Additionally, this paper studies the relationship between on-balance sheet credit risk and off-balance sheet credit risk. In other words, this paper also examines how loans and securitization activity are related.

Second, previous studies that examine the relationship between capital and risk in U.S. banks use data in the 1980s and 1990s. However, this paper's sample period is from the third quarter of 2001 to the first quarter of 2008 since banks started disclosing securitization amount in the notes of financial statement in 2001. Furthermore, during this period, the role of securitization rapidly grows and also declines later in the event of the

subprime crisis. Therefore, studying this relationship between capital and risk in the period of high growth in financial innovation will provide new insight.

CHAPTER 2

LITERATURE REVIEW

1. Relationship between Capital and Risk

Many literatures study the relationship between risk and bank capital and the results are mixed. Some find positive relationship while others find negative relationship. Furthermore, many studies examine the impact of regulatory minimum capital requirement standards on bank risk-taking behavior.

Shrieves and Dahl (1992) provide rationale for both negative and positive relationship between changes in bank capital and changes in risk-taking behavior. The negative relationship occurs when banks maximize the deposit insurance subsidy value by taking more risk, increasing leverage, and thus decreasing capital. In contrast, the positive relationship occurs due to four theories. The first theory is regulatory costs. To alleviate the aforementioned problem of deposit insurance, regulators allow banks with increased capital to take more risk and banks with increased risk to hold more capital through regulatory capital standards. Second, unintended effects of minimum capital standards mean that the implementation of risk-based capital standards requires banks to increase capital; however, an increase in capital provides banks with incentive to take higher risk. This incentive is larger for banks that are near or below capital requirement. Next, the third theory is bankruptcy cost avoidance. In order to reduce probability of bank failure, if banks want to take more risk, they tend to hold more capital. Likewise, if banks have more capital, they tend to increase risk. Finally, the fourth theory is managerial risk aversion. Due to principal-agent problem, managers or agents tend to take less risk than

shareholders or principals. Therefore, managers compensate the increased risk with an increase in capital and vice versa. Furthermore, they also note that these theories are not mutually exclusive.

The positive relationship between changes in capital and changes in risk means that banks increase both risk exposure and capital simultaneously. Banks with high capital are able to take more risk and in the same token, if banks want to take more risk, they obtain more capital as a cushion for higher risk. Nevertheless, undercapitalized banks may take higher risk so that higher return help boost their capital. Furthermore, the rationale of the negative relationship between changes in capital and changes in risk is that undercapitalized banks may improve their capital ratios by either increasing capital or reducing risk or both; however, adequately capitalized banks may have incentive to reduce their capital or take more risk. As can be seen, adequately capitalized and undercapitalized banks have different incentives on capital and risk.

To begin with, Shrieves and Dahl (1992) are the first to use simultaneous equations approach and partial adjustment to study the relationship between changes in capital and changes in risk. This approach is later modified by many authors who also study the relationship between bank capital and risk such as Jacques and Nigro (1997), Aggarwal and Jacques (2001), and Rime (2001). The assumptions are that capital and risk are simultaneously determined and that bank capital is a buffer against unexpected losses and hence, banks should have adequate capital commensurate with risk-taking behavior. Shrieves and Dahl (1992) examine the relationship between changes in capital and changes in risk rather than the relationship between capital levels and risk levels in order to see how banks adjust capital in response to risk and also how banks adjust risk in

response to capital. They sample 1,800 FDIC-insured banks and bank holding companies from 1984 to 1986 and find the positive relationship between changes in capital and changes in risk and conclude that "changes in capital are risk-based." They conclude that regulatory capital standard is effective by finding that undercapitalized banks have higher rate of capital adjustment than adequately capitalized banks.

Second, Calem and Rob (1996) examine the impact of capital standards on risk-taking behavior of U.S. commercial banks from 1984 to 1993. They find the U-shaped relationship between capital and risk. Extremely undercapitalized banks take maximum risk to bet on high return to increase capital ratios because higher risk taking does not dramatically affect probability of bankruptcy. However, as capital increases, moderately undercapitalized banks tend to take less risk to retrieve their capital level since higher risk taking does affect probability of bankruptcy. Furthermore, as capital keeps increasing, well-capitalized banks are able to take more risk because theses banks are far from bankruptcy. This shows unintended effect of capital regulation as increased capital leads to an increase in risk.

Third, Jacques and Nigro (1997) study the impact of risk-based capital standards on bank capital and portfolio risk before and after the implementation of new capital standards in 1991 by modify simultaneous equations by Shrieves and Dahl (1992). They investigate 2,570 FDIC-insured banks including bank holding companies from 1990 to 1991. They conclude that risk-based capital standards are effective to increase capital ratios and decrease risk. They also find the negative relationship between changes in capital and changes in risk in the first year of implementation.

Fourth, Aggarwal and Jacques (2001) study the impact of prompt corrective action (PCA) under the Federal Deposit Insurance Corporation Improvement Act (FDICIA) by examining 1,685 FDIC-insured commercial banks and bank holding companies from 1990 to 1997. Their simultaneous equations model is also based on model developed by Shrieves and Dahl (1992). The authors study two periods, before and after the implementation of PCA. Regarding the effectiveness of PCA, they find that both adequately capitalized and undercapitalized banks increase capital ratio when measured by tier 1 leverage ratio and decrease credit risk; however, if capital ratio is measured by total risk-based capital ratio, PCA has no significant impact on capital ratio but significantly reduce credit risk. The authors conclude that PCA is effective in the sense that U.S. banks increase capital ratios without increasing credit risk. In addition, they interestingly state that "while these results do not guarantee that bank capital levels are adequate, they suggest that PCA has been successful in increasing bank capital ratios without the unintended effect of increasing risk as has been noted in prior research." The unintended effect is that with risk-based capital standards, banks have incentive to increase both capital and risk at the same time.

The first four papers study U.S. banks. However, the next two papers examine the relationship between capital and risk in banks outside the United States.

Fifth, Ediz et al. (1998) study the impact of capital requirement on UK banks from 1989 to 1995. They conclude that UK capital standards are effective because they influence banks to increase capital ratios and that banks increase capital ratios by directly increasing capital (the numerator) rather than substituting away from high to lower risk-weighted assets (the denominator).

Finally, Rime (2001) examines Swiss banks from 1989 to 1995 and finds the positive relationship between changes in risk and changes in capital when capital is measured by a ratio of capital to total assets. However, there is no significant relationship between them when capital is measured by a ratio of capital to risk-weighted assets. Rime (2001) states that "theses two findings are consistent in a regime of risk-based capital standards, as banks constrained by the capital requirements have to increase their ratio of capital to total assets following an increase in risk to keep their risk-adjusted capital ratio constant." Besides, the author concludes that Swiss capital standards influence undercapitalized banks to increase capital; however, show no impact on risk taking.

To summarize, the relationship between capital and risk in commercial banks could be either positive or negative. Adequately capitalized and undercapitalized banks may behave differently under risk-based capital standards.

In addition to the study of the relationship between capital and risk, there are many studies about the impact of minimum capital requirements on bank risk. First, Blum (1999) concludes that in a dynamic framework capital adequacy requirements increase bank risk since banks realize that cost of raising equity is highly expensive; therefore, banks increase risk today in order to increase equity tomorrow. In case of success, higher risk leads to higher return and then increase equity tomorrow. Second, Mingo (2000) concludes that capital standards induce banks to involve in regulatory capital arbitrage such as through securitization. The detail of securitization and capital arbitrage is discussed later in this chapter. The author also concludes that the Basel Accord is a lose/lose proposition. Bank regulators lose in the sense that they are unable to ensure that banks with high risk-based capital ratios have low probability of insolvency

and therefore, minimum capital requirements may not serve safety and soundness of financial system to reduce probability of bank failure. In addition, banks also lose because capital arbitrage is costly and thus, banks may not achieve the goal to maximize shareholders' equity. The author also mentions that banks regulators should recognize that each bank has its own internal risk rating models and take into account when implementing regulatory capital allocation system and that in the long run capital requirements are hard to determine due to more complex financial innovation.

2. Securitization and Credit Risk

Securitization is used to transfer credit risk; however, many studies find that securitization may not actually transfer credit risk. First, Cantor and Rouyer (2000) argue that securitization may or may not transfer credit risk. Securitization transfers credit risk to investors if securitization is more risky than lender's unsecured debt or has lower credit rating lower than lender's unsecured debt. This implies that in order to transfer credit risk, banks securitize high credit risk loans and leave on-balance sheet loans with low credit risk. However, the authors mention that in practice, banks generally securitize low credit risk loans to get higher rating and lower funding cost. Therefore, banks tend to use securitization as a funding source rather than tool to transfer credit risk. Second, Wolfe (2000) concludes that banks have incentive to create securitization pipeline structure since securitization allows banks to receive cash proceeds to generate new loans without increasing deposit and capital and then to increase return on capital. Moreover, the author mention that at first banks tend to securitize low credit risk or high quality loans with low probability of default in order to establish the market. Later, as market

becomes established, banks securitize lower quality or higher credit risk loans. Finally, Murray (2001) suggests that securitization can increase risk to the financial system through lax lending standards to promote loan growth and that banks that use securitization as a vehicle to transfer loans off balance sheets are exposed to higher risk than investors. Additionally, the author also mentions that although securitization is a tool to transfer default risk to investors, in practice banks fail to shift default risk on securitized loans to investors. The accounting rules give illusion of risk transference since securitization affects bank financial statements but does not change the nature of underlying loans. Furthermore, securitization increases risk of loss if banks securitize low credit risk loans and keep high credit risk loans on balance sheets.

3. Securitization and Capital

Through securitization, banks are able to remove loans from balance sheets and reduce their risk-based capital ratios. Some banks use securitization as a tool for capital arbitrage, which is the disadvantage of Basel I Capital Accord. Capital arbitrage means that banks are able to reduce capital requirement without reducing risk or hold the same amount of capital with increased risk and still have capital adequacy above the regulatory minimum requirement. Because loans either low or high credit quality have the same weight when calculating risk-weighted assets, banks have incentive to securitize high quality or low credit risk loans so that on-balance sheet loans are of low quality or high credit risk. Thus, through securitization banks decrease loans and capital but credit risk does not decrease. Regarding banks' perspective, securitization enables banks to exploit capital more efficiently since banks are able to provide more loans with the same amount

of capital. Nevertheless, with respect to bank regulators, capital arbitrage is undesirable since banks have smaller capital ratio and smaller cushion against losses but still have the same amount of risk.

Jones (2000) finds that the Basel Accord creates incentive of regulatory capital arbitrage. Through securitization banks are able to reduce capital requirements without decreasing overall economic risks since securitization decreases risk-weighted assets. Therefore, the author concludes that "these methods are used routinely to lower the *effective* risk-based capital requirements against certain portfolios to levels well below the Basel Capital Accord's *nominal* 8% total risk-based capital standard." Since cost of equity is higher than cost of debt, regulatory capital arbitrage increase shareholders' value by replacing equity with debt and banks can free up some amount of capital. Moreover, regulatory capital arbitrage occurs due to the difference between true economic risks and the measurements of risks in capital standards. The author also raises concern that minimum capital requirements may not be good supervisory tools for bank regulators since banks have incentive to securitize low credit risk loans and loans on balance sheets are of lower credit quality or have high credit risk; therefore, risk-based capital requirements may not indicate banks' true financial condition. Lastly, the author suggests that bank regulators can alleviate the problem of regulatory capital arbitrage if economic and regulatory measures of risk are closely aligned. Nevertheless, the authors indicate that although banks use securitization as a tool of capital arbitrage, banks may use it for other purposes such as to decrease cost of debt financing and to have more funding sources.

The following studies find the evidence of capital arbitrage by showing the negative relationship between securitization and bank capital and that through securitization banks are still subject to credit risk. First, Dionne and Harchaoui (2002) examine commercial bank behavior in Canada from 1988 to 1998 and conclude that securitization is negatively related to both Tier 1 and total risk-based capital ratios and that there is a positive relationship between securitization and banks' risk. They also argue that capital ratios do not efficiently take risk of securitization into account. Their evidence supports capital arbitrage since banks with securitization increase risk but decrease capital ratios. Second, Calomiris and Mason (2003) examine credit card securitization by sampling credit card banks in 1996 and 2000 and conclude that credit card securitization with implicit recourse leads to capital arbitrage and due to implicit recourse, risk still remains within banks. Third, Ambrose et al. (2005) examine conventional fixed rate mortgages originated between 1995 and 1997 and followed through 2000 and their result supports regulatory capital arbitrage by finding that securitized mortgage loans have lower ex-post default than on-balance-sheet mortgage loans. This implies that banks securitize low credit risk loans and hold high credit risk loans on their balance sheets. They also conclude that what drives securitization are capital requirement and reputation. Finally, Uzun and Webb (2007) examine U.S. banks from 2001 to 2005 and also find the evidence of capital arbitrage. They extend their research to show the impact on capital ratios by each type of securitization and conclude that credit card securitization is significantly negative to capital ratio.

CHAPTER 3

MODEL, DATA, AND EMPIRICAL ANALYSIS

1. Simultaneous Equations Model

Previous studies of the relationship between bank capital and risk use simultaneous equations model due to the assumptions that bank capital and risk-taking behavior are simultaneously determined and that risk-based capital standards have impact on both capital and risk. This model is first introduced by Shrieve and Dahl (1992) and later developed by Jacques and Nigro (1997), Aggarwal and Jacques (2001), and Rime (2001). The simultaneous equations model in this study follows Aggarwal and Jacques (2001) because they examine the impact of Prompt Corrective Action (PCA) under Federal Deposit Insurance Corporation Improvement Act (FDICIA) which is currently implemented in the United States. PCA categorizes banks by three capital ratios, which are total risk-based capital ratio, tier 1 risk-based capital ratio, and tier 1 leverage ratio. Bank regulators need to follow PCA to promptly investigate banks that fall below minimum capital requirement.

In this framework, the observed changes in capital and risk are composed of two components: endogenous (i.e. discretionary) adjustment and exogenous random shock. Therefore, the model is

$$\Delta CAP_{j,t} = \Delta^{d} CAP_{j,t} + E_{j,t} \quad (1)$$

$$\Delta RISK_{j,t} = \Delta^{d} RISK_{j,t} + U_{j,t} \quad (2)$$

where $\Delta CAP_{j,t}$ and $\Delta RISK_{j,t}$ are observed total changes in capital and risk levels, respectively, for bank j in period t. The $\Delta^d CAP_{j,t}$ and $\Delta^d RISK_{j,t}$ are discretionary or endogenously determined adjustments in capital and risk, and $E_{j,t}$ and $U_{j,t}$ are random shocks. However, because in any period banks may not be able to adjust their desired capital and risk levels instantaneously, the partial adjustment framework for $\Delta^d CAP_{j,t}$ and $\Delta^d RISK_{j,t}$ is employed by assuming that the discretionary component of changes in capital and risk levels are proportional to the difference between the target levels and previous period (period t-1) levels. Lagged levels are included to capture the speed of adjustment. Thus, the model for partial adjustment of discretionary components is

$$\Delta^d CAP_{j,t} = \alpha (CAP^*_{j,t} - CAP_{j,t-1}) \quad (3)$$

$$\Delta^d RISK_{j,t} = \beta (RISK^*_{j,t} - RISK_{j,t-1}) \quad (4)$$

where $CAP^*_{j,t}$ and $RISK^*_{j,t}$ are bank j's target capital and risk levels in period t, respectively. By substituting equations (3) and (4) into (1) and (2), the observed changes in capital and risk are

$$\Delta CAP_{j,t} = \alpha (CAP^*_{j,t} - CAP_{j,t-1}) + E_{j,t} \quad (5)$$

$$\Delta RISK_{j,t} = \beta (RISK^*_{j,t} - RISK_{j,t-1}) + U_{j,t} \quad (6)$$

Therefore, the observed changes in capital and risk levels are a function of their target levels, lagged value levels and exogenous shocks.

This framework of simultaneous equations model examines changes in capital and risk rather than capital and risk levels since the authors want to observe how banks change capital in response to risk and also how banks change risk in response to capital.

Bank Capital (CAP)

Bank capital (CAP) is defined as the ratio of total equity capital to total assets. The main components of equity capital are common stock and retained earnings. Both total equity capital and total assets are directly derived from balance sheets; therefore, this bank capital (CAP) variable can be called book value capital ratio.

Bank Risk (ON and OFF)

Since the purpose of this study is to examine the relationship between capital and on- and off-balance sheet credit risk in U.S. banks, the model of Aggarwal and Jacques (2001) is modified by categorizing risk into on-balance sheet credit risk and off-balance sheet credit risk. On-balance sheet credit risk (ON) is the ratio of loan loss allowance to total assets and off-balance-sheet credit risk (OFF) is the ratio of total amount of securitization to total assets.

Variables Affecting Target Capital and Risk

Regarding equations (5) and (6), the target capital and risk ($CAP^{*}_{j,t}$ and $RISK^{*}_{j,t}$) are unobservable. Thus, the target capital and risk are assumed to depend on some other observable explanatory variables.

1. Bank Size (SIZE)

SIZE is measured by the natural log of total assets. The target capital and risk levels may depend on bank size due to the relationship to risk diversification, investment opportunities, and access to capital.

2. Bank Holding Company Dummy Variable (BHC)

BHC is a dummy variable and equals to one if that bank is bank holding company and zero otherwise. Bank holding companies and commercial banks may have different opportunities to access capital and to take different levels of risk.

3. Return on Assets (ROA)

Return on assets (ROA) is included in capital equation (ΔCAP) since banks generally increase capital through their profits. Profits in current period increase retained earnings and retained earnings are part of capital. ROA is a proxy of bank profitability and is the ratio of net profit to total assets.

4. Regulatory Pressure (PCAU)

Aggarwal and Jacques (2001) who examine the effectiveness of the prompt corrective action (PCA) add two dummy variables since adequately capitalized and undercapitalized banks have different incentive to take risk. First, PCAA is unity if banks are adequately capitalized and zero otherwise. Second, PCAU is unity if banks are undercapitalized and zero otherwise. Undercapitalized banks have incentive to behave on both capital and risk differently from adequately capitalized banks. On the one hand, undercapitalized banks have incentive to increase capital and decrease risk in order to increase their capital ratios. On the other hand, some may take more risk for higher returns to increase capital. As regards adequately capitalized banks, on the one hand, they may decrease capital ratios and increase risk level since they already have enough capital

and on the other hand, some may choose to increase capital ratio and decrease risk in order to have more capital as a buffer against unexpected shocks.

However, because banks can be in either PCAA or PCAU but not both, PCAA and PCAU dummy variables are mutually exclusive. Therefore, the model in this paper includes only PCAU. Undercapitalized banks are of interest since the purpose of capital standards is to induce banks to have capital above the minimum requirement for bank safety and soundness. Furthermore, the interaction term between regulatory pressure and lagged capital levels ($PCAU*CAP_{t-1}$) is included in capital equation (ΔCAP) to allow for different rates of capital adjustment between undercapitalized and adequately capitalized banks. Undercapitalized banks are expected to adjust their capital levels faster than adequately capitalized banks. This interaction term can be called speed of capital adjustment term.

Time and Bank Fixed Effects

Time fixed effects are included to capture macroeconomic shocks on banks. Time dummy variable for each year is created for all years except year 2001. Moreover, time dummy variable for each quarter is included to capture quarterly or seasonal effects. Quarterly time dummy variables are created for quarters 2, 3, and 4.

Bank fixed effects are also included since each bank has specific characteristic.

Instrument Variables

In order to satisfy order condition of the simultaneous equations where the number of excluded variables are more than or equal to the number of right hand side

endogenous variables in each equation, NPL and LIQUID are used as instruments. First, NPL, which is the ratio of non-performing loans to total assets, is associated with on-balance sheet credit risk since non-performing loans represent loans that banks are unable to collect principal and earn interest. Second, LIQUID, which is the ratio of liquid assets to total assets, is related to off-balance sheet credit risk because securitization improves bank liquidity. Liquid assets are the sum of cash, federal funds sold and government securities. However, in the later section of methodology, test of model specification shows that LIQUID is not a good instrument; however, DEP, which is the ratio of deposits to total assets, is an appropriate one. Therefore, two instruments variables that are used to get the results are NPL and DEP.

By substituting the aforementioned variables together with three endogenous variables (ΔCAP, ΔON and ΔOFF) into equation (5) and (6), three simultaneous equations are as follows.

$$\Delta CAP_{j,t} = a_0 + a_1 SIZE_{j,t} + a_2 BHC_{j,t} + a_3 PCAU_{j,t} + a_4 \Delta ON_{j,t} + a_5 \Delta OFF_{j,t} + a_6 ROA_{j,t} + a_7 CAP_{j,t-1} + a_8 PCAU_{j,t} * CAP_{j,t-1} + \text{Time Fixed Effects} + \text{Bank Fixed Effects} + E_{j,t} \quad (7)$$

$$\Delta ON_{j,t} = b_0 + b_1 SIZE_{j,t} + b_2 BHC_{j,t} + b_3 PCAU_{j,t} + b_4 \Delta CAP_{j,t} + b_5 \Delta OFF_{j,t} + b_6 ON_{j,t-1} + \text{Time Fixed Effects} + \text{Bank Fixed Effects} + U_{j,t} \quad (8)$$

$$\Delta OFF_{j,t} = c_0 + c_1 SIZE_{j,t} + c_2 BHC_{j,t} + c_3 PCAU_{j,t} + c_4 \Delta CAP_{j,t} + c_5 \Delta ON_{j,t} + c_6 OFF_{j,t-1} + \text{Time Fixed Effects} + \text{Bank Fixed Effects} + V_{j,t} \quad (9)$$

Table 3-1 summarizes variables that are in equations (7), (8), and (9).

Table 3-1: List of Variables for Equations (7), (8), and (9)

Variable	Measurement	Codes
CAP	Total Equity Capital/Total Assets	RCFD3210/RCFD2170
ON	Loan Loss Allowance/Total Assets	RCFD3123/RCFD2170
OFF	Total Amount of Securitization/Total Assets	(RCFDB705+RCFDB706+RCFDB707+ RCFDB708+RCFDB709+RCFDB710+ RCFDB711)/RCFD2170
SIZE	Natural Log of Total Assets	Natural log of (RCFD2170)
ROA	Net Profit/Total Assets	RIAD4340/RCFD2170
NPL	Non-performing Loans/Total Assets	(RCFD1407+RCFD1403)/RCFD2170
LIQUID	Liquid Assets/Total Assets	(RCFD0010+RCFD0213+RCFD1290+ RCFD1295+ RCFD8497+RCFD1287+ RCFD1293+RCFD1298+RCFD8499+ RCONB987)/RCFD2170
DEP	Deposits/Total Assets	RCFD2200/RCFD2170

Note: Codes are from the Federal Reserve Bank of Chicago. More detail of codes is in Appendix 2.

2. Methodology

Since the number of banks with securitization varies from quarter to quarter, the sample is unbalanced panel data. First, to deal with bank fixed effects, a fixed effects regression is estimated by demeaning the data. Therefore, one-way demeaned data is used to remove bank fixed effects from equations (7), (8), and (9). The three simultaneous equations (7), (8), and (9) are estimated by using three-stage least squares (3SLS) procedure to recognize the endogeneity of bank capital (ΔCAP), on- balance sheet credit risk (ΔON), and off-balance sheet credit risk (ΔOFF) variables. The estimation is conducted through STATA program and its command for 3SLS is “reg3”. Moreover, together with command “reg3”, command “inst” allows including instruments, which are NPL and LIQUID, from the equations under “reg3”. The results show in table 3-2 and as can be seen, time fixed effects are significant.

Table 3-2: Three-Stage Least Squares Estimates from Equations (7), (8), and (9)

Variable	ΔCAP	ΔON	ΔOFF
SIZE	0.0021	-0.000***	-0.2768***
	(0.0013)	(0.0002)	(0.0178)
BHC	(dropped)	(dropped)	(dropped)
PCAU	0.0620***	0.0004	0.5803***
	(0.0170)	(0.0015)	(0.1165)
ΔCAP		0.0065*	4.6147***
		(0.0038)	(0.2825)
ΔON	0.0793		-3.7738***
	(0.0676)		(0.9051)
ΔOFF	0.0139***	-0.0002*	
	(0.0006)	(0.0001)	
ROA	0.2420***		
	(0.0238)		
CAP_{t-1}	-0.4181***		
	(0.0102)		
PCAU* CAP_{t-1}	-1.0617***		
	(0.1122)		
ON_{t-1}		-0.3895***	
		(0.0095)	
OFF_{t-1}			-0.9721***
			(0.0103)
Year 2002 Dummy	0.0021**	-0.0001	-0.0137
	(0.0010)	(0.0002)	(0.0138)
Year 2003 Dummy	0.0022**	-0.0003*	-0.0296**
	(0.0010)	(0.0002)	(0.0137)
Year 2004 Dummy	0.0043***	-0.0004*	-0.0431***
	(0.0011)	(0.0002)	(0.0145)
Year 2005 Dummy	0.0030***	-0.0005***	-0.0053
	(0.0011)	(0.0002)	(0.0147)
Year 2006 Dummy	0.0042***	-0.0006***	0.0058
	(0.0011)	(0.0002)	(0.0151)
Year 2007 Dummy	0.0044***	-0.0003*	0.0238
	(0.0011)	(0.0002)	(0.0155)
Year 2008 Dummy	0.0036**	0.0005	0.0353
	(0.0017)	(0.0003)	(0.0229)
Quarter 2 Dummy	-0.0032***	0.0001	0.0176*
	(0.0007)	(0.0001)	(0.0097)
Quarter 3 Dummy	-0.0019***	0.0001	0.0030
	(0.0007)	(0.0001)	(0.0095)
Quarter 4 Dummy	-0.0046***	0.0002	0.0254***
	(0.0007)	(0.0001)	(0.0095)
Constant	-0.0005	0.0002	-0.0023
	(0.0011)	(0.0002)	(0.0140)
R^2	0.2887	0.2353	0.6329

*** Significant at the 0.01 level
** Significant at the 0.05 level
* Significant at the 0.10 level

Year dummy variables capture macroeconomic effects and the results show that year-specific effects are significant in every year. Furthermore, quarterly effects are also significant since banks may operate through quarterly cycle. To evaluate the joint significance of the quarterly dummies, the F-test is used for all three equations and for each equation separately. The null hypothesis is that the coefficients of the quarterly dummies of quarter 2 to quarter 4 are equal to each other and equal to zero. Table 3-3 shows the results of conducting the F-test.

Table 3-3: F-Test for Quarterly Effects

	Chi-square	P-value
Across all three equations	48.92	0.0000
ΔCAP equation	44.08	0.0000
ΔON equation	2.58	0.4610
ΔOFF equation	10.22	0.0168

As can be seen, regarding the F-test across all three equations, the results lead to reject the null hypothesis. Therefore, all quarter dummies in all three equations are jointly significant. In addition, regarding the F-test for each equation, the results are to reject the null hypothesis in ΔCAP and ΔOFF equations but not reject in ΔON equation. Therefore, there is no quarterly effect in ΔON equation but when considering the whole system, quarterly effects are jointly significant.

Since time fixed effects are significant, the two-way fixed effects model is adopted to remove both time- and bank-specific effects from the model. The two-way demeaned data is created by subtracting the cross-sectional average and the time average from and adding the overall average to the original data. By using two-way demeaned

data, time and bank fixed effects are excluded from the model. Thus, the three simultaneous equations (7), (8), and (9) that are used to estimate parameters become

$$\Delta CAP_{j,t} = a_0 + a_1 SIZE_{j,t} + a_2 BHC_{j,t} + a_3 PCAU_{j,t} + a_4 \Delta ON_{j,t} + a_5 \Delta OFF_{j,t} + a_6 ROA_{j,t} + a_7 CAP_{j,t-1} + a_8 PCAU_{j,t} * CAP_{j,t-1} + E_{j,t} \quad (10)$$

$$\Delta ON_{j,t} = b_0 + b_1 SIZE_{j,t} + b_2 BHC_{j,t} + b_3 PCAU_{j,t} + b_4 \Delta CAP_{j,t} + b_5 \Delta OFF_{j,t} + b_6 ON_{j,t-1} + U_{j,t} \quad (11)$$

$$\Delta OFF_{j,t} = c_0 + c_1 SIZE_{j,t} + c_2 BHC_{j,t} + c_3 PCAU_{j,t} + c_4 \Delta CAP_{j,t} + c_5 \Delta ON_{j,t} + c_6 OFF_{j,t-1} + V_{j,t} \quad (12)$$

In order to test model specification of equations (10), (11), and (12), over-identification test is used and STATA command is "overid". The null hypothesis is that instruments are uncorrelated with error and explanatory variables are also uncorrelated with the error. The distribution is chi-square with the degree of freedom equal to the number of over-identified parameters. Therefore, rejecting the null hypothesis indicates that the instruments in the model are correlated with the error and this could be due to model misspecification, the endogeneity of instrument variables, or omitted variables. Since the sample size in this study is very large, STATA is unable to execute this command due to matrix size problem. As a result, only subsample is used instead of the full data set and the result shows p-value equal to zero, leading to reject the null hypothesis. Thus, this model is possibly incorrectly specified.

In order to deal with the matrix size problem, the Hausman test is an alternative test of model specification. According to Kennedy (2003), the Hausman test is used to test the contemporaneous correlation between regressors and the error and the exogenetiy/endogeneity of variables. The principle is that "if the model specification is correct, estimates by any two consistent methods should be close to one another; if they are not close to one another, doubt is cast on the model." To conduct the Hausman test, all simultaneous equations are estimated by using both two-stage least squares (2SLS) and three-stage least squares (3SLS) methods. Under the null hypothesis, estimators from both methods are consistent but 3SLS is more efficient than 2SLS because 3SLS estimates all simultaneous equations in the system together whereas 2SLS estimates each equation in simultaneous equations system separately. Hence, 3SLS has a smaller asymptotic variance than 2SLS. Kennedy (2003) describes 2SLS as single-equation or limited information methods and 3SLS as systems or full information methods.

The null hypothesis of Hausman test is that 2SLS and 3SLS estimators are consistent. Therefore, failing to reject the null hypothesis shows that 2SLS and 3SLS estimators are consistent and the model is correctly specified while rejecting the null hypothesis indicates model misspecification. The distribution is chi-square with degree of freedom equal to the number of parameters estimated. Regarding STATA program, two types of estimators are needed. The first estimator is always consistent, which is 2SLS and the second estimator is efficient and consistent, which is 3SLS. The command "hausman" is used for Hausman test and followed by consistent estimator (2SLS) and efficient estimator (3SLS), respectively. Similar to over-identification test, the result of model equations (10), (11), and (12) under Hausman test is also rejecting the null

hypothesis, meaning that 2SLS and 3SLS estimators are inconsistent and this implies model misspecification. Therefore, the system equations of (10), (11), and (12) are incorrectly specified.

To solve model misspecification problem, the system equations (10), (11), and (12) are changed as follows. First, instead of using LIQUID as instrument variable, DEP (deposit to total assets ratio) is adopted because banks with securitization have more liquidity to provide more loans and thus, do not depend much on deposits from customers. Therefore, deposit ratio may affect bank securitization. Second, loan growth (LOANG) is included as exogenous variable in ΔOFF equation since securitization provide funding source for banks to lend more. As a result, the correctly specified model is as follows.

$$\Delta CAP_{j,t} = a_0 + a_1 SIZE_{j,t} + a_2 BHC_{j,t} + a_3 PCAU_{j,t} + a_4 \Delta ON_{j,t} + a_5 \Delta OFF_{j,t} + a_6 ROA_{j,t} + a_7 CAP_{j,t-1} + a_8 PCAU_{j,t} * CAP_{j,t-1} + E_{j,t} \quad (13)$$

$$\Delta ON_{j,t} = b_0 + b_1 SIZE_{j,t} + b_2 BHC_{j,t} + b_3 PCAU_{j,t} + b_4 \Delta CAP_{j,t} + b_5 \Delta OFF_{j,t} + b_6 ON_{j,t-1} + U_{j,t} \quad (14)$$

$$\Delta OFF_{j,t} = c_0 + c_1 SIZE_{j,t} + c_2 BHC_{j,t} + c_3 PCAU_{j,t} + c_4 \Delta CAP_{j,t} + c_5 \Delta ON_{j,t} + c_6 OFF_{j,t-1} + c_7 LOANG_{j,t} + V_{j,t} \quad (15)$$

Furthermore, the model that includes loan growth in both ΔON and ΔOFF equations is also correctly specified under Hausman test. An increase in loans is also

associated with the amount of loan loss allowance or on-balance sheet credit risk. Thus, the alternative model is as follows.

$$\Delta CAP_{j,t} = a_0 + a_1 SIZE_{j,t} + a_2 BHC_{j,t} + a_3 PCAU_{j,t} + a_4 \Delta ON_{j,t} + a_5 \Delta OFF_{j,t} + a_6 ROA_{j,t} + a_7 CAP_{j,t-1} + a_8 PCAU_{j,t} * CAP_{j,t-1} + E_{j,t} \quad (16)$$

$$\Delta ON_{j,t} = b_0 + b_1 SIZE_{j,t} + b_2 BHC_{j,t} + b_3 PCAU_{j,t} + b_4 \Delta CAP_{j,t} + b_5 \Delta OFF_{j,t} + b_6 ON_{j,t-1} + b_7 LOANG_{j,t} + U_{j,t} \quad (17)$$

$$\Delta OFF_{j,t} = c_0 + c_1 SIZE_{j,t} + c_2 BHC_{j,t} + c_3 PCAU_{j,t} + c_4 \Delta CAP_{j,t} + c_5 \Delta ON_{j,t} + c_6 OFF_{j,t-1} + c_7 LOANG_{j,t} + V_{j,t} \quad (18)$$

Regarding the Hausman test of equations (13), (14), and (15), the chi-square with degree of freedom of 8 is 4.99 and p-value is 0.7588. Moreover, with respect to the Hausman test of equations (16), (17), and (18), the chi-square with degree of freedom of 8 is 3.20 and p-value is 0.9211. These results lead to failing to reject the null hypothesis, meaning that 2SLS and 3SLS estimators are consistent and that these two models are correctly specified.

All in all, in this study, two simultaneous equations models that are correctly specified are system equations of (13), (14), and (15) and of (16), (17), and (18). Three endogenous variables are ΔCAP, ΔON and ΔOFF. The exogenous explanatory variables are SIZE, BHC dummy variable, PCAU dummy variable, ROA, lagged CAP (CAP_{t-1}), the interaction term between PCAU dummy variable and lagged CAP ($PCAU*CAP_{t-1}$),

lagged ON (ON_{t-1}), lagged OFF (OFF_{t-1}), and LOANG. The instruments variables are NPL and DEP. Table 3-4 summarizes variables that are in equations (13) to (18).

Table 3-4: List of Variables for Equations (13) to (18)

Variable	Measurement	Codes
CAP	Total equity capital/total assets	RCFD3210/RCFD2170
ON	Loan loss allowance/total assets	RCFD3123/RCFD2170
OFF	Total amount of securitization/total assets	(RCFDB705+RCFDB706+RCFDB707+ RCFDB708+RCFDB709+RCFDB710+ RCFDB711)/RCFD2170
SIZE	Natural log of total assets	Natural log of (RCFD2170)
ROA	Net profit/total assets	RIAD4340/RCFD2170
LOANG	Loan growth	Natural log of (RCFD2122) - Natural log of (Lagged RCFD2122)
NPL	Non-performing loans/total assets	(RCFD1407+RCFD1403)/RCFD2170
DEP	Deposits/total assets	RCFD2200/RCFD2170

Note: Codes are from the Federal Reserve Bank of Chicago. More detail of codes is in Appendix 2.

3. Statements of Hypotheses

The two problem statements are that whether banks simultaneously determine changes in capital, on-balance-sheet credit risk, and off-balance-sheet credit risk and that whether risk-based capital standards in the United States are effective.

First, to examine whether banks simultaneously determine changes in capital, on- and off-balance sheet credit risk or whether all three endogenous variables (ΔCAP, ΔON and ΔOFF) are jointly determined, the signs of a_4, a_5, b_4, b_5, c_4, and c_5 are expected to be significantly different from zero. In other words, there exists relationship among ΔCAP, ΔON, and ΔOFF variables.

Second, to examine whether risk-based capital standards in the United States are effective, regulatory pressure dummy variable (PCAU) are of interest by considering the impact of PCAU on ΔCAP, ΔON, and ΔOFF variables. In other words, this paper studies

how undercapitalized banks react to capital and on- and off-balance sheet credit risk taking. Since the purpose of risk-based capital standards is to promote bank safety and soundness and to decrease probability of bank failure, minimum capital requirements are effective if they induce banks to increase risk-based capital ratios by either increasing capital or reducing risk or both. Therefore, the expected sign of a_3 is positive while the expected signs of b_3 and c_3 are negative. Additionally, since the interaction terms between regulatory pressure and lagged capital ($PCAU*CAP_{t-1}$) are included in ΔCAP equation to capture the speed of capital adjustment, undercapitalized banks are expected to adjust capital faster than adequately capitalized banks. Thus, the coefficient of ($PCAU*CAP_{t-1}$) or a_8 is expected to be negative.

Third, because banks adjust capital and risk to target value as in equations (3), (4), (5) and (6), the coefficients of lagged value of all endogenous variables (CAP_{t-1}, ON_{t-1} and OFF_{t-1}) are expected to be negative. In other words, a_7, b_6 and c_6 are expected to be negative.

Fourth, since profit increases retained earnings and then capital, the expected sign of return on assets (ROA) or a_6 are positive.

Finally, through loan growth (LOANG), banks are expected to increase the amount of loan loss allowance to be associated with the increased credit risk; therefore, the coefficient of LOANG in ΔON equation or b_7 is expected to be positive. Furthermore, securitization provides banks with funding to finance new loans and banks that can initiate more loans are able to increase the amount of securitization. Therefore, securitization and loan growth are expected to be positively related. As a result, the coefficient of LOANG in ΔOFF equation or c_7 is also expected to be positive.

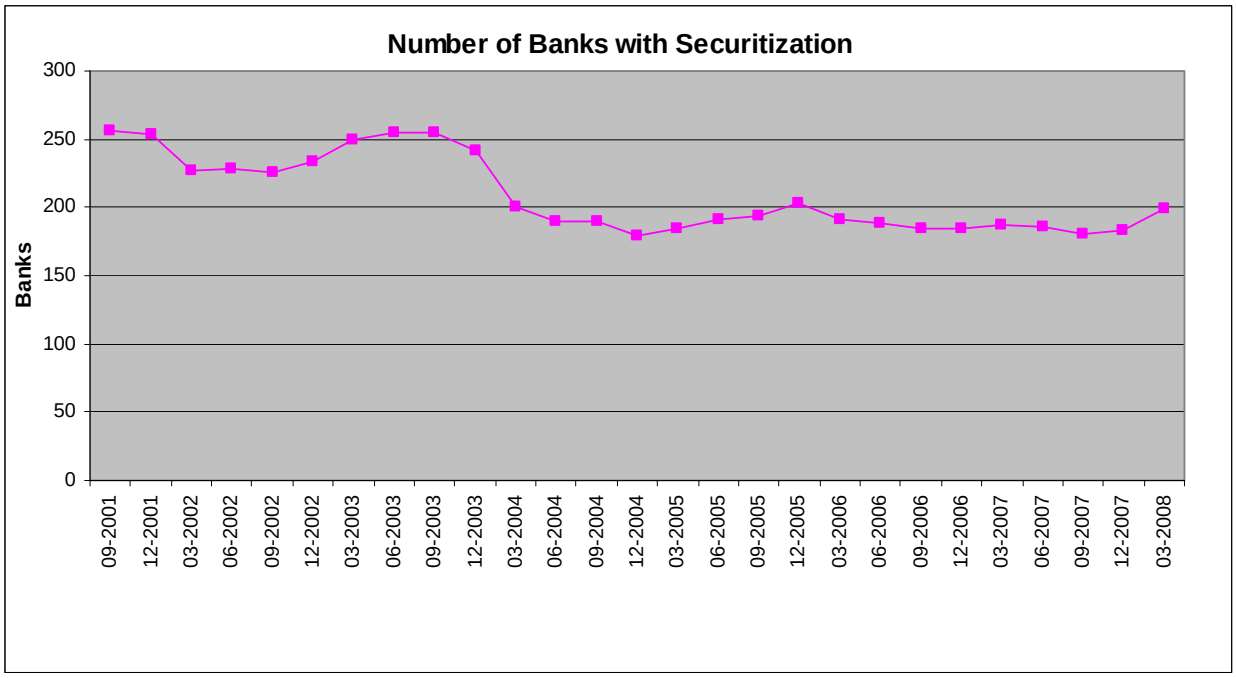
4. Data

The sample in this study consists of securitizing commercial banks and bank holding companies in the United States for 27 quarters from the third quarter of 2001[1] to the first quarter of 2008. The quarterly data is obtained from the database of Federal Reserve Bank of Chicago. Appendix 2 shows more detail of variables. The sample banks are banks with either type of securitization in each quarter and with total assets in excess of $100 million.

This paper examines a total of 5,642 bank observations, consisting of 3,151 commercial bank observations and 2,491 bank holding company observations. Of all 5,642 bank observations, 35 bank observations are undercapitalized and 5,607 bank observations that are adequately capitalized. Figure 3-1 shows number of banks with securitization in each quarter. Figure 3-2 shows the percentage of banks with securitization and the ratio of total assets of banks with securitization to total assets of all banks in each quarter. Both figures indicate that although there are roughly 200 banks with securitization in each quarter or about 2% of all banks, total assets of securitizing banks are over 50% of total assets of all banks. Moreover, this percentage has been increasing to over 60% since 2006. Thus, this implies that banks with securitization are relatively larger than banks without securitization.

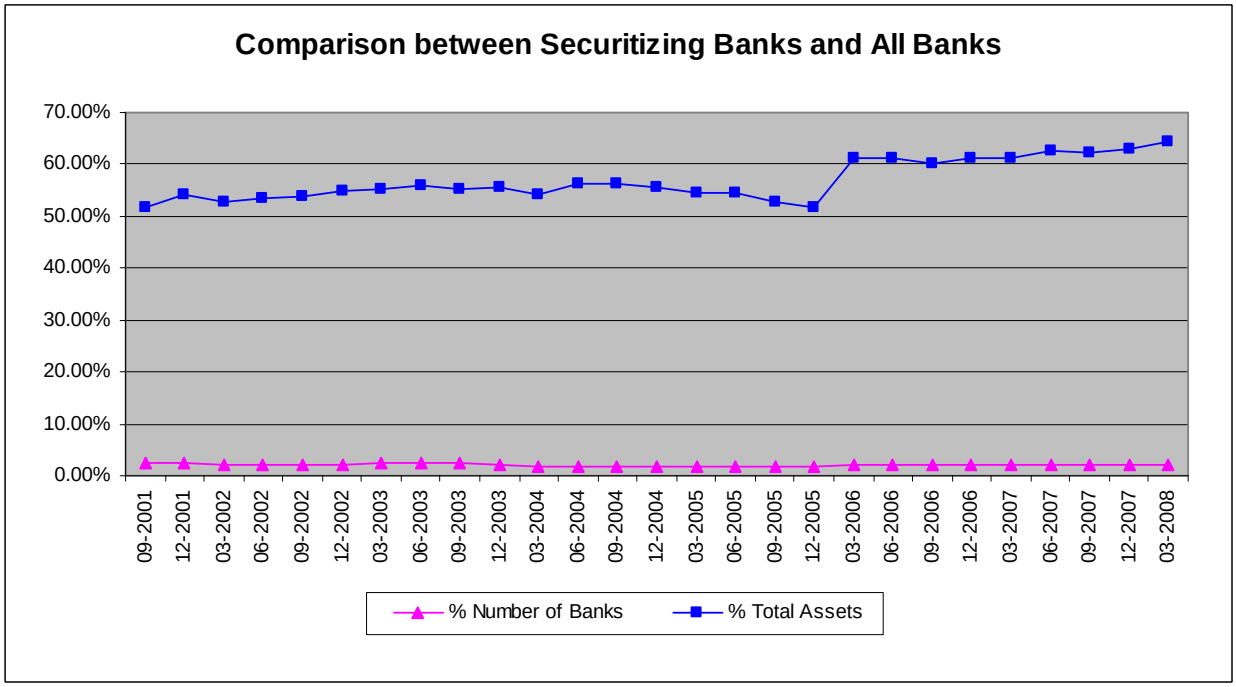
[1] Since model equations involve lagged value, lagged capital and risk levels in the third quarter of 2001 are from the second quarter of 2001.

Figure 3-1: Number of Banks with Securitization



Note: Source of data is from the Federal Reserve Bank of Chicago. Data on securitization is not reported before June 2001.

Figure 3-2: Percentage of Banks with Securitization

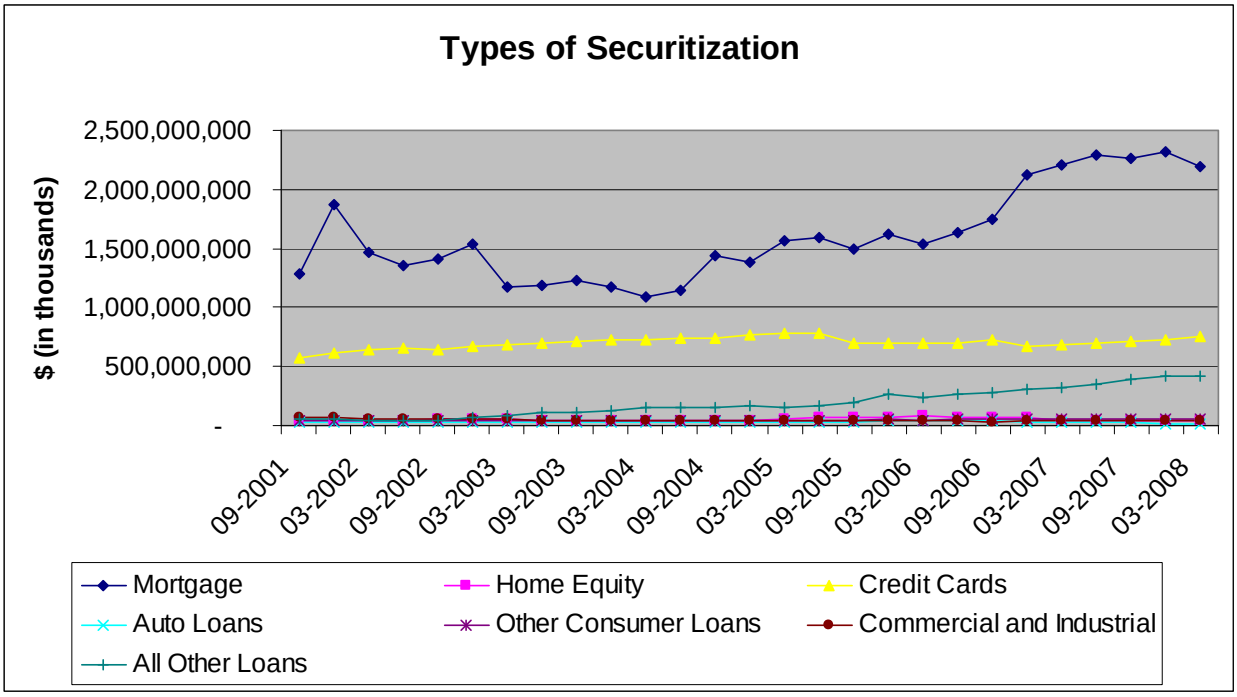


Note: Source of data is from the Federal Reserve Bank of Chicago. Data on securitization is not reported before June 2001.

Regarding Figure 3-1, the ratios of total assets of banks with securitization to total assets of all banks are around 50% and level off from 2001 to 2005; however, in the first quarter of 2006, this ratio dramatically jumps to around 60%. This jump is due to a large decrease in total assets of bank holding companies in that quarter, reducing total assets of all banks (the denominator) and thus, increasing the ratio. According to Federal Reserve Bulletin (2007), the Federal Reserve increase the asset threshold for bank holding companies to file FR Y-9C (Consolidated Financial Statements for Bank Holding Companies) and FR Y-9LP (Parent Company Only Financial Statements for Large Bank Holding Companies) forms from $150 million to $500 million. Therefore, in the first quarter of 2006, number of bank holding companies who file these forms considerably decrease by more than 1,200 companies. Therefore, the reported total assets of bank holding companies are much smaller.

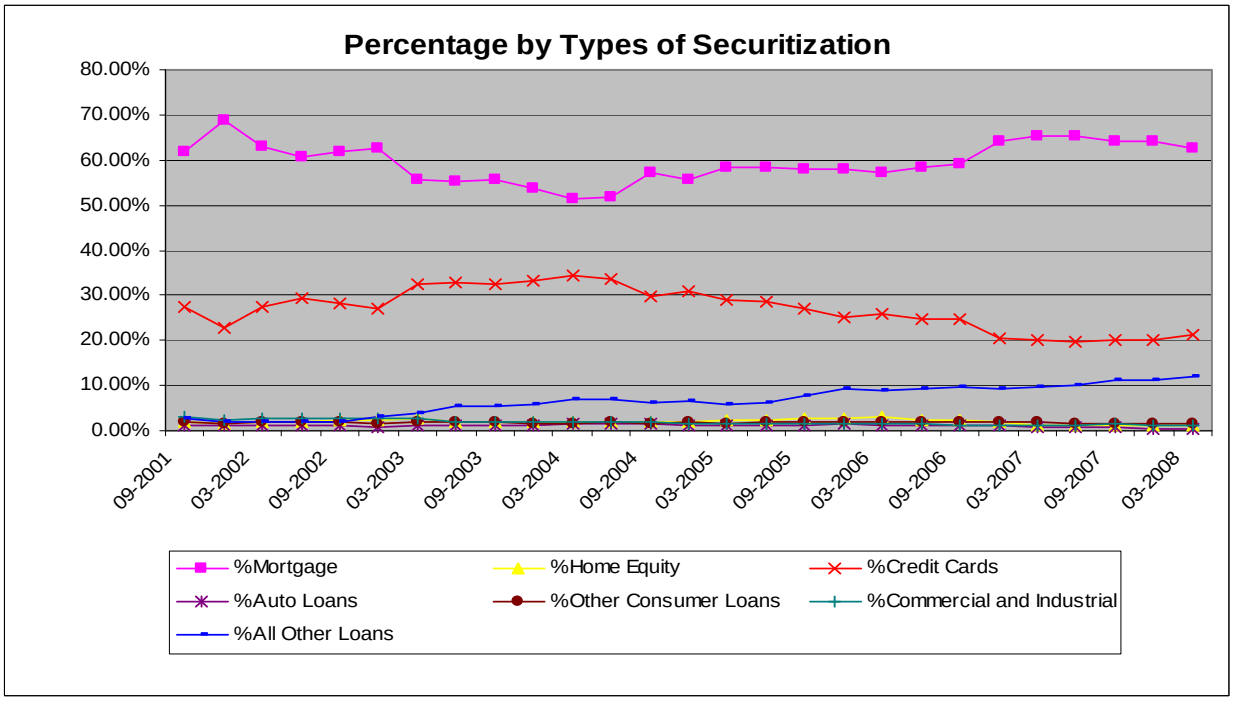
Securitization activities as shown in the notes to banks' financial statements are categorized into seven types depending on types of loans. As can bee seen in Figure 3-3, the largest two categories of securitization are 1-4 family residential or mortgage loans and credit cards receivables. As discussed in Chapter 1, mortgage-backed securities are backed by mortgage loans while asset-backed securities are backed by other types of loans. Mortgage securitization has steadily grown since 2004. From Figure 3-4, mortgage securitization is about 60% of total securitization whereas credit cards securitization is approximately 25% of total securitization.

Figure 3-3: Types of Securitization in Dollar Amount



Note: Source of data is from the Federal Reserve Bank of Chicago. Data on securitization is not reported before June 2001.

Figure 3-4: Types of Securitization in Percentage



Note: Source of data is from the Federal Reserve Bank of Chicago. Data on securitization is not reported before June 2001.

Table 3-5 shows variable means of data in the sample and number of observations for each quarter for all 27 quarters.

Table 3-5: Means of Variables in Each Quarter

Quarter	Obs	ΔCAP_t	ΔON_t	ΔOFF_t	CAP_{t-1}	ON_{t-1}	OFF_{t-1}	$LOANG_t$	$SIZE_t$	ROA_t
Q3:01	256	0.00173	0.00042	-0.03550	0.09874	0.01190	0.43692	0.00860	15.1059	0.01097
Q4:01	254	-0.00492	0.00105	0.02645	0.10108	0.01230	0.34099	0.00148	15.2876	0.01189
Q1:02	227	0.00449	-0.00019	0.11026	0.09708	0.01373	0.37188	0.00034	15.4028	0.00522
Q2:02	228	0.00156	0.00013	0.02191	0.10001	0.01349	0.34064	0.01818	15.4317	0.00898
Q3:02	226	0.00061	-0.00002	-0.02539	0.10178	0.01351	0.35969	0.23931	15.4905	0.01292
Q4:02	233	0.00055	-0.00017	0.00756	0.10304	0.01329	0.31941	0.02965	15.4773	0.01652
Q1:03	249	0.00142	-0.00046	-0.01514	0.10321	0.01288	0.31052	0.00682	15.3374	0.00428
Q2:03	255	-0.00043	-0.00001	-0.02208	0.10346	0.01177	0.27218	0.04509	15.3311	0.00795
Q3:03	255	0.00146	0.00004	0.01813	0.10258	0.01191	0.24792	0.02312	15.3377	0.01212
Q4:03	242	-0.00068	0.00021	-0.00824	0.10398	0.01205	0.27451	0.02266	15.4259	0.01579
Q1:04	201	0.00436	-0.00016	0.00165	0.10776	0.01273	0.27201	0.02906	15.7992	0.00529
Q2:04	190	-0.00322	-0.00015	-0.00288	0.11108	0.01183	0.28675	0.04563	15.9663	0.00912
Q3:04	190	0.00575	-0.00014	-0.00077	0.10789	0.01158	0.28216	0.03791	15.9058	0.01295
Q4:04	179	0.00351	-0.00042	0.00780	0.10892	0.01047	0.27717	0.04665	15.8345	0.01644
Q1:05	184	0.00027	-0.00024	-0.00325	0.11018	0.00971	0.26249	0.03022	15.7694	0.00438
Q2:05	191	0.00247	-0.00020	0.00855	0.10833	0.00949	0.24914	0.05356	15.7056	0.00844
Q3:05	194	-0.00087	0.00014	0.00068	0.11190	0.00931	0.25188	0.03093	15.6566	0.01234
Q4:05	203	-0.00087	-0.00030	-0.00278	0.10862	0.00932	0.23483	0.02874	15.4845	0.01479
Q1:06	191	0.00387	-0.00004	-0.00448	0.10767	0.00893	0.22770	0.01779	15.6321	0.00416
Q2:06	189	-0.00065	-0.00019	0.01520	0.11294	0.00894	0.22626	0.09228	15.6254	0.00830
Q3:06	185	0.00242	3.56e-06	-0.00415	0.11137	0.00890	0.24312	0.07449	15.5869	0.01229
Q4:06	184	-0.00010	-0.00007	0.00093	0.11367	0.00856	0.22471	0.13698	15.5290	0.01473
Q1:07	187	0.00311	0.00008	0.00418	0.11271	0.00842	0.20182	0.08950	15.5220	0.00359
Q2:07	186	-0.00319	0.00001	0.00285	0.11438	0.00849	0.20603	0.08654	15.5372	0.00696
Q3:07	181	0.00265	2.42e-06	-0.00048	0.11061	0.00883	0.20657	0.11964	15.4719	0.00946
Q4:07	183	-0.00169	0.00065	0.00069	0.11230	0.00885	0.18266	0.09984	15.5052	0.01071
Q1:08	199	0.00166	0.00077	0.01023	0.10976	0.00955	0.16293	0.09026	15.3450	0.00293

Source: The Federal Reserve Bank of Chicago

Tables 3-6 and 3-7 indicate minimum and maximum value of all three endogenous variables and lagged variables in each quarter. Regarding the ratio of securitization to total assets or OFF_{t-1} variable in table 3-7, the amount of securitization of some banks is many times larger than their total assets.

Table 3-6: Minimum and Maximum of Endogenous Variables in Each Quarter

Quarter	ΔCAP_t		ΔON_t		ΔOFF_t	
	Min	Max	Min	Max	Min	Max
Q3:2001	-0.09386	0.05894	-0.00638	0.03447	-9.28067	1.33046
Q4:2001	-0.71178	0.16027	-0.08585	0.17230	-0.51454	3.12760
Q1:2002	-0.21620	0.51082	-0.04291	0.02334	-6.31205	28.0997
Q2:2002	-0.19224	0.08672	-0.02446	0.03961	-1.68953	2.78421
Q3:2002	-0.04570	0.06922	-0.02895	0.04007	-2.41889	0.41286
Q4:2002	-0.24789	0.34997	-0.04985	0.03649	-1.76243	1.22593
Q1:2003	-0.03483	0.10182	-0.05091	0.01028	-1.18011	0.41081
Q2:2003	-0.05326	0.04194	-0.00932	0.02594	-2.36095	0.77469
Q3:2003	-0.09186	0.22884	-0.01186	0.02166	-0.96852	2.59300
Q4:2003	-0.21914	0.07058	-0.01123	0.03708	-2.29271	1.22303
Q1:2004	-0.09116	0.29563	-0.01307	0.01020	-0.49118	1.78362
Q2:2004	-0.23857	0.11931	-0.01157	0.04048	-0.86049	0.65511
Q3:2004	-0.10715	0.32955	-0.01002	0.01341	-0.39470	1.17032
Q4:2004	-0.02564	0.14803	-0.00915	0.00934	-0.57011	0.85616
Q1:2005	-0.09408	0.12284	-0.01133	0.00389	-1.36484	0.79192
Q2:2005	-0.03954	0.08529	-0.00563	0.00421	-0.26153	0.75824
Q3:2005	-0.11638	0.07924	-0.00358	0.01300	-0.24497	0.32995
Q4:2005	-0.12098	0.09881	-0.01017	0.00545	-0.99596	0.22521
Q1:2006	-0.02029	0.19397	-0.00387	0.00315	-0.49986	0.29095
Q2:2006	-0.04393	0.03981	-0.00868	0.00462	-0.24241	1.14702
Q3:2006	-0.04222	0.03502	-0.00453	0.00495	-0.66986	0.33406
Q4:2006	-0.16544	0.15205	-0.00495	0.01549	-0.79938	0.50767
Q1:2007	-0.03394	0.09305	-0.00713	0.00357	-0.42044	0.28408
Q2:2007	-0.07990	0.02316	-0.01560	0.00699	-0.27896	0.37688
Q3:2007	-0.07331	0.17051	-0.01040	0.00821	-0.44843	0.92262
Q4:2007	-0.06181	0.07961	-0.00353	0.00983	-0.15561	0.27233
Q1:2008	-0.06658	0.12246	-0.01167	0.01371	-0.69276	0.51435

Source: The Federal Reserve Bank of Chicago

Table 3-7: Minimum and Maximum of Other Variables in Each Quarter

Quarter	CAP_{t-1}		ON_{t-1}		OFF_{t-1}		$LOANG_t$	
	Min	Max	Min	Max	Min	Max	Min	Max
Q3:2001	0.03185	0.66694	0	0.12190	0	23.35584	-0.59875	0.78519
Q4:2001	0.02813	0.92482	0	0.13895	0	7.45721	-1.22890	1.10308
Q1:2002	0.02490	0.68127	0	0.29299	0	7.79700	-2.50898	2.26132
Q2:2002	0.02412	0.65762	0	0.28007	0	7.19192	-0.37144	0.61506
Q3:2002	0.02464	0.67906	0	0.25561	0	8.41587	-1.87959	0.93959
Q4:2002	0.02183	0.67208	0	0.22667	0	5.99698	-0.78414	2.03196
Q1:2003	0.01857	0.67616	0	0.20046	0	6.09393	-0.57086	0.63026
Q2:2003	-0.05326	0.04194	0	0.17688	0	5.57954	-0.37745	1.52330
Q3:2003	0.01315	0.63168	0	0.20282	0	4.62796	-0.79233	0.52240
Q4:2003	0.01261	0.61831	0	0.19796	0	6.45518	-0.64811	0.62222
Q1:2004	0.01324	0.61998	0	0.23504	0	4.87556	-0.37174	0.90687
Q2:2004	0.01200	0.61138	0	0.13601	0	4.38438	-0.44913	0.67499
Q3:2004	0.01283	0.60721	0	0.17649	0	4.88667	-0.75811	1.24047
Q4:2004	0.01351	0.62252	0	0.04941	0	4.69034	-0.24130	0.82818
Q1:2005	0.01291	0.63166	0	0.05094	0	5.33318	-0.25768	0.82091
Q2:2005	0.01240	0.64330	0	0.05122	0	5.06862	-0.46216	1.24446
Q3:2005	0.01300	0.72859	0	0.05414	0	5.36853	-0.25140	0.47394
Q4:2005	-0.12098	0.09881	0	0.05557	0	5.19749	-0.63054	0.71193
Q1:2006	0.01251	0.70776	0	0.05436	0	4.75422	-0.25391	0.33671
Q2:2006	0.01173	0.71359	0	0.05668	0	4.64025	-0.50770	0.46009
Q3:2006	0.01200	0.70226	0	0.05813	0	5.04567	-0.20718	0.70113
Q4:2006	0.01191	0.70597	0	0.03045	0	4.58971	-0.37567	0.94412
Q1:2007	0.01184	0.73495	0	0.03315	0	4.80038	-0.35913	0.71558
Q2:2007	0.00974	0.73089	0	0.03495	0	4.37994	-0.53258	0.65581
Q3:2007	0.00888	0.74209	0	0.03632	0	4.47071	-0.45396	1.33597
Q4:2007	0.00651	0.73772	0.00004	0.03667	0	4.25072	-0.33511	1.00902
Q1:2008	0.00393	0.72848	0.00001	0.03999	0	4.13356	-0.54530	0.52088

Source: The Federal Reserve Bank of Chicago

Besides, table 3-8 shows overall variable means from all 27 quarters and includes their minimum and maximum value. Means are the average of all 27 quarters.

Table 3-8: Overall Mean, Minimum, and Maximum of Variables

Variable	Mean	Min	Max
ΔCAP_t	0.00088	-0.71178	0.51082
ΔON_t	0.00004	-0.08585	0.17230
ΔOFF_t	0.00413	-9.28067	28.0997
CAP_{t-1}	0.10668	0.00393	0.92482
ON_{t-1}	0.01094	0	0.29299
OFF_{t-1}	0.27460	0	23.35584
$LOANG_t$	0.02591	-2.50898	2.26132
$SIZE_t$	15.51868	11.51744	21.58119
ROA_t	0.00982	-0.12990	0.29194

Source: The Federal Reserve Bank of Chicago

Table 3-9 shows variable means by quarter and by overall. Means of all three endogenous variables vary from quarter to quarter and are different from overall. Therefore, quarterly or seasonal effects may impact banks on change in capital and on- and off-balance sheet credit risk.

Table 3-9: Variable Means by Quarter

	Q1	Q2	Q3	Q4	Overall
ΔCAP_t	0.00275	-0.00049	0.00189	-0.00079	0.00088
ΔON_t	-0.00005	-0.00006	0.00008	0.00017	0.00004
ΔOFF_t	0.01605	0.00302	-0.00743	0.00509	0.00413
CAP_{t-1}	0.10650	0.10783	0.10576	0.10681	0.10668
ON_{t-1}	0.01102	0.01082	0.01102	0.01089	0.01094
OFF_{t-1}	0.26312	0.26653	0.29671	0.27031	0.27460
$LOANG_t$	0.01369	0.03782	0.02583	0.02791	0.02591
$SIZE_t$	15.53176	15.58057	15.48256	15.49041	15.51868
ROA_t	0.00429	0.00830	0.01188	0.01442	0.00982

Source: The Federal Reserve Bank of Chicago

Table 3-10 shows correlations among both endogenous and exogenous variables.

Table 3-10: Correlations among Variables

Variable	ΔCAP_t	ΔON_t	ΔOFF_t	CAP_{t-1}	ON_{t-1}	OFF_{t-1}	$LOANG_t$	$SIZE_t$	ROA_t
ΔCAP_t	1.0000								
ΔON_t	0.0126	1.0000							
ΔOFF_t	0.1990	0.0837	1.0000						
CAP_{t-1}	-0.0638	0.0208	-0.0387	1.0000					
ON_{t-1}	0.0881	-0.0230	-0.0227	0.2599	1.0000				
OFF_{t-1}	0.0008	0.0051	-0.1492	0.4513	0.2285	1.0000			
$LOANG_t$	-0.2228	-0.0345	-0.1940	0.0475	-0.063	0.0339	1.0000		
$SIZE_t$	-0.0009	-0.0175	-0.0373	-0.0776	-0.0391	-0.0392	0.0338	1.0000	
ROA_t	0.0739	-0.0426	-0.0061	0.5853	0.3314	0.4253	-0.0231	-0.0354	1.0000

Source: The Federal Reserve Bank of Chicago

5. Results

Tables 3-11 and 3-12 present the results of estimation of simultaneous equations (13), (14) and (15) and of simultaneous equations (16), (17) and (18), respectively. The only difference between these two models is that the latter includes loan growth (LOANG) in ΔON equation. The coefficient signs and their significance levels are the same.

Table 3-11: Three-Stage Least Squares Estimates from Equations (13), (14), and (15) with the Ratio of Equity Capital to Total Assets

Variable	ΔCAP	ΔON	ΔOFF
SIZE	0.0007	-0.0003*	-0.0284***
	(0.0009)	(0.0002)	(0.0081)
BHC	-0.0005	0.0060***	0.1457*
	(0.0091)	(0.0017)	(0.0810)
PCAU	0.0723***	0.0003	0.1635**
	(0.0165)	(0.0015)	(0.0720)
ΔCAP		0.0032	1.3373***
		(0.0048)	(0.2267)
ΔON	-0.0746		-0.2166
	(0.1303)		(1.0899)
ΔOFF	0.0218***	0.0016***	
	(0.0024)	(0.0005)	
ROA	0.1776***		
	(0.0241)		
CAP_{t-1}	-0.3410***		
	(0.0108)		
PCAU* CAP_{t-1}	-1.1372***		
	(0.1094)		
ON_{t-1}		-0.3567***	
		(0.0093)	
OFF_{t-1}			-0.3795***
			(0.0092)
LOANG			-0.2385***
			(0.0182)
Constant	0.00008	1.92e-06	-0.0001
	(0.0002)	(0.00004)	(0.0019)
R^2	0.2242	0.2174	0.3122

*** Significant at the 0.01 level
** Significant at the 0.05 level
* Significant at the 0.10 level

Table 3-12: Three-Stage Least Squares Estimates from Equations (16), (17), and (18) with the Ratio of Equity Capital to Total Assets

Variable	ΔCAP	ΔON	ΔOFF
SIZE	0.0007	-0.0003*	-0.0284***
	(0.0009)	(0.0002)	(0.0081)
BHC	-0.0005	0.0062***	0.1455*
	(0.0091)	(0.0017)	(0.0810)
PCAU	0.0712***	0.0006	0.1633**
	(0.0165)	(0.0015)	(0.0720)
ΔCAP		0.0064	1.3406***
		(0.0050)	(0.2267)
ΔON	-0.0682		-0.0671
	(0.1303)		(1.0899)
ΔOFF	0.0218***	0.0019***	
	(0.0024)	(0.0005)	
ROA	0.1759***		
	(0.0241)		
CAP_{t-1}	-0.3411***		
	(0.0109)		
PCAU* CAP_{t-1}	-1.1289***		
	(0.1094)		
ON_{t-1}		-0.3559***	
		(0.0093)	
OFF_{t-1}			-0.3793***
			(0.0092)
LOANG		0.0008*	-0.2385***
		(0.0004)	(0.0182)
Constant	0.00008	1.63e-06	-0.0001
	(0.0002)	(0.00004)	(0.0019)
R^2	0.2243	0.2168	0.3125

*** Significant at the 0.01 level
** Significant at the 0.05 level
* Significant at the 0.10 level

Regarding the first purpose of studying whether banks simultaneously determine changes in capital and on- and off-balance sheet credit risk, only change in capital (ΔCAP) and change in off-balance sheet credit risk (ΔOFF) are simultaneously determined and they have a positive relationship. Banks with more capital are able to take

more off-balance sheet credit risk or securitize more loans. Likewise, banks that securitize more loans have to increase capital in order to absorb unexpected losses arising from off-balance sheet credit risk. However, change in capital (ΔCAP) and change in on-balance sheet credit risk (ΔON) show no significant relationship to each other. Bank capital is not related to on-balance sheet credit risk. While banks increase on-balance sheet credit risk, they do not increase capital. Thus, bank capital may not be adequate to absorb unexpected losses from on-balance sheet credit risk. Moreover, as can be seen in ΔON equation, off-balance sheet credit risk (ΔOFF) exogenously determines on-balance sheet credit risk (ΔON) and they have a positive relationship. Banks that securitize more loans or have more off-balance sheet loans also increase on-balance sheet loans and recognize higher amount of loan loss allowance accordingly. This could be due to originate-to-distribute model that banks move toward securitization and keep growing loans through securitization. Banks that want to increase securitization transactions have to originate on-balance sheet loans first and securitize later. Banks that increase off-balance sheet credit risk also increase on-balance sheet credit risk and vice versa. In other words, securitized loans have the same credit risk or quality as on-balance sheet loans. All in all, capital is positively related to off-balance sheet credit risk but has no significant impact on on-balance sheet credit risk. On-balance sheet credit risk shows no significant impact on both capital and off-balance sheet credit risk. However, off-balance sheet credit risk has significant impact on both capital and on-balance sheet credit risk and it is positively related to both of them.

Next, with respect to the second purpose of examining the effectiveness of U.S. capital standards, regulatory pressure (PCAU) induces undercapitalized banks to increase

capital as its coefficient is positive as expected. However, the sign of PCAU in ΔOFF equation is positive but the expected sign is negative. This indicates that capital standards encourage undercapitalized banks to take more off-balance sheet credit risk. Additionally, capital standards have no significant impact on on-balance sheet credit risk. Although capital standards are effective in inducing undercapitalized banks to increase capital, capital standards are not effective in the sense that undercapitalized banks not only are not concerned about on-balance sheet credit risk but also take more off-balance sheet credit risk. However, the interaction term between regulatory pressure and lagged capital (PCAU* CAP_{t-1}) is negative as expected. Capital standards are effective in inducing undercapitalized banks to adjust capital faster than adequately capitalized banks.

Next, regarding all lagged levels (CAP_{t-1}, ON_{t-1}, and OFF_{t-1}), they all show negative signs as expected, meaning that banks adjust capital and on- and off-balance sheet credit risk to their target levels. Besides, the coefficient of return on assets (ROA) is positive as expected since bank capital generally increases through profit.

With respect to loan growth (LOANG), loan growth in ΔON equation is positively related to on-balance sheet credit risk as expected. Banks that have more on-balance sheet loans increase on-balance sheet credit risk associated with those loans and hence increase loan loss allowance. However, loan growth in ΔOFF equation shows unexpected negative sign. Banks with loan growth decrease securitization transactions. This could be that since loan growth is calculated from on-balance sheet loans, banks that keep more loans on balance sheet have smaller amount of off-balance sheet loans, leading to a decrease in the amount of securitization and credit risk associated with those off-balance sheet loans. After the loan origination, banks may hold loans on balance sheet

first and securitize in later quarter. Banks may not be able to securitize right after the loans origination.

Finally, bank size (SIZE) and bank holding company dummy variable (BHC) have significant impact only on ΔON and ΔOFF equations. Bank size is negatively related to both on- and off-balance sheet credit risk. As banks become larger, they decrease both on- and off-balance sheet credit risk because they may have opportunity of risk diversification. Unlike bank size, bank holding company dummy variable (BHC) is positively related to both on- and off-balance sheet credit risk. Bank holding companies are able to increase more on- and off-balance sheet credit risk and get more involved in securitization transactions than commercial banks but have no difference in terms of access to capital.

6. Robustness Checks

For the robustness checks, three other types of capital ratios are used and they all are capital ratios that banks regulators set the minimum requirements. In other words, regarding CAP variable, book value capital ratio, which is the ratio of equity capital to total assets, is replaced by risk-based capital ratios and table 3-13 lists three types of risk-based capital ratios.

Table 3-13: List of Risk-Based Capital Ratios

Variable	Measurement	Code
Total risk-based capital ratio	Total risk-based capital/risk weighted assets	RCFD7205
Tier 1 risk-based capital ratio	Tier 1 risk-based capital/risk weighted assets	RCFD7206
Tier 1 leverage ratio	Tier 1 risk-based capital/average total assets	RCFD7204

Source: The Federal Reserve Bank of Chicago

When using total risk-based capital ratio and testing model specification of Hausman test, the chi-square with degree of freedom of 8 is 1.65 and p-value is 0.9898 in the system of simultaneous equations of (13), (14), and (15) and the chi-square degree of freedom of 8 is 0.52 and p-value is 0.9998 in the system of simultaneous equations of (16), (17), and (18). Therefore, failing to reject the null hypothesis shows that those models are correctly specified. Moreover, levels of instruments are used instead of differenced or demeaned data since levels are usually more stable. However, when using tier 1 risk-based capital ratio and tier 1 leverage ratio, p-values under Hausman test are zero, leading to rejecting the null hypothesis and implying model misspecification.

Table 3-14 shows the results of total risk-based capital ratio for simultaneous equations (13), (14), and (15) with loan growth only in ΔOFF equation. Table 3-15 shows the results of total risk-based capital ratio for simultaneous equations (16), (17), and (18) with loan growth in ΔON and ΔOFF equation. Table 3-14 is the robustness check of table 3-11 while table 3-15 is the robustness check of table 3-12. Since the endogenous and exogenous variables in table 3-15 have signs and significance levels the same as those in table 3-14, the explanation of the robustness checks is the same.

Table 3-14: Three-Stage Least Squares Estimates from Equations (13), (14), and (15) with Total Risk-Based Capital Ratio

Variable	ΔCAP	ΔON	ΔOFF
SIZE	-0.0009***	-0.0003*	-0.0325***
	(0.0012)	(0.0002)	(0.0082)
BHC	0.0748***	0.0060***	0.1720**
	(0.0091)	(0.0017)	(0.0822)
PCAU	-0.0506***	0.0001	0.0689
	(0.0185)	(0.0015)	(0.0709)
ΔCAP		-0.0001	0.0052
		(0.0002)	(0.0100)
ΔON	0.1888		-1.5416
	(0.1944)		(1.1946)
ΔOFF	0.0033	0.0016***	
	(0.0032)	(0.0004)	
ROA	0.8673***		
	(0.0326)		
CAP_{t-1}	-0.9923***		
	(0.0108)		
PCAU* CAP_{t-1}	-0.4434***		
	(0.1023)		
ON_{t-1}		-0.3557***	
		(0.0092)	
OFF_{t-1}			-0.3973***
			(0.0093)
LOANG			-0.2475***
			(0.0172)
Constant	3.05e-06	2.30e-06	0.00003
	(0.0003)	(0.00004)	(0.0020)
R^2	0.9873	0.2177	0.2916

*** Significant at the 0.01 level
** Significant at the 0.05 level
* Significant at the 0.10 level

Table 3-15: Three-Stage Least Squares Estimates from Equations (16), (17), and (18) with Total Risk-Based Capital Ratio

Variable	ΔCAP	ΔON	ΔOFF
SIZE	-0.0091***	-0.0003*	-0.0325***
	(0.0012)	(0.0002)	(0.0083)
BHC	0.0748***	0.0062***	0.1722*
	(0.0125)	(0.0017)	(0.0822)
PCAU	-0.0503***	0.0001	0.0689
	(0.0186)	(0.0015)	(0.0709)
ΔCAP		-0.0001	0.0052
		(0.0002)	(0.0100)
ΔON	0.1896		-1.4932
	(0.1944)		(1.1946)
ΔOFF	0.0033	0.0019***	
	(0.0032)	(0.0005)	
ROA	0.8682***		
	(0.0326)		
CAP_{t-1}	-0.9923***		
	(0.0015)		
PCAU* CAP_{t-1}	-0.4455***		
	(0.1023)		
ON_{t-1}		-0.3546***	
		(0.0093)	
OFF_{t-1}			-0.3974***
			(0.0093)
LOANG		0.0006	-0.2469***
		(0.0004)	(0.0172)
Constant	3.05e-06	2.37e-06	0.00003
	(0.0003)	(0.00004)	(0.0020)
R^2	0.9873	0.2177	0.2917

*** Significant at the 0.01 level
** Significant at the 0.05 level
* Significant at the 0.10 level

The basic results with total risk-based capital ratio are the same as those with book value capital ratio. Regarding endogenous variables, change in capital (ΔCAP) and change in off-balance sheet credit risk (ΔOFF) also have a positive relationship although the relationship is insignificant under total risk-based capital ratio. Moreover, the robustness checks confirm that change in capital (ΔCAP) and change in on-balance sheet

credit risk (ΔON) have no significant relationship with each other and that change in off-balance sheet credit risk (ΔOFF) has significant and positive impact on change in on-balance sheet credit risk (ΔON) but change in on-balance sheet credit risk (ΔON) does not affect change in off-balance sheet credit risk (ΔOFF).

Furthermore, similar to the results with book value capital ratio, regulatory pressure (PCAU) does not have significant impact on change in on-balance sheet credit risk (ΔON) and the interaction term between PCAU and lagged CAP (PCAU* CAP_{t-1}) is significant and negative as expected. Thus, capital standards induce undercapitalized banks to have higher speed of capital adjustment than adequately capitalized banks. However, unlike the results with book value capital ratio, PCAU is negatively related to change in capital (ΔCAP) and insignificant to change in off-balance sheet credit risk (ΔOFF). Therefore, the results with total risk-based capital ratio also confirm that capital standards are ineffective in that regulatory pressure induces undercapitalized banks to decrease total risk-based capital ratios and has no impact on both on- and off-balance sheet credit risk. Further, with minimum capital requirements, undercapitalized banks increase book value capital ratio while decreasing total risk-based capital ratio. This indicates that an increase in capital ratio that is derived from balance sheet does not necessarily lead to an increase in risk-based capital ratio. Therefore, undercapitalized banks that are able to increase equity capital may not have adequate capital associated with their portfolio risk.

Additionally, the results of other variables with total risk-based capital ratio that are the same as those with book value capital ratio are as follows. Coefficients of lagged levels (CAP_{t-1}, ON_{t-1}, and OFF_{t-1}) are significant and negative as expected and coefficient

of return on assets (ROA) is significant and positive as expected. In addition, bank size (SIZE) is negatively related to both ΔON and ΔOFF and bank holding company status (BHC) is also positively related to both ΔON and ΔOFF. Moreover, the robustness checks also confirm that loan growth (LOANG) has significant and negative impact on ΔOFF but has a positive effect on ΔON. Although the relationship between loan growth and change in on-balance sheet credit risk is statistically insignificant under total risk-based capital ratio, this positive relationship has economic meaning. Loan growth leads to an increase in on-balance sheet credit risk; therefore, banks recognize higher loan loss allowance. However, SIZE and BHC have significant impact on ΔCAP under total risk-based capital ratio while they do not have such impact under book value capital ratio.

With respect to tier 1 risk-based capital ratio and tier 1 leverage ratio, the Hausman tests fail to show that the systems of simultaneous equations of (13), (14) and (15) and of (16), (17) and (18) are correctly specified since p-value is zero. Tables 3-16 and 3-17 indicate the results from simultaneous equations of (13), (14) and (15) regarding tier 1 risk-based capital ratio and tier 1 leverage ratio, respectively.

Table 3-16: Three-Stage Least Squares Estimates from Equations (13), (14), and (15) with Tier 1 Risk-Based Capital Ratio

Variable	ΔCAP	ΔON	ΔOFF
SIZE	-0.0103***	-0.0003*	-0.0322***
	(0.0012)	(0.0002)	(0.0082)
BHC	0.0518***	0.0060***	0.1704**
	(0.0124)	(0.0017)	(0.0822)
PCAU	-0.0296	0.0001	0.0684
	(0.0183)	(0.0015)	(0.0709)
ΔCAP		-0.0001	0.0063
		(0.0002)	(0.0107)
ΔON	0.6250***		-1.4837
	(0.1928)		(1.1932)
ΔOFF	0.0046	0.0016***	
	(0.0032)	(0.0004)	
ROA	0.8503***		
	(0.0323)		
CAP_{t-1}	-0.9914***		
	(0.0016)		
PCAU* CAP_{t-1}	-0.5964***		
	(0.1083)		
ON_{t-1}		-0.3560***	
		(0.0092)	
OFF_{t-1}			-0.3964***
			(0.0093)
LOANG			-0.2512***
			(0.0172)
Constant	-2.65e-06	2.30e-06	0.00003
	(0.0003)	(0.00004)	(0.0020)
R^2	0.9857	0.2177	0.2918

*** Significant at the 0.01 level
** Significant at the 0.05 level
* Significant at the 0.10 level

Table 3-17: Three-Stage Least Squares Estimates from Equations (13), (14), and (15) with Tier 1 Leverage Ratio

Variable	ΔCAP	ΔON	ΔOFF
SIZE	-0.0070***	-0.0003*	-0.0317***
	(0.0009)	(0.0002)	(0.0082)
BHC	0.0023	0.0060***	0.1666**
	(0.0091)	(0.0017)	(0.0822)
PCAU	0.0222	0.0001	0.0671
	(0.0152)	(0.0015)	(0.0709)
ΔCAP		-0.0001	0.0036
		(0.0004)	(0.0173)
ΔON	-0.0310		-1.5090
	(0.1417)		(1.1867)
ΔOFF	-0.0092***	0.0015***	
	(0.0023)	(0.0004)	
ROA	0.4341***		
	(0.0237)		
CAP_{t-1}	-0.9873***		
	(0.0019)		
PCAU* CAP_{t-1}	-0.8480***		
	(0.1004)		
ON_{t-1}		-0.3556***	
		(0.0092)	
OFF_{t-1}			-0.3944***
			(0.0092)
LOANG			-0.2591***
			(0.0172)
Constant	-1.35e-06	2.28e-06	0.00003
	(0.0002)	(0.00004)	(0.0020)
R^2	0.9797	0.2177	0.2916

*** Significant at the 0.01 level
** Significant at the 0.05 level
* Significant at the 0.10 level

Furthermore, tables 3-18 and 3-19 indicate the results from simultaneous equations of (16), (17) and (18) regarding tier 1 risk-based capital ratio and tier 1 leverage ratio, respectively.

Table 3-18: Three-Stage Least Squares Estimates from Equations (16), (17), and (18) with Tier 1 Risk-Based Capital Ratio

Variable	ΔCAP	ΔON	ΔOFF
SIZE	-0.0103***	-0.0003*	-0.0322***
	(0.0012)	(0.0002)	(0.0083)
BHC	0.0517***	0.0061***	0.1705**
	(0.0124)	(0.0017)	(0.0822)
PCAU	-0.0292	0.0001	0.0683
	(0.0183)	(0.0015)	(0.0709)
ΔCAP		-0.0001	0.0063
		(0.0002)	(0.0107)
ΔON	0.6253***		-1.4314
	(0.1928)		(1.1932)
ΔOFF	0.0046	0.0017***	
	(0.0032)	(0.0005)	
ROA	0.8511***		
	(0.0323)		
CAP_{t-1}	-0.9914***		
	(0.0016)		
PCAU* CAP_{t-1}	-0.5988***		
	(0.1083)		
ON_{t-1}		-0.3555***	
		(0.0093)	
OFF_{t-1}			-0.3964***
			(0.0093)
LOANG		0.0003	-0.2510***
		(0.0004)	(0.0172)
Constant	-2.65e-06	2.34e-06	0.00003
	(0.0003)	(0.00004)	(0.0020)
R^2	0.9857	0.2178	0.2919

*** Significant at the 0.01 level
** Significant at the 0.05 level
* Significant at the 0.10 level

Table 3-19: Three-Stage Least Squares Estimates from Equations (16), (17), and (18) with Tier 1 Leverage Ratio

Variable	ΔCAP	ΔON	ΔOFF
SIZE	-0.0070***	-0.0003**	-0.0317***
	(0.0009)	(0.0002)	(0.0082)
BHC	0.0023	0.0062***	0.1669**
	(0.0124)	(0.0017)	(0.0822)
PCAU	0.0222	0.0001	0.0671
	(0.0152)	(0.0015)	(0.0709)
ΔCAP		-0.00005	0.0036
		(0.0004)	(0.0173)
ΔON	-0.0310		-1.4538
	(0.1417)		(1.1868)
ΔOFF	-0.0092***	0.0019***	
	(0.0023)	(0.0005)	
ROA	0.4340***		
	(0.0237)		
CAP_{t-1}	-0.9873***		
	(0.0019)		
PCAU* CAP_{t-1}	-0.8477***		
	(0.1004)		
ON_{t-1}		-0.3544***	
		(0.0093)	
OFF_{t-1}			-0.3946***
			(0.0092)
LOANG		0.0007*	-0.2583***
		(0.0004)	(0.0172)
Constant	-1.34e-06	2.35e-06	0.00003
	(0.0003)	(0.00004)	(0.0020)
R^2	0.9797	0.2178	0.2917

*** Significant at the 0.01 level
** Significant at the 0.05 level
* Significant at the 0.10 level

By comparing tables 3-16 and 3-17 to table 3-14 (with total risk-based capital ratios) and tables 3-18 and 3-19 to table 3-15 (with total risk-based capital ratios), the signs of coefficients and significance levels are the same for most of variables; nevertheless, as discussed earlier, models with tier 1 risk-based capital ratio and tier 1 leverage capital ratio are not correctly specified under Hausman tests.

CHAPTER 4

FURTHER EXAMINATION

1. Alternative Model

Regarding the simultaneous equations model of (13), (14) and (15) and of (16), (17) and (18), lagged value of off-balance sheet credit risk (OFF_{t-1}) is included only in ΔOFF equation. However, securitization may also have exogenous impact on ΔCAP and ΔON variables. Therefore, to capture those effects, OFF_{t-1} variable is included in both ΔCAP and ΔON equations. Therefore, this alternative model has OFF_{t-1} in all three simultaneous equations. The simultaneous equations model of (13), (14) and (15) is changed to the following.

$$\Delta CAP_{j,t} = a_0 + a_1 SIZE_{j,t} + a_2 BHC_{j,t} + a_3 PCAU_{j,t} + a_4 \Delta ON_{j,t} + a_5 \Delta OFF_{j,t} + a_6 ROA_{j,t} + a_7 CAP_{j,t-1} + a_8 PCAU_{j,t} * CAP_{j,t-1} + a_9 OFF_{j,t-1} + E_{j,t} \quad (19)$$

$$\Delta ON_{j,t} = b_0 + b_1 SIZE_{j,t} + b_2 BHC_{j,t} + b_3 PCAU_{j,t} + b_4 \Delta CAP_{j,t} + b_5 \Delta OFF_{j,t} + b_6 ON_{j,t-1} + b_7 OFF_{j,t-1} + U_{j,t} \quad (20)$$

$$\Delta OFF_{j,t} = c_0 + c_1 SIZE_{j,t} + c_2 BHC_{j,t} + c_3 PCAU_{j,t} + c_4 \Delta CAP_{j,t} + c_5 \Delta ON_{j,t} + c_6 OFF_{j,t-1} + c_7 LOANG_{j,t} + V_{j,t} \quad (21)$$

The results of these three simultaneous equations are shown in table 4-1. Lagged value of off-balance sheet credit risk (OFF_{t-1}) has significant impact on all of three endogenous variables. However, under the Hausman test of simultaneous equations (19), (20), and (21), the chi-square with degree of freedom of 9 is 300.09 and p-value is zero, leading to rejecting the null hypothesis. Therefore, the model with OFF_{t-1} in all three equations is incorrectly specified and is not the preferred model.

Table 4-1: Three-Stage Least Squares Estimates from Equations (19), (20), and (21) with the Ratio of Equity Capital to Total Assets

Variable	ΔCAP	ΔON	ΔOFF
SIZE	0.0030***	-0.0005***	-0.0281***
	(0.0011)	(0.0002)	(0.0081)
BHC	-0.0133	0.0071***	0.1439*
	(0.0105)	(0.0018)	(0.0810)
PCAU	0.0402**	0.0022	0.2448***
	(0.0167)	(0.0016)	(0.0718)
ΔCAP		0.0212***	2.3074***
		(0.0058)	(0.2160)
ΔON	0.1875		-2.0442*
	(0.1444)		(1.0844)
ΔOFF	0.0771***	-0.0044***	
	(0.0089)	(0.0017)	
ROA	0.1471***		
	(0.0233)		
CAP_{t-1}	-0.2842***		
	(0.0128)		
PCAU* CAP_{t-1}	-0.9351***		
	(0.1063)		
ON_{t-1}		-0.3516***	
		(0.0095)	
OFF_{t-1}	0.0248***	-0.0024***	-0.3790***
	(0.0038)	(0.0007)	(0.0092)
LOANG			-0.1984***
			(0.0183)
Constant	0.0001	-2.84e-08	-0.0003
	(0.0002)	(0.00004)	(0.0019)
R^2	0.0012	0.1573	0.2959

*** Significant at the 0.01 level
** Significant at the 0.05 level
* Significant at the 0.10 level

Next, the simultaneous equations model of (16), (17) and (18) that includes OFF_{t-1} in all three equations is changed to the following.

$$\Delta CAP_{j,t} = a_0 + a_1 SIZE_{j,t} + a_2 BHC_{j,t} + a_3 PCAU_{j,t} + a_4 \Delta ON_{j,t} + a_5 \Delta OFF_{j,t} + a_6 ROA_{j,t} + a_7 CAP_{j,t-1} + a_8 PCAU_{j,t} * CAP_{j,t-1} + a_9 OFF_{j,t-1} + E_{j,t} \quad (22)$$

$$\Delta ON_{j,t} = b_0 + b_1 SIZE_{j,t} + b_2 BHC_{j,t} + b_3 PCAU_{j,t} + b_4 \Delta CAP_{j,t} + b_5 \Delta OFF_{j,t} + b_6 ON_{j,t-1} + b_7 OFF_{j,t-1} + b_8 LOANG_{j,t} + U_{j,t} \quad (23)$$

$$\Delta OFF_{j,t} = c_0 + c_1 SIZE_{j,t} + c_2 BHC_{j,t} + c_3 PCAU_{j,t} + c_4 \Delta CAP_{j,t} + c_5 \Delta ON_{j,t} + c_6 OFF_{j,t-1} + c_7 LOANG_{j,t} + V_{j,t} \quad (24)$$

The results of these three simultaneous equations are shown in table 4-2. Similar to table 4-1, lagged value of off-balance sheet credit risk (OFF_{t-1}) show the same signs and has significant impact on all of three endogenous variables. Nevertheless, the results of Hausman test of simultaneous equations (22), (23), and (24) also indicate model misspecification. The chi-square with degree of freedom of 9 is 357.36 and the p-value is zero. Therefore, this model with OFF_{t-1} in all three equations is also not the preferred model.

Table 4-2: Three-Stage Least Squares Estimates from Equations (22), (23), and (24) with the Ratio of Equity Capital to Total Assets

Variable	ΔCAP	ΔON	ΔOFF
SIZE	0.0030***	-0.0011***	-0.0285***
	(0.0011)	(0.0003)	(0.0081)
BHC	-0.0135	0.0100***	0.1474*
	(0.0105)	(0.0022)	(0.0810)
PCAU	0.0413**	0.0060***	0.2499***
	(0.0168)	(0.0019)	(0.0718)
ΔCAP		0.0512***	2.2369***
		(0.0074)	(0.2161)
ΔON	0.4407***		-5.6048***
	(0.1429)		(1.0468)
ΔOFF	0.0765***	-0.0261***	
	(0.0089)	(0.0047)	
ROA	0.1498***		
	(0.0233)		
CAP_{t-1}	-0.2865***		
	(0.0128)		
PCAU* CAP_{t-1}	-0.9484***		
	(0.1063)		
ON_{t-1}		-0.3270***	
		(0.0106)	
OFF_{t-1}	0.0250***	-0.0108***	-0.3846***
	(0.0038)	(0.0018)	(0.0092)
LOANG		-0.0051***	-0.2006***
		(0.0011)	(0.0183)
Constant	0.0001	-3.48e-06	-0.0003
	(0.0002)	(0.00004)	(0.0019)
R^2	-0.0032[2]	-1.0748[2]	0.2794

*** Significant at the 0.01 level
** Significant at the 0.05 level
* Significant at the 0.10 level

In sum, although lagged value of off-balance sheet credit risk (OFF_{t-1}) is highly significant to in all three simultaneous equations, the Hausman tests show that those two

[2] Negative R-squared statistic is possible for instrument variable estimators. Since R-squared statistic is the ratio of the difference between total sum of squares and residual (error) sum of square over total sum of squares, negative R-squared statistic occurs when residual sum of square is more than total sum of squares.

models of simultaneous equations of (19), (20), and (21) and of (22), (23), and (24) are incorrectly specified.

However, the following model has OFF_{t-1} in all three equations and is correctly specified under the Hausman test. This alternative model is adapted from the previous model of simultaneous equations (22), (23), and (24) by including the ratio of deposit to total assets (DEP) in ΔON and ΔOFF equations and using only the ratio of non-performing loans to total assets (NPL) as an instrument. Therefore, the alternative model is as follows.

$$\Delta CAP_{j,t} = a_0 + a_1 SIZE_{j,t} + a_2 BHC_{j,t} + a_3 PCAU_{j,t} + a_4 \Delta ON_{j,t} + a_5 \Delta OFF_{j,t} + a_6 ROA_{j,t} + a_7 CAP_{j,t-1} + a_8 PCAU_{j,t} * CAP_{j,t-1} + a_9 OFF_{j,t-1} + E_{j,t} \quad (25)$$

$$\Delta ON_{j,t} = b_0 + b_1 SIZE_{j,t} + b_2 BHC_{j,t} + b_3 PCAU_{j,t} + b_4 \Delta CAP_{j,t} + b_5 \Delta OFF_{j,t} + b_6 ON_{j,t-1} + b_7 OFF_{j,t-1} + b_8 LOANG_{j,t} + b_9 DEP_{j,t} + U_{j,t} \quad (26)$$

$$\Delta OFF_{j,t} = c_0 + c_1 SIZE_{j,t} + c_2 BHC_{j,t} + c_3 PCAU_{j,t} + c_4 \Delta CAP_{j,t} + c_5 \Delta ON_{j,t} + c_6 OFF_{j,t-1} + c_7 LOANG_{j,t} + c_8 DEP_{j,t} + V_{j,t} \quad (27)$$

As can be seen in table 4-3, the results of the Hausman tests of simultaneous equations (25), (26), and (27) fail to reject the null hypothesis under all types of capital ratios although the result with the ratio of equity capital to total assets fails to reject at the 1% level. Therefore, this model is correctly specified.

Table 4-3: The Results of Hausman Tests of Simultaneous Equations (25), (26), and (27)

Capital Ratios	Chi-Square with degree of freedom of 9	P-Value
Equity capital to total assets	20.30	0.0162
Total risk-based capital ratio	7.49	0.5864
Tier 1 risk-based capital ratio	8.15	0.5193
Tier 1 leverage ratio	9.58	0.3858

The statements of hypotheses are the same as previously discussed in chapter 3. However, there are two more hypotheses since OFF_{t-1} and DEP_t variables are added. First, the signs of OFF_{t-1} in ΔCAP, ΔON and ΔOFF equations are expected to be negative if banks use securitization to transfer credit risk. Banks with more securitization are able to not only reduce both on- and off-balance sheet credit risk but also decrease capital due to a decrease in credit risk. Second, the coefficient of DEP in ΔON equation is expected to be positive since more deposits enable banks to lend more and thus, banks increase on-balance sheet credit risk and recognize higher amount of loan loss allowance associated with those loans. However, the coefficient of DEP in ΔOFF equation is expected to be negative because banks with more securitization have funding source for lending and therefore, do not depend on deposits as much as traditional banks.

Table 4-4 shows the results of model of simultaneous equations (25), (26), and (27) when using the ratio of equity capital to total assets ratio.

Table 4-4: Three-Stage Least Squares Estimates from Equations (25), (26), and (27) with the Ratio of Equity Capital to Total Assets

Variable	ΔCAP	ΔON	ΔOFF
SIZE	0.0031***	-0.0057***	-0.0377***
	(0.0011)	(0.0009)	(0.0083)
BHC	-0.0143	0.0248***	0.0733
	(0.0105)	(0.0089)	(0.0819)
PCAU	0.0482**	0.0334***	0.2319***
	(0.0167)	(0.0076)	(0.0718)
ΔCAP		0.2632***	1.7333***
		(0.0299)	(0.2376)
ΔON	0.3557**		-3.4272***
	(0.1488)		(0.9684)
ΔOFF	0.0765***	-0.1664***	
	(0.0090)	(0.0127)	
ROA	0.1565***		
	(0.0233)		
CAP_{t-1}	-0.3060***		
	(0.0133)		
PCAU* CAP_{t-1}	-1.0010***		
	(0.1056)		
ON_{t-1}		-0.2146***	
		(0.0332)	
OFF_{t-1}	0.0250***	-0.0647***	-0.3864***
	(0.0038)	(0.0049)	(0.0093)
LOANG		-0.0358***	-0.2183***
		(0.0033)	(0.0186)
DEP		-0.0134***	-0.2255***
		(0.0045)	(0.0388)
Constant	0.0001	-0.00003	-0.0002
	(0.0002)	(0.0002)	(0.0019)
R^2	0.0005	-47.8156[2]	0.2894

*** Significant at the 0.01 level
** Significant at the 0.05 level
* Significant at the 0.10 level

From table 4-4, the coefficients of all three endogenous variables are significant as expected. Therefore, banks simultaneously determine change in capital and on- and off-balance sheet credit risk. The variables ΔCAP and ΔOFF have a significant and

positive relationship. Banks with an increased capital take more off-balance sheet credit risk or get more involved in securitization. Likewise, banks that securitize more loans increase capital at the same time. Moreover, the variables ΔCAP and ΔON also have a significant and positive relationship. Banks with increased capital are able to recognize higher loan loss allowance or take more on-balance sheet credit risk. Similarly, banks with more on-balance sheet credit risk increase capital in order to absorb losses arising from credit risk. In addition, the variables ΔON and ΔOFF have a significant and negative relationship. Banks that securitize low credit loans have high credit risk loans on balance sheet. In contrast, banks that securitize high credit loans have low credit risk loans on balance sheet. However, the former evidence supports capital arbitrage since banks increase on-balance sheet credit risk while having the same amount of capital and still conforming to the minimum capital requirements.

Next, with respect to the effectiveness of capital standards, regulatory pressure (PCAU) is significant in all three equations. The regulatory pressure induces undercapitalized banks to increase capital as expected; however, it induces undercapitalized banks to take more credit risk, which is undesirable. They may expect higher returns from higher risk-taking to replenish capital. Moreover, an increase in capital may create incentive to take more risk since more capital means more cushion to absorb losses. Nevertheless, interaction term between PCAU and lagged CAP (PCAU* CAP_{t-1}) is significant and negative as expected. Undercapitalized banks have a higher speed of capital adjustment than adequately capitalized banks. This is desirable effect under capital standards. All in all, capital standards are effective in the sense that they induce undercapitalized banks to increase capital and adjust capital faster than adequately

capitalized banks; however, capital standards are not effective in that they induce undercapitalized banks to take more credit risk.

In addition, regarding the lagged levels of endogenous variables, CAP_{t-1} in ΔCAP equation, ON_{t-1} in ΔON equation, and OFF_{t-1} in ΔOFF equation are all negative as expected, meaning that banks adjust capital and on- and off-balance sheet credit risk to their target levels. Moreover, lagged value of off-balance sheet credit risk (OFF_{t-1}) has significant impact on all of three endogenous variables. The coefficients of OFF_{t-1} in ΔON and ΔOFF equations are negative as expected. If banks use securitization to transfer credit risk, they are able to decrease both on- and off-balance sheet credit risk. However, the coefficient of OFF_{t-1} in ΔCAP equation has unexpected positive sign. Banks with higher securitization transactions in previous period tend to increase capital in current period. On the one hand, this could be that banks with securitization reduce loans on balance sheet and hence, total assets. As book value capital ratio is defined as the ratio of equity capital to total assets, a decrease in total assets (the denominator) results in an increase in book value capital ratio while banks still have the same amount of equity capital (the numerator). On the other hand, this could also be that securitization enables banks to recognize gains at the time of loan sales and earn service fee, leading to an increase in revenue, profit, and capital. Moreover, as discussed in the introduction, banks move toward originate-to-distribute model since securitization is the new revenue generating source in banking competitive business. Therefore, banks with securitization increase capital more than the offset to reduce capital due to a decreased credit risk.

Furthermore, the coefficients of loan growth (LOANG) have unexpected negative sign in both ΔON and ΔOFF equations. With higher loan growth, banks recognize

smaller on-balance sheet credit risk or loan loss allowance, leading to overstated ability of capital to absorb unexpected losses during economic downturns. Moreover, loan growth is expected to increase securitization; however, the results show a decrease in securitization. As previously discussed, banks may not securitize loans right after loans originations. Additionally, this could be possible that since off-balance sheet credit risk (OFF) is measured as the ratio of total amount of securitization to total assets, loan growth increase total assets (the denominator) more than an increase in securitization amount (the numerator). Thus, banks may not securitize all of originated loans. In other words, banks keep some loans on balance sheets.

Next, the coefficient of the ratio of deposits to total assets (DEP) has unexpected negative sign in ΔON equation. Banks that have more deposits are able to provide more loans but recognize less loan loss allowance. Similar to the result of loan growth, owing to understated loan loss allowance, banks may not have adequate capital or buffer to absorb unexpected losses. However, the coefficient of DEP in ΔOFF equation is negative as expected. Banks with securitization are able to provide more loans by depending on deposits less than without securitization.

With respect to other variables, return on assets (ROA) in ΔCAP equation is positive as expected. More profits replenish bank capital. Bank size (SIZE) is also significant in all three equations. Larger banks have more access to capital and also are able to reduce on- and off-balance sheet credit risk due to risk diversification. Finally, bank holding company dummy variable (BHC) is significant only in ΔON equation. Bank holding companies are able to absorb expected credit losses from on-balance sheet loans

more than commercial banks. Nevertheless, bank holding companies and commercial banks have no difference in changing capital and off-balance sheet credit risk.

The tables below check the robustness of the results from table 4-4. Tables 4-5, 4-6, and 4-7 are the results by using total risk-based capital ratio, tier 1 risk-based capital ratio, and tier 1 leverage ratio, respectively. The basic results from tables 4-5 and 4-6 are the same as table 4-4 but the results from table 4-7 are different from the other three in some variables.

Regarding tables 4-5 and 4-6, change in on-balance sheet credit risk (ΔON) and change in off-balance sheet credit risk (ΔOFF) are simultaneously determined and positively related. Although ΔCAP variable in ΔON and ΔOFF equations are insignificant, they have the same positive sign as in table 4-4, showing economic meaning of these variables. Therefore, the results confirm that the relationships between ΔCAP and ΔON and between ΔCAP and ΔOFF are positive.

Next, with respect to regulatory pressure, PCAU is also positively related to ΔON and ΔOFF variables. However, while PCAU is positive in ΔCAP equation when using book value capital ratio, it is negative when using total risk-based capital ratio and tier 1 risk-based capital ratio. Although undercapitalized banks increase book value capital ratio, they decrease risk-based capital ratios. An increase in book value capital ratio does not necessarily increase risk-based capital ratios. Thus, capital standards are not effective in that on-balance sheet equity capital may be insufficient to absorb unexpected losses from bank risk. However, the speed of capital adjustment term (PCAU* CAP_{t-1}) is negative as expected.

Table 4-5: Three-Stage Least Squares Estimates from Equations (25), (26), and (27) with Total Risk-Based Capital Ratio

Variable	ΔCAP	ΔON	ΔOFF
SIZE	-0.0047***	-0.0068***	-0.0409***
	(0.0015)	(0.0010)	(0.0084)
BHC	0.0486***	0.0271***	0.0752
	(0.0144)	(0.0091)	(0.0833)
PCAU	-0.0567***	0.0151**	0.0992
	(0.0195)	(0.0074)	(0.0711)
ΔCAP		0.0010	0.0060
		(0.0010)	(0.0100)
ΔON	1.1124***		-2.1446*
	(0.2155)		(1.1231)
ΔOFF	0.0895***	-0.1812***	
	(0.0115)	(0.0137)	
ROA	0.8890***		
	(0.0325)		
CAP_{t-1}	-0.9918***		
	(0.0017)		
PCAU* CAP_{t-1}	-0.4716***		
	(0.1020)		
ON_{t-1}		-0.2428***	
		(0.0366)	
OFF_{t-1}	0.0416***	-0.0723***	-0.3966***
	(0.0050)	(0.0054)	(0.0092)
LOANG		-0.0486***	-0.2794***
		(0.0040)	(0.0172)
DEP		-0.0217***	-0.2573***
		(0.0041)	(0.0387)
Constant	-3.51e-06	6.20e-06	-0.00002
	(0.0003)	(0.0002)	(0.0020)
R^2	0.9838	-58.0312[2]	0.2812

*** Significant at the 0.01 level
** Significant at the 0.05 level
* Significant at the 0.10 level

Table 4-6: Three-Stage Least Squares Estimates from Equations (25), (26), and (27) with Tier 1 Risk-Based Capital Ratio

Variable	ΔCAP	ΔON	ΔOFF
SIZE	-0.0061***	-0.0070***	-0.0406***
	(0.0015)	(0.0010)	(0.0084)
BHC	0.0272*	0.0276***	0.0782
	(0.0143)	(0.0096)	(0.0833)
PCAU	-0.0281	0.0157**	0.0990
	(0.0192)	(0.0077)	(0.0711)
ΔCAP		0.0012	0.0071
		(0.0012)	(0.0107)
ΔON	1.5442***		-2.3334**
	(0.2137)		(1.1044)
ΔOFF	0.0845***	-0.1879***	
	(0.0114)	(0.0147)	
ROA	0.8885***		
	(0.0323)		
CAP_{t-1}	-0.9908***		
	(0.0018)		
PCAU* CAP_{t-1}	-0.6738***		
	(0.1081)		
ON_{t-1}		-0.2314***	
		(0.0374)	
OFF_{t-1}	0.0388***	-0.0750***	-0.3969***
	(0.0050)	(0.0058)	(0.0092)
LOANG		-0.0504***	-0.2785***
		(0.0042)	(0.0172)
DEP		-0.0228***	-0.2497***
		(0.0043)	(0.0390)
Constant	-8.84e-06	6.21e-06	0.00002
	(0.0003)	(0.0002)	(0.0020)
R^2	0.9817	-62.3625[2]	0.2809

*** Significant at the 0.01 level
** Significant at the 0.05 level
* Significant at the 0.10 level

In addition, similar to the results with book value capital ratio, lagged levels of all three endogenous variables (CAP_{t-1}, ON_{t-1}, and OFF_{t-1}) are negative and return on assets (ROA) is positive as expected. Moreover, lagged level of off-balance sheet credit risk

(OFF_{t-1}) is also positive to ΔCAP variable and negative to ΔON variable. Loan growth (LOANG) and deposits-to-assets ratio (DEP) are also negative to both ΔON and ΔOFF variables. Besides, bank size (SIZE) has significant and negative relationship to both ΔON and ΔOFF variables and bank holding company status (BHC) has significant and positive relationship to ΔON variable and is insignificant to ΔOFF variable. However, unlike the results with book value capital ratio in table 4-4, SIZE in ΔCAP equation is negative. This could be that larger banks are able to increase book value capital ratio shown on balance sheets but lower risk-based capital ratios. In addition, BHC in ΔCAP equation in tables 4-5 and 4-6 becomes significant, meaning that bank holding companies are able to increase total and tier 1 risk-based capital ratios more than commercial banks. Bank holding companies may have better risk management so that they can increase total and tier 1 risk-based capital ratios.

Regarding table 4-7, unlike the results from tables 4-4, 4-5, and 4-6, the coefficients of DEP are positive in both ΔON and ΔOFF equations. The variable DEP in ΔON equation is positive as expected. Banks with increased deposit ratio are able to lend more and recognize credit losses from those loans. However, the variable DEP in ΔOFF equation is positive, which is not expected.

Table 4-7: Three-Stage Least Squares Estimates from Equations (25), (26), and (27) with Tier 1 Leverage Ratio

Variable	ΔCAP	ΔON	ΔOFF
SIZE	-0.0090***	-0.0040***	-0.0165**
	(0.0011)	(0.0010)	(0.0084)
BHC	0.0136	0.0515***	0.3281
	(0.0104)	(0.0097)	(0.0833)
PCAU	0.0400**	0.0066	0.0228
	(0.015)	(0.0079)	(0.0711)
ΔCAP		0.0002	0.0001
		(0.0019)	(0.0173)
ΔON	0.1088		-3.6625***
	(0.1541)		(1.0925)
ΔOFF	-0.0529***	-0.1752***	
	(0.0083)	(0.0147)	
ROA	0.4471***		
	(0.0237)		
CAP_{t-1}	-0.9877***		
	(0.0021)		
PCAU* CAP_{t-1}	-0.9551***		
	(0.1006)		
ON_{t-1}		-0.1844***	
		(0.0375)	
OFF_{t-1}	-0.0188***	-0.0670***	-0.3981***
	(0.0036)	(0.0058)	(0.0092)
LOANG		-0.0415***	-0.2257***
		(0.0043)	(0.0172)
DEP		0.0515***	0.4405***
		(0.0045)	(0.0394)
Constant	1.24e-06	7.30e-06	0.00004
	(0.0002)	(0.0002)	(0.0020)
R^2	0.9750	-54.2459[2]	0.2762

*** Significant at the 0.01 level
** Significant at the 0.05 level
* Significant at the 0.10 level

In sum, the robustness checks by using the other three types of capital ratios indicates that the basic results are the same as using book value capital ratio.

2. Reduced Form Model

The above results of the structural form equations show the partial effects of exogenous variables on endogenous variables. However, in order to see the direct effects of all exogenous variables on endogenous variables, the model in reduced form is applied. The reduced form model is the model in which only exogenous variables are on the right-hand side. Furthermore, to test whether the instruments are correlated with the endogenous variables, both DEP and NPL variables are also included on the right-hand side in all three equations. Since the Hausman test examines whether the instruments are uncorrelated with error terms, the reduced form directly tests whether the instruments are correlated with the endogenous variables. The reduced from model of simultaneous equations (13), (14) and (15) and of (16), (17) and (18) is the same and shows as follows.

$$\begin{aligned}\Delta CAP_{j,t} = {} & a_0 + a_1 SIZE_{j,t} + a_2 BHC_{j,t} + a_3 PCAU_{j,t} + a_4 ROA_{j,t} + a_5 CAP_{j,t-1} \\ & + a_6 PCAU_{j,t} * CAP_{j,t-1} + a_7 ON_{j,t-1} + a_8 OFF_{j,t-1} + a_9 LOANG_{j,t} \\ & + a_{10} NPL_{j,t} + a_{11} DEP_{j,t} + E_{j,t} \end{aligned} \quad (28)$$

$$\begin{aligned}\Delta ON_{j,t} = {} & b_0 + b_1 SIZE_{j,t} + b_2 BHC_{j,t} + b_3 PCAU_{j,t} + b_4 ROA_{j,t} + b_5 CAP_{j,t-1} \\ & + b_6 PCAU_{j,t} * CAP_{j,t-1} + b_7 ON_{j,t-1} + b_8 OFF_{j,t-1} + b_9 LOANG_{j,t} \\ & + b_{10} NPL_{j,t} + b_{11} DEP_{j,t} + U_{j,t} \end{aligned} \quad (29)$$

$$\begin{aligned}\Delta OFF_{j,t} = {} & c_0 + c_1 SIZE_{j,t} + c_2 BHC_{j,t} + c_3 PCAU_{j,t} + c_4 ROA_{j,t} + c_5 CAP_{j,t-1} \\ & + c_6 PCAU_{j,t} * CAP_{j,t-1} + c_7 ON_{j,t-1} + c_8 OFF_{j,t-1} + c_9 LOANG_{j,t} \\ & + c_{10} NPL_{j,t} + c_{11} DEP_{j,t} + V_{j,t} \end{aligned} \quad (30)$$

The reduced form model is seeming unrelated regression (SUR) where error terms of all three equations are correlated. The STATA command to run this model is "sureg". The results of the reduced form model show in table 4-8.

Table 4-8: Seeming Unrelated Regression Estimates from Equations (28), (29), and (30)

Variable	ΔCAP	ΔON	ΔOFF
SIZE	-0.0024***	-0.0006***	-0.0251***
	(0.0009)	(0.0002)	(0.0084)
BHC	-0.0366***	0.0075***	0.1727**
	(0.0091)	(0.0017)	(0.0836)
PCAU	0.0840***	-0.0330***	0.2844*
	(0.0166)	(0.0031)	(0.1527)
ROA	0.1498***	-0.0331***	0.5318**
	(0.0227)	(0.0043)	(0.2086)
CAP_{t-1}	-0.3845***	-0.0056***	-0.4900***
	(0.0107)	(0.0020)	(0.0980)
PCAU* CAP_{t-1}	-1.1497***	0.1936***	-1.8586*
	(0.1073)	(0.0203)	(0.9861)
ON_{t-1}	-0.0612	-0.3863***	0.0271
	(0.0499)	(0.0094)	(0.4587)
OFF_{t-1}	-0.0054***	-0.0005***	-0.3897***
	(0.0010)	(0.0002)	(0.0091)
LOANG	-0.0222***	0.0001	-0.2416***
	(0.0019)	(0.0004)	(0.0173)
NPL	-0.0620	0.2686***	0.9265
	(0.0869)	(0.0164)	(0.7988)
DEP	-0.0960***	-0.0042***	0.0668
	(0.0049)	(0.0009)	(0.0451)
Constant	0.0001	1.20e-06	-0.0001
	(0.0002)	(0.00004)	(0.0020)
R^2	0.2737	0.2682	0.3003

*** Significant at the 0.01 level
** Significant at the 0.05 level
* Significant at the 0.10 level

The variables of interest are regulatory pressure (PCAU) and the speed of capital adjustment term (PCAU* CAP_{t-1}). First, the direct effect of regulatory pressure indicate

that undercapitalized banks increase book value capital ratio and off-balance sheet credit risk. These results are the same as the structural form models as in tables 3-11 and 3-12. However, the direct effect of regulatory pressure is significant and negative in ΔON equation whereas in the structural form models PCAU variables are insignificant in ΔON equation as can be seen in tables 3-11 and 3-12. Second, the direct effect of the speed of capital adjustment term is significant and negative as expected, meaning that capital standards are effective in that undercapitalized banks have higher speed of capital adjustment than other banks.

With respect to the instruments, both DEP and NPL variables are significant in ΔON equation and only DEP variable is significant in ΔCAP equation but none is significant in ΔOFF equation. This result shows that the instruments used for the main model are correlated with the endogenous variables. The main model is simultaneous equations of (13), (14) and (15) and of (16), (17) and (18) and is correctly specified under the Hausman test. The results of Hausman test indicate that the instruments are uncorrelated with the error term. Therefore, the results from the reduced form and the Hausman test show that the instrument variable condition is met and that the two instruments, NPL and DEP, are not weak since they are correlated with the endogenous variables and uncorrelated with the error terms. Hence, the results of the main model as shown in tables 3-11 and 3-12 do not have significant bias.

Regarding the alternative model of simultaneous equations (25), (26) and (27), this model has lagged value of off-balance sheet credit risk (OFF_{t-1}) in all three equations and is correctly specified under the Hausman test. The only one instrument is NPL and also included on the right-hand side. Thus, the reduced form model is as follows.

$$\Delta CAP_{j,t} = a_0 + a_1 SIZE_{j,t} + a_2 BHC_{j,t} + a_3 PCAU_{j,t} + a_4 ROA_{j,t} + a_5 CAP_{j,t-1} + a_6 PCAU_{j,t} * CAP_{j,t-1} + a_7 ON_{j,t-1} + a_8 OFF_{j,t-1} + a_9 LOANG_{j,t} + a_{10} DEP_{j,t} + a_{11} NPL_{j,t} + E_{j,t} \quad (30)$$

$$\Delta ON_{j,t} = b_0 + b_1 SIZE_{j,t} + b_2 BHC_{j,t} + b_3 PCAU_{j,t} + b_4 ROA_{j,t} + b_5 CAP_{j,t-1} + b_6 PCAU_{j,t} * CAP_{j,t-1} + b_7 ON_{j,t-1} + b_8 OFF_{j,t-1} + b_9 LOANG_{j,t} + b_{10} DEP_{j,t} + b_{11} NPL_{j,t} + U_{j,t} \quad (31)$$

$$\Delta OFF_{j,t} = c_0 + c_1 SIZE_{j,t} + c_2 BHC_{j,t} + c_3 PCAU_{j,t} + c_4 ROA_{j,t} + c_5 CAP_{j,t-1} + c_6 PCAU_{j,t} * CAP_{j,t-1} + c_7 ON_{j,t-1} + c_8 OFF_{j,t-1} + c_9 LOANG_{j,t} + c_{10} DEP_{j,t} + c_{11} NPL_{j,t} + V_{j,t} \quad (32)$$

The simultaneous equations of (30), (31) and (32) are exactly the same as of (28), (29) and (30). Therefore, the results are also in table 4-8.

CHAPTER 5

MORTGAGE SECURITIZATION

1. Model

In chapter 3, the data shows that the amount of mortgage securitization is over half of all types of securitization. Moreover, 3,629 out of 5,642 bank observations securitize mortgage loans, accounting for over half of all banks observations. Therefore, the relationship between capital and credit risk of banks only with mortgage securitization is also of interest.

The models of mortgage securitization are based on the simultaneous equations of (13), (14) and (15), the one with loan growth (LOANG) in ΔOFF equation, and also based on the simultaneous equations of (16), (17) and (18), the one with loan growth (LOANG) in both ΔON and ΔOFF equations. Moreover, the two instrument variables, NPL and DEP, are also the same. However, off-balance sheet credit risk variable (OFF) is changed from total securitization to mortgage securitization and loan growth (LOANG) is growth of mortgage loans. Regarding on-balance sheet credit risk variable (ON), it is the same as models with total securitization, due to no detail of loan loss allowance for mortgage loans. Table 5-1 lists all variables for mortgage securitization models.

Table 5-1: List of Variables for Mortgage Securitization

Variable	Measurement	Codes
CAP	Total equity capital/total assets	RCFD3210/RCFD2170
ON	Loan loss allowance/total assets	RCFD3123/RCFD2170
OFF	Amount of mortgage securitization/total assets	RCFDB705/RCFD2170
SIZE	Natural log of total assets	Natural log of (RCFD2170)
ROA	Net profit/total assets	RIAD4340/RCFD2170
LOANG	Mortgage loan growth	Natural log of (RCON1430) - Natural log of (Lagged RCON1430)
NPL	Non-performing loans/total assets	(RCFD1407+RCFD1403)/RCFD2170
DEP	Deposits/total assets	RCFD2200/RCFD2170

Note: Codes are from the Federal Reserve Bank of Chicago. More detail of codes is in Appendix 2.

After substituting for mortgage loans, the Hausman tests for model specification show that the p-value is around zero; therefore, the simultaneous equations of (13), (14) and (15) and of (16), (17) and (18) are incorrectly specified. Therefore, the alternative model that is correctly specified under Hausman test is to include lagged value of off-balance sheet credit risk (OFF_{t-1}) in all three equations as shown in chapter 4. After substituting for mortgage loans, the Hausman test of simultaneous equations (19), (20) and (21) model, which is the model with mortgage loan growth (LOANG) only in ΔOFF equation, indicates that the chi-square with degree of freedom of 9 is 29.97 and p-value is 0.0004; therefore, applying this model applied to mortgage securitization is inappropriate. However, by applying the simultaneous equations (22), (23) and (24) model, which is the model with mortgage loan growth (LOANG) in both ΔON and ΔOFF equations, the Hausman test shows that the chi-square with degree of freedom of 9 is 12.49 and p-value is 0.1870, leading to failing to reject the null hypothesis. Therefore, the correctly specified model for mortgage securitization is based on the simultaneous equations of

(22), (23) and (24) and it is the model that has OFF_{t-1} in all three equations and LOANG in both ΔON and ΔOFF equations.

With respect to the statements of hypotheses, they are the same as model with total securitization as discussed in chapters 3 and 4.

2. Data

The criteria of sample for mortgage securitization are the same as for total securitization but only banks with mortgage securitization are selected. There are a total of 3,692 bank observations. The following tables indicate descriptive statistics. Table 5-2 shows variable means of data in the sample and number of observations for each quarter for all 27 quarters. Tables 5-3 and 5-4 indicate minimum and maximum of all three endogenous variables and lagged variables in each quarter. Similar to total securitization, the amount of mortgage securitization of some banks is many times larger than their total assets. The variable OFF_{t-1} represents the ratio of mortgage securitization and total assets and $LOANG_t$ is the growth of mortgage loans. Nevertheless, other variables are the same as for total securitization.

Table 5-2: Means of Variables in Each Quarter for Mortgage Securitization

Quarter	Obs	ΔCAP_t	ΔON_t	ΔOFF_t	CAP_{t-1}	ON_{t-1}	OFF_{t-1}	$LOANG_t$	$SIZE_t$	ROA_t
Q3:01	159	0.00142	0.00010	0.00226	0.08415	0.00882	0.18674	-0.00103	14.8292	0.00795
Q4:01	164	-0.00250	-0.00001	0.02238	0.08478	0.00873	0.21936	0.01286	15.1076	0.01044
Q1:02	140	0.00264	0.00015	-0.00899	0.08159	0.00885	0.24192	-0.00853	15.2390	0.00327
Q2:02	142	0.00150	0.00003	0.00630	0.08341	0.00882	0.20443	0.04338	15.3059	0.00608
Q3:02	144	-0.00019	-0.00024	-0.01655	0.08507	0.00888	0.20393	0.04053	15.3353	0.00894
Q4:02	145	-0.00038	-0.00001	-0.00275	0.08475	0.00866	0.18272	0.02557	15.3869	0.01171
Q1:03	161	-0.00012	-0.00007	-0.00521	0.08642	0.00853	0.15969	0.00851	15.2192	0.00346
Q2:03	169	-0.00061	-0.00011	-0.01810	0.08729	0.00853	0.14628	0.03527	15.1941	0.00656
Q3:03	168	0.00012	-0.00002	0.02820	0.08596	0.00860	0.12607	0.01677	15.2491	0.00962
Q4:03	166	0.00125	-0.00012	-0.02086	0.08663	0.00873	0.15002	0.00706	15.2202	0.01248
Q1:04	133	0.00134	-0.00016	-0.00612	0.08932	0.00858	0.09031	0.03908	15.6678	0.00335
Q2:04	124	-0.00364	-0.00022	0.00851	0.08897	0.00863	0.08536	0.07953	16.0166	0.00623
Q3:04	128	0.00412	-0.00008	0.00259	0.08568	0.00832	0.08973	0.03763	15.8055	0.00898
Q4:04	126	0.00128	-0.00031	-0.00099	0.08910	0.00799	0.09084	0.04620	15.7462	0.01138
Q1:05	125	-0.00096	-0.00012	0.00773	0.09040	0.00769	0.08823	0.07033	15.7378	0.00299
Q2:05	129	0.00213	-0.00014	0.00436	0.08777	0.00770	0.09202	0.04198	15.7133	0.00587
Q3:05	131	-0.00091	0.00006	0.00474	0.09108	0.00744	0.09133	0.03583	15.6260	0.00834
Q4:05	137	-0.00062	-0.00020	0.00608	0.08966	0.00765	0.08954	0.04708	15.5570	0.01075
Q1:06	113	0.00093	-0.00007	-0.00213	0.08910	0.00713	0.09885	0.00789	15.8530	0.00283
Q2:06	115	-0.00071	-0.00005	0.00592	0.09190	0.00713	0.09616	0.02999	15.7955	0.00530
Q3:06	116	0.00236	0.00010	0.00582	0.08985	0.00719	0.09733	0.00393	15.8247	0.00792
Q4:06	113	0.00289	-0.00009	0.00938	0.09403	0.00731	0.10106	0.07602	15.8926	0.01011
Q1:07	115	0.00196	0.00013	0.00632	0.09644	0.00715	0.07714	0.00769	15.9156	0.00223
Q2:07	113	-0.00207	0.00003	0.00929	0.09598	0.00725	0.08348	-0.00822	15.9407	0.00413
Q3:07	113	0.00540	-0.00008	0.00112	0.09394	0.00776	0.08137	0.02339	15.8762	0.00508
Q4:07	113	-0.00119	0.00053	0.00245	0.09993	0.00769	0.09101	0.02505	15.8998	0.00510
Q1:08	127	0.00156	0.00064	0.00851	0.09774	0.00835	0.07455	-0.01759	15.5039	0.00133

Source: The Federal Reserve Bank of Chicago

Table 5-3: Minimum and Maximum of Endogenous Variables in Each Quarter for Mortgage Securitization

Quarter	ΔCAP_t		ΔON_t		ΔOFF_t	
	Min	Max	Min	Max	Min	Max
Q3:2001	-0.01912	0.03678	-0.00182	0.00581	-0.47366	0.45529
Q4:2001	-0.06321	0.02276	-0.00534	0.00263	-0.43388	3.12760
Q1:2002	-0.01125	0.10686	-0.00509	0.00460	-6.36958	3.83758
Q2:2002	-0.01366	0.03397	-0.00416	0.00453	-1.68308	1.21354
Q3:2002	-0.02464	0.01127	-0.00468	0.00157	-2.41926	0.29399
Q4:2002	-0.01953	0.00718	-0.00151	0.00238	-0.56615	0.27489
Q1:2003	-0.01358	0.01453	-0.00214	0.00103	-0.83905	0.30014
Q2:2003	-0.03015	0.01446	-0.00164	0.00963	-1.71320	0.09517
Q3:2003	-0.02930	0.03098	-0.00248	0.00353	-0.13319	2.59123
Q4:2003	-0.01256	0.07058	-0.00445	0.00503	-2.29271	1.22342
Q1:2004	-0.01443	0.01858	-0.00519	0.00136	-0.28937	0.38742
Q2:2004	-0.02094	0.03266	-0.00503	0.00236	-0.08706	0.44298
Q3:2004	-0.00912	0.09931	-0.00182	0.00977	-0.37750	0.31672
Q4:2004	-0.01912	0.13580	-0.00309	0.00283	-0.11410	0.14446
Q1:2005	-0.03338	0.02208	-0.00141	0.00074	-0.04334	0.70527
Q2:2005	-0.01428	0.05408	-0.00269	0.00111	-0.18580	0.60645
Q3:2005	-0.07160	0.01002	-0.00358	0.00707	-0.03222	0.16499
Q4:2005	-0.02338	0.09881	-0.01017	0.00202	-0.30200	0.20373
Q1:2006	-0.01728	0.05590	-0.00172	0.00094	-0.38599	0.17152
Q2:2006	-0.02913	0.01861	-0.00455	0.00135	-0.08367	0.32773
Q3:2006	-0.01543	0.03502	-0.00189	0.00495	-0.01136	0.21471
Q4:2006	-0.02037	0.15205	-0.00487	0.00566	-0.02419	0.25225
Q1:2007	-0.03394	0.03380	-0.00462	0.00270	-0.10115	0.28454
Q2:2007	-0.02181	0.00768	-0.01560	0.00699	-0.03067	0.37688
Q3:2007	-0.01788	0.17051	-0.01040	0.00430	-0.04728	0.14111
Q4:2007	-0.06181	0.07961	-0.00353	0.00631	-0.08413	0.16211
Q1:2008	-0.06658	0.12246	-0.00183	0.01371	-0.06540	0.23220

Source: The Federal Reserve Bank of Chicago

Table 5-4: Minimum and Maximum of Other Variables in Each Quarter for Mortgage Securitization

Quarter	CAP_{t-1}		ON_{t-1}		OFF_{t-1}		$LOANG_t$	
	Min	Max	Min	Max	Min	Max	Min	Max
Q3:2001	0.03714	0.15366	0.00083	0.02346	0	2.48377	-0.36600	0.53477
Q4:2001	0.02813	0.18213	0.00080	0.02568	0	7.36111	-2.08989	2.71169
Q1:2002	0.03804	0.14619	0.00047	0.02299	0	7.72261	-0.55006	0.79830
Q2:2002	0.02412	0.15735	0.00057	0.01990	0	7.17593	-1.39621	2.63055
Q3:2002	0.02464	0.17088	0.00049	0.01984	0	8.38947	-0.50373	0.91302
Q4:2002	0.02183	0.17327	0.00051	0.01846	0	5.97022	-0.57944	0.52247
Q1:2003	0.01857	0.17428	0.00069	0.01831	0	5.52017	-0.89363	0.80914
Q2:2003	0.01625	0.17546	0.00058	0.01830	0	5.56235	-0.22737	0.66281
Q3:2003	0.01315	0.16909	0.00044	0.02686	0	3.84914	-0.42019	0.49228
Q4:2003	0.01261	0.16744	0.00057	0.02437	0	6.44038	-0.30908	0.27422
Q1:2004	0.01324	0.20051	0.00053	0.02633	0	1.63381	-0.80113	1.75304
Q2:2004	0.01200	0.16708	0.00063	0.02261	0	1.70554	-0.12879	0.70160
Q3:2004	0.01283	0.16094	0.00063	0.02094	0	1.89644	-0.31135	0.42125
Q4:2004	0.01351	0.19068	0.00065	0.02003	0	1.51895	-0.20097	0.48247
Q1:2005	0.01291	0.25732	0.00059	0.01716	0	1.48713	-0.41807	4.41017
Q2:2005	0.01240	0.17582	0.00016	0.01575	0	2.19240	-0.90794	0.62855
Q3:2005	0.01300	0.17601	0.00016	0.01463	0	2.16360	-0.98208	0.70433
Q4:2005	0.01364	0.18266	0.00014	0.02395	0	2.32859	-0.96970	3.68848
Q1:2006	0.01251	0.18619	0.00013	0.02018	0	2.50532	-0.57222	0.33441
Q2:2006	0.01173	0.20565	0.00012	0.01876	0	2.67685	-0.73723	0.68104
Q3:2006	0.01200	0.18250	0.00009	0.01971	0	2.59317	-0.92467	0.36453
Q4:2006	0.01191	0.20921	0.00008	0.01939	0	2.80788	-0.41611	2.19320
Q1:2007	0.01184	0.25360	0.00010	0.01610	0	0.93479	-0.49933	0.44651
Q2:2007	0.00974	0.22321	0.00014	0.01629	0	0.94330	-2.17771	0.19929
Q3:2007	0.00888	0.21127	0.00002	0.02537	0	0.86826	-0.36136	1.17848
Q4:2007	0.00651	0.28396	0.00004	0.02460	0	1.05296	-1.23124	1.39588
Q1:2008	0.00393	0.22956	0.00001	0.02583	0	1.08709	-3.20495	0.87027

Source: The Federal Reserve Bank of Chicago

Furthermore, table 5-5 shows overall variable means from all 27 quarters including minimum and maximum value. Table 5-6 compare variables mean in each quarter to overall mean. In addition, table 5-7 shows correlations among the variables.

Table 5-5: Overall Mean, Minimum, and Maximum of Variables for Mortgage Securitization

Variable	Mean	Min	Max
ΔCAP_t	0.00057	-0.07160	0.17051
ΔON_t	-0.00002	-0.01560	0.01371
ΔOFF_t	0.00196	-6.36958	3.83758
CAP_{t-1}	0.08886	0.00393	0.28396
ON_{t-1}	0.00815	0.00001	0.02686
OFF_{t-1}	0.12835	0	8.38947
$LOANG_t$	0.02624	-3.20495	4.41017
$SIZE_t$	15.53279	11.51744	21.58119
ROA_t	0.00693	-0.11483	0.05385

Source: The Federal Reserve Bank of Chicago

Table 5-6: Variable Means by Quarter for Mortgage Securitization

	Q1	Q2	Q3	Q4	Overall
ΔCAP_t	0.00103	-0.00048	0.00158	0.00001	0.00057
ΔON_t	0.00007	-0.00008	-0.00002	-0.00004	-0.00002
ΔOFF_t	-0.00041	0.00149	0.00466	0.00192	0.00196
CAP_{t-1}	0.08981	0.08884	0.08760	0.08921	0.08886
ON_{t-1}	0.00810	0.00808	0.00821	0.00818	0.00815
OFF_{t-1}	0.12268	0.12209	0.12948	0.13775	0.12835
$LOANG_t$	0.01495	0.03767	0.02194	0.03185	0.02624
$SIZE_t$	15.56398	15.62133	15.4617	15.50121	15.53279
ROA_t	0.00282	0.00578	0.00824	0.01048	0.00693

Source: The Federal Reserve Bank of Chicago

Table 5-7: Correlations among Variables for Mortgage Securitization

Variable	ΔCAP_t	ΔON_t	ΔOFF_t	CAP_{t-1}	ON_{t-1}	OFF_{t-1}	$LOANG_t$	$SIZE_t$	ROA_t
ΔCAP_t	1.0000								
ΔON_t	0.0114	1.0000							
ΔOFF_t	0.0471	-0.0009	1.0000						
CAP_{t-1}	-0.0690	-0.0352	0.0039	1.0000					
ON_{t-1}	-0.0058	-0.1071	0.0014	0.1227	1.0000				
OFF_{t-1}	-0.0350	0.0003	-0.1997	0.0158	-0.1444	1.0000			
$LOANG_t$	-0.0600	-0.0221	0.0046	0.0679	-0.0025	0.0205	1.0000		
$SIZE_t$	0.0099	-0.0202	-0.0389	-0.0970	-0.0464	0.0650	0.0582	1.0000	
ROA_t	-0.0072	-0.0705	0.0037	0.1715	0.0959	0.0662	0.0486	0.0495	1.0000

Source: The Federal Reserve Bank of Chicago

3. Results

Table 5-8 shows the results of simultaneous equations of (22), (23) and (24) and CAP variable in this table is the ratio of equity capital to total assets or book value capital ratio.

Table 5-8: Three-Stage Least Squares Estimates from Equations (22), (23), and (24) with the Ratio of Equity Capital to Total Assets

Variable	ΔCAP	ΔON	ΔOFF
SIZE	0.0025***	-0.0013***	-0.0365***
	(0.0009)	(0.0002)	(0.0080)
BHC	-0.0050	0.0021**	0.0839
	(0.0041)	(0.0010)	(0.0568)
PCAU	-0.0238	0.0005	0.1825*
	(0.0217)	(0.0016)	(0.0964)
ΔCAP		0.0571**	0.9239
		(0.0235)	(1.5190)
ΔON	0.7204		-0.2985
	(0.6803)		(8.5916)
ΔOFF	0.0161	-0.0291***	
	(0.0178)	(0.0044)	
ROA	-0.0513		
	(0.0233)		
CAP_{t-1}	-0.1217***		
	(0.0129)		
PCAU* CAP_{t-1}	-0.0489		
	(0.1969)		
ON_{t-1}		-0.2129***	
		(0.0310)	
OFF_{t-1}	0.0061	-0.0124***	-0.4248***
	(0.0076)	(0.0019)	(0.0113)
LOANG		-0.0013***	-0.0454***
		(0.0003)	(0.0126)
Constant	-9.82e-06	5.44e-06	0.0001
	(0.0001)	(0.00004)	(0.0022)
R^2	0.0092	-20.6657[2]	0.2990

*** Significant at the 0.01 level
** Significant at the 0.05 level
* Significant at the 0.10 level

First, with regard to the study of whether banks simultaneously determine changes in capital and on- and off-balance sheet credit risk, the results show that none of endogenous variables are simultaneously determined; however, both ΔCAP and ΔOFF variables exogenously determine ΔON variable. Change in capital (ΔCAP) has significant and positive relationship with change in on-balance sheet credit risk (ΔON). Banks with more capital have more buffer to absorb expected credit losses and hence are able to recognize higher amount of loan loss allowance. On the contrary, banks with lower capital do not have much cushion to absorb losses from on-balance sheet credit risk; therefore, they are reluctant to recognize loan loss allowance. Furthermore, change in off-balance sheet credit risk (ΔOFF) has significant and negative relationship with change in on-balance sheet credit risk (ΔON). This could be possible that banks securitize low credit risk mortgage loans and keep high credit risk mortgage loans on balance sheets, leading to an increase in loan loss allowance. This evidence supports capital arbitrage. Nevertheless, it could also be possible that banks securitize high credit risk mortgage loans and keep low credit risk mortgage loans on balance sheets; therefore, banks are able to recognize lower loan loss allowance due to high credit quality of those mortgage loans.

Second, regarding the effectiveness of capital standards, regulatory pressure (PCAU dummy variable) shows no impact on ΔCAP and ΔON but has a significant and positive relationship with ΔOFF. Thus, capital standards are ineffective for mortgage securitization because undercapitalized banks are not induced to increase capital or reduce both on- and off- balance sheet credit risk. Moreover, to make the matter worse, those undercapitalized banks incline to increase off-balance sheet credit risk or get more

involved in mortgage securitization by hoping that higher risk could yield higher returns and these higher returns replenish capital. Additionally, the interaction term between regulatory pressure and lagged capital (PCAU* CAP_{t-1}) is insignificant, meaning that speed of capital adjustment of undercapitalized banks is not different from that of adequately capitalized banks. All in all, capital minimum requirements are not effective for banks with mortgage securitization.

Next, regarding all lagged levels (CAP_{t-1}, ON_{t-1}, and OFF_{t-1}), they all show negative signs as expected, meaning that banks adjust capital and on- and off-balance sheet credit risk to their target levels. Additionally, lagged value of mortgage securitization (OFF_{t-1}) in ΔON and ΔOFF equations is significant and negative as expected. Banks securitize mortgage loans to transfer credit risk. However, lagged value of mortgage securitization (OFF_{t-1}) is insignificant in ΔCAP equation, showing that off-balance sheet credit risk from mortgage securitization in previous period does not affect banks to change capital in current period. In addition, return on assets (ROA) is unexpectedly insignificant to increase capital.

Furthermore, mortgage loan growth (LOANG) is significant in both ΔON and ΔOFF equations; however, the signs are unexpected. They are expected to be positive but the results show negative signs in both equations. Banks that increase mortgage loans decrease the amount of loan loss allowance. Since understated loan loss allowance leads to overstated capital, bank capital may not be adequate to absorb unexpected losses during economic downturns. Besides, mortgage loan growth in ΔOFF equation also shows negative sign. As discussed earlier in model with total securitization, banks with mortgage loan growth securitize less mortgage loans. This could be possible that since

mortgage loan growth is calculated from on-balance sheet mortgage loans, banks that keep more mortgage loans on balance sheet have smaller amount of off-balance sheet mortgage loans, leading to a decrease in mortgage securitization and off-balance sheet credit risk. In addition, after loans origination, banks may hold loans on balance sheet first and securitize in later quarter. Bank may not be able to securitize instantaneously.

Moreover, bank size (SIZE) is significant in all three equations. As banks with mortgage securitization become larger, they tend to increase capital because larger banks may access to capital more easily than smaller ones. Larger banks are also able to decrease both on- and off-balance sheet credit risk possibly due to risk diversification.

Finally, bank holding company dummy variable (BHC) is significant only in ΔON equation. Bank holding companies tend to increase on-balance sheet credit risk or realize higher loan loss allowance than commercial banks. However, BHC dummy variable is insignificant in both ΔCAP and ΔOFF equations, implying that bank holding companies and commercial banks have no difference in changing capital and off-balance sheet credit risk.

4. Robustness Checks

For the robustness checks, book value capital ratio, which is the ratio of equity capital and total assets, is replaced by other three types of capital ratios. The following tables of 5-9, 5-10, and 5-11 show the results of simultaneous equations of (22), (23) and (24) according to total risk-based capital ratio, tier 1 risk-based capital ratio, and tier 1 leverage ratio, respectively.

Table 5-9: Three-Stage Least Squares Estimates from Equations (22), (23), and (24) with Total Risk-Based Capital Ratio

Variable	ΔCAP	ΔON	ΔOFF
SIZE	-0.0050***	-0.0016***	-0.0355***
	(0.0010)	(0.0005)	(0.0078)
BHC	0.0134***	0.0028*	0.0738
	(0.0050)	(0.0017)	(0.0569)
PCAU	-0.0966***	0.0009	0.1028
	(0.0170)	(0.0025)	(0.0903)
ΔCAP		0.0001	0.0022
		(0.0002)	(0.0091)
ΔON	2.6606***		-13.2947**
	(0.8949)		(6.6497)
ΔOFF	0.0124	-0.0387***	
	(0.0214)	(0.0119)	
ROA	0.5337***		
	(0.0475)		
CAP_{t-1}	-0.9985***		
	(0.0007)		
PCAU* CAP_{t-1}	0.4795***		
	(0.1095)		
ON_{t-1}		-0.1805***	
		(0.0503)	
OFF_{t-1}	0.0053	-0.0166***	-0.4275***
	(0.0091)	(0.0051)	(0.0111)
LOANG		-0.0018***	-0.0466***
		(0.0006)	(0.0125)
Constant	-0.00003	7.21e-06	0.0002
	(0.0002)	(0.00005)	(0.0023)
R^2	0.9981	-36.8369[2]	0.2864

*** Significant at the 0.01 level
** Significant at the 0.05 level
* Significant at the 0.10 level

Table 5-10: Three-Stage Least Squares Estimates from Equations (22), (23), and (24) with Tier 1 Risk-Based Capital Ratio

Variable	ΔCAP	ΔON	ΔOFF
SIZE	-0.0060***	-0.0004	-0.0355***
	(0.0011)	(0.0003)	(0.0078)
BHC	0.0027	-3.72e-08	0.0961*
	(0.0055)	(0.0008)	(0.0571)
PCAU	-0.0691***	-0.0046***	0.2340**
	(0.0180)	(0.0013)	(0.0941)
ΔCAP		0.00001	0.0020
		(0.00006)	(0.0098)
ΔON	6.1396***		16.5076*
	(0.9896)		(8.9697)
ΔOFF	0.0008	-0.0048	
	(0.0235)	(0.0081)	
ROA	0.5871***		
	(0.0479)		
CAP_{t-1}	-0.9984***		
	(0.0009)		
PCAU* CAP_{t-1}	0.5168***		
	(0.1211)		
ON_{t-1}		-0.1870***	
		(0.0271)	
OFF_{t-1}	0.0010	-0.0022	-0.4245***
	(0.0100)	(0.0034)	(0.0111)
LOANG		-0.0002	-0.0461***
		(0.0004)	(0.0125)
Constant	-0.00003	2.28e-06	0.0001
	(0.0002)	(0.00001)	(0.0023)
R^2	0.9974	-0.4967[2]	0.2906

*** Significant at the 0.01 level
** Significant at the 0.05 level
* Significant at the 0.10 level

Table 5-11: Three-Stage Least Squares Estimates from Equations (22), (23), and (24) with Tier 1 Leverage Ratio

Variable	ΔCAP	ΔON	ΔOFF
SIZE	0.0060	-0.0017***	-0.0355***
	(0.0098)	(0.0003)	(0.0078)
BHC	-0.0295	0.0031**	0.0784
	(0.0487)	(0.0014)	(0.0569)
PCAU	-0.0697	0.0011	0.1301
	(0.2535)	(0.0022)	(0.0914)
ΔCAP		0.00005	0.0004
		(0.0005)	(0.0229)
ΔON	-0.5069		-7.0244
	(8.1528)		(7.4352)
ΔOFF	0.0318	-0.0410***	
	(0.2047)	(0.0063)	
ROA	-0.0026		
	(0.4661)		
CAP_{t-1}	-0.4733***		
	(0.0084)		
PCAU* CAP_{t-1}	0.3803		
	(2.4286)		
ON_{t-1}		-0.2037***	
		(0.0445)	
OFF_{t-1}	-0.0121	-0.0176***	-0.4268***
	(0.0875)	(0.0027)	(0.0111)
LOANG		-0.0019***	-0.0468***
		(0.0004)	(0.0125)
Constant	0.0779	7.58e-06	0.0002
	(0.0022)	(0.00005)	(0.0023)
R^2	0.4709	-41.3176^2	0.2915

*** Significant at the 0.01 level
** Significant at the 0.05 level
* Significant at the 0.10 level

With regards to Hausman tests of model specification, model with total risk-based capital ratio has the chi-square with degree of freedom of 9 is 17.35 and p-value is 0.0435, leading to failing to reject the null hypothesis at the 1% level. Next, model with tier 1 risk-based capital ratio has the chi-square with degree of freedom of 9 is 50.26 and p-value is zero, leading to reject the null hypothesis. Lastly, model with tier 1 leverage

ratio has the chi-square with degree of freedom of 9 is 4.00 and p-value is 0.9117, leading to failing to reject the null hypothesis. Thus, there is model misspecification with tier 1 risk-based capital ratio but models with total risk-based capital ratio and tier 1 leverage ratio are correctly specified. Since model with tier 1 leverage capital ratio shows stronger results, it is compared to model with book value capital ratio for the robustness checks.

Most of variables in model with tier 1 leverage ratio have significance level the same as model with book value capital ratio with the exception of SIZE in ΔCAP equation, ΔCAP in ΔON equation, and PCAU in ΔOFF equation. In spite of a few differences in significance level, all variables have the same signs, indicating the economic meaning of the results of model with mortgage securitization.

5. Alternative Model

The alternative model that is also correctly specified under the Hausman test is to use model of simultaneous equations (25), (26) and (27). The results with book value capital ratio or the ratio of equity capital to total asset are in table 5-12. With the Hausman test, the chi-square with degree of freedom of 9 equals 6.97 and p-value is 0.6399, leading to failing to reject the null hypothesis.

Table 5-12: Three-Stage Least Squares Estimates from Equations (25), (26), and (27) with the Ratio of Equity Capital to Total Assets

Variable	ΔCAP	ΔON	ΔOFF
SIZE	0.0009	-0.0012***	-0.0263***
	(0.0009)	(0.0002)	(0.0081)
BHC	-0.0015	0.0041***	0.1282**
	(0.0045)	(0.0012)	(0.0574)
PCAU	-0.0158	-0.0001	0.1604*
	(0.0216)	(0.0017)	(0.0972)
ΔCAP		0.0274	-0.2563
		(0.0252)	(1.4338)
ΔON	0.3528		4.4139
	(0.7522)		(9.1305)
ΔOFF	-0.0283*	-0.0351***	
	(0.0165)	(0.0048)	
ROA	-0.0547		
	(0.0377)		
CAP_{t-1}	-0.1282***		
	(0.0141)		
PCAU* CAP_{t-1}	-0.0637		
	(0.1941)		
ON_{t-1}		-0.2434***	
		(0.0383)	
OFF_{t-1}	-0.0128*	-0.0150***	-0.4241***
	(0.0071)	(0.0021)	(0.0113)
LOANG		-0.0013***	-0.0310**
		(0.0003)	(0.0122)
DEP		0.0098***	0.2677***
		(0.0014)	(0.0645)
Constant	-4.37e-06	4.47e-06	0.0001
	(0.0002)	(0.00004)	(0.0023)
R^2	-0.2174[2]	-29.9313[2]	0.2935

*** Significant at the 0.01 level
** Significant at the 0.05 level
* Significant at the 0.10 level

Regarding the endogenous variables, the results are the same as the previous model, showing that none of endogenous variable is simultaneously determined. However, change in off-balance sheet credit risk exogenously determines not only change in on-balance sheet credit risk but also change in capital and they both show positive

relationship. An increase in off-balance sheet credit risk decrease on-balance sheet credit risk and capital. On the one hand, banks that securitize high credit risk mortgage loans keep low credit risk mortgage loans on balance sheet and hence, decrease loan loss allowance. Banks consider mortgage securitization to transfer credit risk and reduce on-balance sheet credit risk and capital accordingly. On the other hand, banks that securitize low credit risk mortgage loans have high credit risk loans on balance sheets and recognize higher loan loss allowance, which encourages banks to increase capital.

Furthermore, with respect to regulatory pressure (PCAU), the results are the same as the previous model in that regulatory pressure does not induce undercapitalized banks to change capital and on-balance sheet credit risk but induce undercapitalized banks to increase mortgage securitization or off-balance sheet credit risk. Moreover, the speed of capital adjustment of undercapitalized banks is not different from other banks.

Also similar to the previous model, lagged level of endogenous variables are all negative as expected as banks adjust to their desired levels and return on assets (ROA) is insignificant. Moreover, loan growth is negative and significant in both ΔON and ΔOFF equations.

Next, lagged value of off-balance sheet credit risk (OFF_{t-1}) is negative as expected in all three equations as banks recognize mortgage securitization to transfer credit risk and thus, reduce capital and on- and off-balance sheet credit risk accordingly. Regarding deposit-to-assets ratio (DEP), it is positive in ΔON equation as expected since banks with more deposits are able to provide more mortgage loans and then recognize higher loan loss allowance; however, it is negative in ΔOFF equation, which is unexpected. Banks that want to securitize mortgage loans depend on deposits. This could be that banks

depend on deposits to finance more mortgage loans and mortgage securitization depends on an increase in those mortgage loans.

All in all, the basic results of endogenous variables and regulatory pressure are the same as the previous model.

CHAPTER 6

CONCLUSIONS

The purposes of this study are to examine whether U.S. banks simultaneously determined capital and on- and off-balance sheet credit risk and to determine whether U.S. capital standards are effective. Only banks with securitization are selected and the sample period is from the third quarter of 2001 to the first quarter of 2008. By using simultaneous equations model, three-stage least squares (3SLS) is applied to account for the endogeneity problem. Three models are discussed and different models yield different results.

First, regarding the main model that has lagged level of off-balance sheet credit risk only in change in off-balance sheet equation, the results show that banks with securitization only simultaneously determine change in capital and off-balance sheet credit risk and they have a positive relationship. Banks with more capital are able to take more off-balance sheet credit risk or get more involved in securitization since banks increase cushion against unexpected losses. Similarly, banks with higher degree of securitization want to increase capital to be associated with higher off-balance sheet credit risk. Further, change in off-balance sheet credit risk exogenously determines change in on-balance sheet credit risk and they have a positive relationship. This evidence supports that banks operate in originate-to-distribute model and keep growing loans through securitization. Banks that want to increase securitization transactions have to originate on-balance sheet loans first and securitize later. Therefore, with an increase in on-balance sheet loans, banks increase on-balance sheet credit risk by recognizing

higher loan loss allowance. Additionally, there is evidence that change in capital and change in on-balance sheet credit risk have no significant relationship.

Next, regarding the effectiveness of capital standards, the results show that U.S. capital standards are partially effective during the sample period. The reason might be that financial innovations including securitization have rapidly grown during that time and capital standards are not adapted as fast as changes in financial world. Capital standards are effective in that regulatory pressure induces undercapitalized banks to increase book value capital ratio, which is the ratio of equity capital to total assets, and to adjust capital faster than adequately capitalized banks. However, capital standards are not effective in that with regulatory pressure, undercapitalized banks take more off-balance sheet credit risk or securitize more loans by hoping higher returns to increase capital ratio. Moreover, regulatory pressure has no impact on change in on-balance sheet credit risk since change in loan loss allowance might affect undercapitalized banks' balance sheets and hence, their capital ratios. Therefore, undercapitalized banks do not concern about loan loss allowance. In addition, although capital standards induce banks to increase book value capital ratio, they are not effective due to a decrease in risk-based capital ratios of undercapitalized banks. This evidence points out that an increase in book value capital ratio does not necessarily lead to an increase in risk-based capital ratios. Although undercapitalized banks are able to increase capital to their balance sheets, an increase in capital may not be adequate to an increase in risk.

Second, regarding the alternative model with lagged level of off-balance sheet credit risk in all three simultaneous equations, there is evidence that all three endogenous variables are simultaneously determined. Change in capital and change in on-balance

sheet credit risk is positively related. Banks with increased capital are able to take more on-balance sheet credit or recognize higher loan loss allowance. Similarly, banks that want to take more on-balance sheet credit risk tend to increase capital to absorb unexpected credit losses. Furthermore, change in capital and change in off-balance sheet credit risk is also positively related. This result is similar to the main model. Additionally, the relationship between changes in on- and off-balance sheet credit risk is negative. Banks that securitize low credit loans have high credit risk loans on balance sheets. In contrast, banks that securitize high credit loans have low credit risk loans on balance sheets. However, the former evidence supports capital arbitrage since banks increase on-balance sheet credit risk while still conforming to the minimum capital requirements. Next, with respect to the effective of U.S. capital standards, the results are similar to the results of the main model by indicating that U.S. capital standards are partially effective. Capital standards are effective in that undercapitalized banks under regulatory pressure increase book value capital ratio and have a higher speed of capital adjustment than other banks. Nevertheless, capital standards are ineffective in that undercapitalized banks are induced to increase both on- and off-balance sheet credit risk. With regulatory pressure, they also decrease risk-based capital ratios. This also points out that although undercapitalized banks increase book value capital ratios, their risk-based capital ratios decrease and thus, an increase in capital may not be adequate to absorb unexpected losses from risk.

Finally, regarding mortgage securitization based on the alternative model with lagged value of off-balance sheet credit risk in all three equations, the results show that none of endogenous variables is simultaneously determined and that change in capital

and change in off-balance sheet credit risk exogenously determine change in on-balance sheet credit risk. Change in capital is positively related to change in on-balance sheet credit risk while change in off-balance sheet credit risk is negatively related to change in on-balance sheet credit risk. Furthermore, capital standards are ineffective for mortgage securitization during the sample period because regulatory pressure does not affect undercapitalized banks to change book value capital ratio and on-balance sheet credit risk and it also induce undercapitalized banks to increase off-balance sheet credit risk or mortgage securitization transactions. Besides, undercapitalized banks tend to decrease risk-based capital ratio. Lastly, with regulatory pressure, speed of capital adjustment of undercapitalized banks is not different from that of other banks.

All in all, whether banks simultaneously determine changes in capital and on- and off-balance sheet credit risk depends on model specification. However, regarding the effectiveness of U.S. capital standards, the results indicate that U.S. capital standards are only partially effective and specifically ineffective for mortgage securitization. During the sample period, U.S. capital standards are not so stringent that banks have adequate capital to absorb unexpected losses that may arise during economic downturns. There is clear evidence during the subprime crisis that some banks failed due to inadequate capital. Therefore, U.S. bank regulators should consider more rigorous capital rules to achieve banking safety and soundness.

APPENDIX 1

ACCOUNTING TRANSACTIONS

1. Balance Sheet

Accounting equation for balance sheet is that total assets equal the sum of liabilities and capital (or owners' equity). Both sides of balance sheet must be equal so that balance sheet is balanced. Assets increase through debit but decrease through credit. In contrast, both liabilities and capital increase through credit but decrease through debit.

Regarding loans account, which is the biggest type of assets of banks, Ryan (2000) clearly explains that loans account increases through loans origination and purchases and decreases through repayments, loan sales and securitization, and net loan charge-offs. Loan charge-offs are loans that are actually default or uncollectible during the period. Furthermore, with respect to loan loss allowance account, it shows the expected credit losses from outstanding loans. It is a contra-asset account of loans account and therefore, shown in balance sheet. In other words, it reduces the amount of loans account. Loan loss allowance increases through loan loss provision and loan write-downs and decreases through net loan charge-offs.

Next, regarding loan loss provision, it is credit losses expected during the period. Loan loss provision is an expense shown in income statement and therefore, decreases revenue and bank profit. Ryan (2000) notes that loan loss allowance and loan loss provision are expected credit losses in the future and thus, more timely than loan charge-offs. However, since they are estimated, they are more judgmental than loan charge-offs.

2. Loan Accounting

Suppose that the following is Bank A's balance sheet as of January 1, 2007.

Assets			Liabilities	
Reserves and Cash		$ 300	Deposits	$ 650
Securities and Investment		40	Borrowings	250
Total Loans	700		Equity Capital	100
Less Loan Loss Allowance	(40)			
Net Loans		660		
Total		$1,000	Total	$1,000

Bank A operates in traditional originate-to-hold model. It keeps loans on balance sheet and does not involve in securitization. During the year 2007, Bank A loans to borrower in the amount of $200. It records this transaction by debiting loans and crediting cash by the same amount.

Dr. Loans $200

Cr. Cash $200

By including this transaction, Bank A's balance sheet is as follows.

Assets			Liabilities	
Reserves and Cash		$ 100	Deposits	$ 650
Securities and Investment		40	Borrowings	250
Total Loans	900		Equity Capital	100
Less Loan Loss Allowance	(40)			
Net Loans		860		
Total		$1,000	Total	$1,000

Further, suppose that banks realize that loans in the amount of $10 are definitely uncollectible. Bank A records this transaction by debiting loan loss allowance and crediting loans account by the same amount.

Dr. Loan Loss Allowance $10

Cr. Loans $10

Since loan loss allowance increases from estimates of credit losses in the future, when credit losses actually occur, loan loss allowance has to decrease and is on debit side. This is because loans are assets and increase through debit but loan loss allowance is contra-asset account and thus, increases through credit and decreases through debit.

By including this transaction, Bank A's balance sheet is as follows.

Assets			Liabilities	
Reserves and Cash		$ 100	Deposits	$ 650
Securities and Investment		40	Borrowings	250
Total Loans	890		Equity Capital	100
Less Loan Loss Allowance	(30)			
Net Loans		860		
Total		$1,000	Total	$1,000

Moreover, to follow Generally Accepted Accounting Principles (GAAP), at the end of each period, Bank A has to estimate credit quality of loan portfolio. Suppose that expected losses from bad loans are $30. Bank A records this transaction at December 31, 2007 as follows.

Dr. Loan Loss Provision $30

Cr. Loan Loss Allowance $30

The above transaction is for expected credit losses for unimpaired loans. According to Ryan (2000), unimpaired loans are composed of individually small and homogenous loans such as consumer loans and individually large and heterogeneous loans such as commercial and industrial loans. The expected credit losses from unimpaired loans are estimated at the portfolio level.

However, the other type of credit losses is for impaired loans and it is called loan write-downs. The impairment is estimated at the individual level. For example, banks

estimate that loans of $20 are not repaid with probability more likely than 50%. Banks record this transaction as follows.

Dr. Loan Loss Provision $20

Cr. Loan Loss Allowance $20

Therefore, during the period of 2007, Bank A estimates expected credit losses with the total amount of $50. In other words, loan loss allowance is increased by $50. Also, loan loss provision is increased by the same amount of $50.

Since loan loss provision is an expense in income statement, it decreases Bank A's profit by $50. Since profit account is closed to retained earnings, which are part of capital, capital is also decreased by $50, the same amount as profit.

Therefore, the following is Bank A's balance sheet as of December 31, 2007 when considering loan credit losses.

Assets			Liabilities	
Reserves and Cash		$ 100	Deposits	$ 650
Securities and Investment		40	Borrowings	250
Total Loans	890		Equity Capital	50
Less Loan Loss Allowance	(80)			
Net Loans		810		
Total		$950	Total	$950

Further suppose that Bank A has interest income of $70 and receives in cash. Bank A records this transaction as follows.

Dr. Cash	$70	
Cr. Interest Income		$70

Interest income increases profit and retained earnings by $70. Therefore, capital is also increased by $70. The following is Bank A's balance sheet as of December 31, 2007 when taking both loan credit losses and interest income into account.

Assets			Liabilities	
Reserves and Cash		$ 170	Deposits	$ 650
Securities and Investment		40	Borrowings	250
Total Loans	890		Equity Capital	120
Less Loan Loss Allowance	(80)			
Net Loans		810		
Total		$1,020	Total	$1,020

As can be seen, the balance sheet is still balanced. Regarding equity capital, its beginning balance is $100 and ending balance is $120. The net increase is $20, which is the same amount as profit. Revenue in this case is interest income, which is $70 and expense is total loan loss provision, which is $50. Since profit is revenue reduced by expense, profit in this period is $20 ($70-$50).

3. Securitization Accounting

With securitization, banks cannot only transfer credit risk by removing loan out of their balance sheets but also receive fund to finance new loans. Each bank transfers loans to special purpose vehicle (SPV) or special purpose entity (SPE), which is usually owned by that bank. Statement of Financial Accounting Standards No. 140 requires that a transferor, which is a bank in this case, can remove loans from balance sheet only if the transfer is a true sale, meaning that "the transferor has surrendered control over transferred assets." All of three conditions are needed to satisfy. First, the transferred assets are isolated from the transferor. Second, transferee or SPE has the right to pledge or exchange the assets. Third, transferor does not maintain effective control over the transferred assets. If all three conditions are not satisfied, banks recognize this transaction as secured borrowing, not sale, and thus, cannot remove loans from balance sheets.

Moreover, in order to recognize gain on sale, SPE has to be a qualifying SPE (QSPE) as defined is this SFAS No. 140. It has to be distinct from the transferor and has limits on permitted activities, on assets a QSPE can hold, and on sales or other dispositions of assets.

In addition, a QSPE is not included when transferor prepares consolidated financial statements. Therefore, transferred loans, which are assets on balance sheet of a QSPE, are not shown in transferor's balance sheet.

Since securitization has been first developed for mortgage loans, the characteristics of mortgage banks can also be applied for other banks that have securitization. Ryan (2000) indicates that mortgage banks have three main assets on balance sheets. The first type is mortgages and mortgage-backed securities (MBS) held

for sales. The second one is retained securities from securitization. If underlying mortgage is more risky, mortgage banks have to hold more retained securities or provide credit enhancement in order to attract more investors. Finally, the third type is mortgage servicing rights (MSRs). Mortgage banks are servicers for billing, collecting payments, and customer services. The value of MSRs decreases in case of prepayment and default by borrowers. Moreover, mortgage banks may provide recourse and recognize recourse liability when selling mortgages. Regarding income statement, major revenues are mortgage loans origination fees, gains on sale of loans, and loan servicing revenues. Typically, gains on sales of subprime mortgage are higher than that of prime mortgages.

Banks with securitization usually operates in originate-to-distribute model and involves in securitization process by holding some portion of loans on balance sheets and selling the other portion to their SPVs.

Case 1: Selling Loans with No Retained Interest

Suppose that Bank B originates loans in the amount of $1,000. Out of carrying amount or book value of $1,000, Bank B wants to sell loans with carrying amount of $700 (book value) to its SPV for $800 (fair value or price paid). Since it is sale, gain or loss is recognized. In this case, gain is recognized since the amount received is higher than the amount of loans. Bank B records this transaction as follows.

Dr. Cash	$800	
Cr. Loans		$700
Gain on Sale		100

Case 2: Selling Loans with Retained Interests

Suppose that Bank C originates loans in the amount of $1,500. Out of carrying amount or book value of $1,500, Bank C wants to sell loans with carrying amount of $1,000 (book value) for $1,200 (fair value or price paid). However, Bank C also wants to hold retained securities and servicing rights. At the date of sale, Bank C has to measure fair value of loans sold, retained securities, and servicing right. Both retained securities and servicing right are retained assets and recorded at carrying amount or book value of loans sold based on relative fair value.

	Fair Value	Percentage of Fair Value	Allocated Carrying Amount
Loans Sold	$1,200	80.0	$800
Retained Securities	200	13.3	133
Servicing Rights	100	6.7	67
Total	1,500	100.0	$1,000

Total amount of allocated carrying amount is $1,000, which is from carrying amount or book value of loans sold. Bank C records this transaction as follows.

Dr. Cash	$1,200	
Securities	133	
Servicing Rights	67	
Cr. Loans		$1,000
Gain on Sale		400

Case 3: Selling Loans with Retained Interests and Recourse Obligation

In addition to retained assets as in case 2, Bank C also enters into recourse obligation to repurchase delinquent loans. This is retained liability and measured at fair value. At the date of sale, fair value of recourse obligation is $100. Bank C records this transaction as follows.

Dr. Cash	$1,200	
Securities	133	
Servicing Rights	67	
Cr. Loans		$1,000
Recourse Liability		100
Gain on Sale		300

Accounting for Transferee or SPV

SPV records purchased loans at fair value; therefore, regarding case 2 and case 3, SPV pay $1,200 to Bank C to buy loans. Therefore, the price paid is the fair value of purchased loans. SPV records this transaction as follows.

Dr. Investment in Receivable	$1,200	
Cr. Cash		$1,200

Moreover, SPV issues bonds or securities and sells them to investors. SPV records this transaction as follows.

Dr. Cash	$1,200	
Cr. Bonds		$1,200

Repurchase Agreements

Generally, when a transferor sells loans to SPV with repurchase agreement, that transferor still maintains effective control. Thus, this is not a sale and a transferor cannot remove loans from its balance sheet. However, Ryan (2000) notes that "SFAS no. 140 requires sale accounting to be applied even if issuers hold repurchase options on the transferred financial assets, as long as these options require the issuer to pay the fair value of these assets or do not otherwise provide a more than trivial benefit to the issuer."

In case of loan repurchases by banks, banks pay cash to SPVs at the fair value. Banks record this transaction as follows.

Dr. Loan (at fair value)	XX	
Cr. Cash (at fair value)		XX

SPVs record this transaction as follows.

Dr. Cash (at fair value)	XX	
Loss	XX	
Cr. Investment in Receivable (at book value)		XX

APPENDIX 2

DATA

1. Dataset

The dataset used in this study is quarterly data taken from the database of the Federal Reserve Bank of Chicago. (http://www.chicagofed.org/economic_research_and_data/weekly_report_of_assets_and_liabilities.cfm)

Commercial bank data is from Consolidated Reports of Condition and Income (Call Reports) or Form FFIEC 031. Bank holding company data is from Consolidated Financial Reports for Bank Holding Companies or Form FR Y-9C.

2. On-Balance Sheet Items

	Commercial Banks	Bank Holding Companies
Total assets	RCFD2170	BHCK2170
Total loans	RCFD2122	BHCK2122
Mortgage loans	RCON1430	BHDM1797+BHDM536 +BHDM5368
Total equity capital	RCFD3210	BHCK3210
Total risk-based capital ratio	RCFD7205	BHCK7205
Tier 1 risk-based capital ratio	RCFD7206	BHCK7206
Tier 1 leverage ratio	RCFD7204	BHCK7204
Loan loss allowance	RCFD3123	BHCK3123
Net income	RIAD4340	BHCK4340
Non-performing loans	RCFD1407+RCFD1403	BHCK1407+BHCK1403
Loans 90+ days late	RCFD1407	BHCK1407
Total loans not accruing	RCFD1403	BHCK1403
Liquid assets	RCFD0010+RCFD0213+ RCFD1290+RCFD1295+ RCFD8497+RCFD1287+ RCFD1293+RCFD1298+ RCFD8499+RCONB987	BHCK0010+BHCK0213+ BHCK1290+BHCK1295+ BHCK8497+BHCK1287+ BHCK1293+BHCK1298+ BHCK8499+BHDMB987

	Commercial Banks	Bank Holding Companies
Cash and balances due from depository institutions	RCFD0010	BHCK0010
U.S. Treasury securities	RCFD0213+RCFD1287	BHCK0213+BHCK1287
U.S. Government agency obligation (excluded mortgage-backed securities)	RCFD1290+RCFD1295+ RCFD1293+RCFD1298	BHCK1290+BHCK1295+ BHCK1293+BHCK1298
Securities issued by states and political subdivisions in the U.S.	RCFD8497+ RCFD8499	BHCK8497+BHCK8499
Federal funds sold	RCONB987	BHDMB987
Deposits (both noninterest-bearing and interest-bearing)	RCFD2200	BHDM6631+BHDM6636

3. Off-Balance Sheet Items

Outstanding principal balance of assets securitized by	Commercial Banks	Bank Holding Companies
1-4 Family residential loans (mortgages)	RCFDB705	BHCKB705
Home equity lines	RCFDB706	BHCKB706
Credit cards receivables	RCFDB707	BHCKB707
Auto loans	RCFDB708	BHCKB708
Other consumer loans	RCFDB709	BHCKB709
Commercial and industrial loans	RCFDB710	BHCKB710
All other loans	RCFDB711	BHCKB711

Banks disclose securitization activities in Schedule S in consolidated financial statements. The disclosed amount is the outstanding principal balance of assets sold and securitized with servicing retained or with recourse or other seller-provided credit enhancements.

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