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Loan Securitization, Bank Risk, and Efficiency

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Submitted in fulfilment of the requirements of the
Degree of Ph.D in Finance

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Abstract

The 2007-09 financial crisis highlighted the devastating impact of securitization on the stability of the banking system. However, studies on securitization are far from sufficient to show the impact on a bank's performance. To better understand the impact of securitization in order to prevent such crisis to happen again, I study bank loan securitization in this Ph.D. thesis.

This thesis aims to provide empirical explanations to answer two dilemmas in securitization literature. First, ambiguous results are presented in the impact of securitization on bank risk. Classic theories suggest that loan securitization allows securitizers to transfer the potential risk to outside investors and diversify the large exposure to a single shock by sharing this potential riskiness with all investors linked by securitized assets, which in turn decreases bank risk and increases the stability of financial system. However, recent evidence reveals that securitizers have the intention to ignore potential risk and take on more risk, introducing more risk into the financial system and increasing the level of bank riskiness. Second, securitization introduces a higher flexibility for banks to allocate their resources and increases bank efficiency accordingly. However, securitization process is closely linked to a large amount of upfront and managerial costs, which can lead to an additional burden to banks and decrease securitizers' efficiency. This thesis develops a synthetic empirical analysis and shows a short- and long-term impact of securitization on bank risk, and a positive impact on a bank's efficiency score. Details information are as follows.

In the first chapter, I provide an introduction of the thesis. In chapter two, I present a comprehensive introduction on securitization, including both background history, literature, and related empirical issues. I also provide detailed information on securitization transaction in practice. In the empirical method review, this thesis highlights the self-selection problem in securitization. For example, the impact of securitization on bank performance may simply depend on a bank's choice of whether to securitize their loans or not. In order to address such a problem, estimation methods including Heckman model,

instrumental variable analysis, propensity score matching and Difference-in-Difference analysis, are discussed.

From chapter three, I present empirical studies on the impact of bank securitization activities in the U.S. I first study the conflicts of the impact of securitization on bank risk. Risk transfer and diversification theories suggest that securitization reduce bank risk, while commentators blame the lending standard decrease as the main driver of the subprime crisis. Therefore, I conduct several methodologies to study the impact of securitization on bank risk in chapter three and the impact of securitization on the likelihood of bank failure in chapter four. The thesis studies the impact of securitzation on bank efficiency scores in Chapter five. The reported results suggest that bank loan securitization is associated with an efficiency increase effect. The reported results suggest that loan securitization allows banks to shift off undesirable risk through the true sale process, which in turn decreases bank's capital requirement due to a decreased risk of capital. Bank liquidity can also be increased by transferring the illiquid loans into marketable securities. Both effects increase a bank's financial flexibility and efficiency. The diversification of securitization also allows securitizers to allocate more of their resources efficiently. During the cross-variation analysis, results support the arguments above.

In chapter six, I review all empirical results and provide explanations on the results. First, a short- and long-term explanation of the impact of loan securitization is provided. That is, bank loan securitization could reduce bank risk within a short term through risk transfer and diversification effect but increases the likelihood of bank failure in the long run, because securitizers are more likely to lower the lending standard or pursue regulatory arbitrage. Recent development of the securitization studies and practice are also presented.

The last chapter concludes the study and point out the possible extensions of the study. This thesis provides extensive empirical results that adds to the extant studies on securitization.

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Author's Declaration

"I declare that, except where explicit reference is made to the contribution of others, that this dissertation is the result of my own work and has not been submitted for any other degree at the University of Glasgow or any other institution."

Printed Name: Zhizhen Chen

Signature:

Abbreviations

ABCP	Asset-backed Commercial Paper
ABS	Asset-Backed Securities
ATT	Average Treatment Effect on the Treated
BMA	Bond Market Association
BHC	Bank Holding Company
CLO	Collateralized Loan Obligation
CMBS	Commercial Mortgage-Backed Securities
CMO	Collateralized Mortgage Obligations
DEA	Data Envelopment Analysis
DiD	Difference-in-Difference Analysis
Fannie Mae	Federal National Mortgage Association
Freddie Mac	Federal Home Loan Mortgage Corporation
Ginnie Mae	Government National Mortgage Association
GSE	Government-Sponsored-Enterprise
HMDA	Home Mortgage Disclosure Act
IMF	International Monetary Fund
IV	Instrument Variable
MBS	Mortgage-Backed Securities
ML	Maximum Likelihood
MSA	Metropolitan Statistical Area
OBS	Off-Balance-Sheet
PSM	Propensity Score Matching
REMIC	Real Estate Mortgage Investment Conduits
RMBS	Residential-Mortgage-Backed Securities
Repo	Repurchase Agreement
SEM	Structural Equation Models
SIFMA	Securities Industry and Financial Markets Association
SPV	Special Purpose Vehicle
2SLS	Two-Stage Least Squares

Chapter 1
Introduction

The standard problem of external financing for banks is resolved by either direct or indirect finance method. In the former case, fund suppliers support demand through ownership participation (acquisition of equity positions) and/or the acquisition of debt instruments (for example, bonds) directly issued by the agents demanding the funds. In the latter case, fund supply is funneled to “in-between” agents, the financial intermediaries, which are then responsible for the allocation to demand. However, such intermediaries, e.g., commercial banks, may not able to satisfy the financing needs in the market due to the shortage of liquidity.

Traditionally, commercial banks stick to the hold-to-maturity banking model which requires originators to hold the illiquid loans until maturity. Since banks may grant loans as many as possible to pursue higher profits, the proportion of liquidity on their balance sheets decreases significantly. Loan securitization is a financial innovation that allows banks to transfer their illiquid assets into marketable securities, which in turn increases bank’s liquidity on the balance sheet. Thus, securitization contributes to the so-called shadow banking model of financial intermediation (Pozsar et al., 2010), which decomposes the simple process of deposit-funded, hold-to-maturity lending conducted by banks into a more complex, wholesale-funded, securitization-based lending process that involves a range of shadow banks. Securitization also allows banks to decrease their cost of capital (Pennacchi, 1988), and increases the performance (Casu et al., 2013). Therefore, the development of securitization enjoyed a dramatic increase before the 2007-09 financial crisis, as shown in Figure 1-1 and 1-2.

<Insert Figure 1-1 Here>

<Insert Figure 1-2 Here>

As shown in Figure 1-1, the proportion of held-for-sale loans (represented by the bars) reported increased substantially from the early 1990s. This proportion even reached the peak during the 2007-09 crisis. Since those banks accounted for roughly 80 percent of total commercial bank loans (the solid line) over the same period, it suggests that banks increasingly shifted from the originate-to-hold to an originate-to-securitize model of lending. More specifically, reports from the Home Mortgage Disclosure Act (HMDA) provide details for the residential mortgage subset of these securitized assets, revealing that actual loan origination by commercial banks has grown over time (Figure 1-2).

However, the development of securitization creates more possible problems. The 2007-09 financial crisis has been felt across virtually all economic sectors and in all parts of the world. Although the devastating impact of the crisis has been widespread, it roots originated from the financial sector and manifested itself first through disruptions in the system of financial intermediation. It is a common agreement among academics, practitioners and commentators that the crisis originated as a run on the liabilities of issuers of asset-backed commercial paper (ABCP), a short-term funding instrument used to finance asset portfolios of long-term maturities (e.g., Gorton, 2010; Covitz, Liang, and Suarez, 2009; Acharya, Schnabl, and Suarez, 2013; Kacperczyk and Schnabl, 2010). In this sense, ABCP issuers (conduits) perform typical financial intermediation functions, but they are not banks. Certainly, in many instances banks were the driving force behind ABCP funding growth, sponsoring conduit activity and providing the needed liquidity and credit enhancements. But the main point is that ABCP financing shifts a component of financial intermediation away from the traditional location—the bank’s own balance sheet. Similarly, and concurrently with the ABCP disruptions, financial markets also witnessed a bank-like run on investors that funded their balance sheet through repurchase agreement (repo) transactions, another form of financial intermediation that grew rapidly but did not take place on bank balance sheets (Gorton 2010; Gorton and Metrick 2012). Additionally, in the aftermath of Lehman Brothers’ default, money market mutual funds, yet another class of nonbank entities that serve as financial intermediaries, experienced a run on their liabilities, an event that triggered in turn an even bigger run on ABCP issuers (Acharya, Schnabl, and Suarez, 2013). However, the impact of securitization on bank’s risk and efficiency is far from conclusion.

The first dilemma in the literature is the impact of loan securitization on bank risk. On the one hand, securitization includes a true sale process of the underlying assets to SPVs, which confirms the ownership transferred to the security buyers (Affinito and Tagliaferri, 2010; Franke, Herrmann, and Webber; 2011), leading to a risk transfer effect. The tranching process of securitization creates securities with different riskiness levels and allows investors to buy based on their risk preferences, attracting a large number of investors to share the potential risk within the securitization network. Therefore, the classic securitization theory suggests that loan securitization will decrease bank risk and increase financial system's stability. However, the asymmetric information embed in the securitization process encourages securitizers to take this advantage and in turn take on more risk such as granting more risky loans without careful screening (Morrison, 2005; Parlour and Plantin, 2008) and lack of monitoring incentives (Key et al., 2012; Wang and Xia, 2014). This is also considered as the main reason caused the 2007-09 subprime crisis in the U.S., supported by a number of studies during the aftermath of crisis (e.g., Agarwal, Chang and Yavas, 2012). The second dilemma falls into the topic of efficiency. By creating new external sources for securitizers, loan securitization increases a bank's performance in allocating the financial resources, which in turn increases the efficiency. However, information asymmetry triggers the related financial costs such as credit ratings and extra monitoring from the third parties. Meanwhile, conducting a securitization process requires a large amount of upfront and legal costs, which will in turn decrease the available sources of finance and the efficiency score. This thesis aims to answer both questions and provide empirical evidence to explain the existed dilemmas using a step by step analysis strategy in each chapter.

In Chapter two, a comprehensive discussion is provided to explain securitization including its background, process, and theories. To focus on the core topic of this thesis, the theories are closely related to the impact of securitization on bank's performance, risk and efficiency. Securitization is related to self-selection problems. Therefore, methodological explanations on self-selection bias, and the related empirical strategies, such as Heckman self-selection model, and propensity score matching (PSM) approach are discussed in detail.

The relationship between securitization and bank risk is the focus in chapter three. Bank risk measure using $\boldsymbol{Zscore}$ and the OLS method as the baseline framework is implemented in the study. To address the endogeneity problem, several identification strategies, e.g., the Heckman self-selection model, two-stage least squares approach, and PSM method are implemented. All methods yield consistent and robust results. The reported results suggest that bank loan securitization could decrease bank risk measured by $\boldsymbol{Zscore}$. This finding confirms the risk transfer theory of securitization. The breakout of the 2007-09 financial crisis changes the liquidity in the market dramatically, which can, in turn, lead to fundamental variations in securitization. Hence, the sample period is divided into pre- and post-crisis subsamples. The split sample results show that the economic impact of securitization on bank risk decreases significantly after the breakout of the crisis, although the risk reduction effect still holds. It can be argued that the liquidity shortage in the secondary market broke down the chain in securitization which was meant to keep funding new projects, which in turn decreased its impact and magnitude. To shed more light on the risk transfer argument, securitization is decomposed into mortgage and non-mortgage categories. The results suggest that non-mortgage securitization is more significantly associated with risk reduction than mortgage securitization. It also suggests that non-mortgage loans are, on average, riskier than mortgage loans, which further confirms the risk transfer theory. In the additional analysis, a test of the impact of loan sale activities report similar impact with securitization.

In Chapter four, a study of the impact of securitization on the likelihood of bank failure is investigated. Based on the survival analysis using Cox model, the reported results suggest that loan securitization increases the likelihood of bank failure. The robust test employs weighted-least-squares to address the endogeneity problem, which reports consistent results. Securitization is also decomposed into mortgage and non-mortgage securitizations, and the reported results suggest that the impact on the likelihood of bank failure is more significant for mortgage securitization. It can be argued that securitization of high quality mortgage loans is more attractive to investors, and a more standard process to securitize mortgages makes securitizers to easily securitize mortgage loans, which in turn increases the incentive of securitizers to be more reckless when granting loans. Loan quality is decreased and so as the likelihood of bank failure.

In Chapter five, the impact of loan securitization on bank efficiency is discussed. A measure of bank efficiency using efficiency scores which are estimated from the DEA model is implemented. The analysis is based on the Heckman self-selection model, panel Heckman self-selection model, propensity score matching method, and the Difference-in-Difference method which are used to address the possible endogeneity problem. All reported results are consistent and robust. Overall the results show that securitization increases bank efficiency. To find the possible channels through which securitization could impact on bank efficiency, a cross-variation regressions is run between securitization ratio and several bank-specific variables. The reported results show that the efficiency increase effect of securitization is more significant for those banks with higher capital ratio and bank risk, as well as lower liquidity and diversification levels.

In Chapter six, the results of chapters three and four are reviewed and a short- and long-term explanation of the impact of securitization on bank risk is discussed. The overall conclusion is that loan securitization can reduce bank risk within a short term due to risk transfer and diversification effect but increases the likelihood of bank failure in the long run because securitizers are more likely to lower their lending standards and pursue regulatory arbitrage opportunities. The explanations on the mechanisms are as follows. Loan securitization allows securitizers to transfer the potential risk to outside investors and diversify the large exposure to a single shock by sharing this potential riskiness with all investors linked by securitized assets, which in turn decreases bank risk and increases the stability of financial system.Securitization can increase the likelihood of bank failure because securitizers have the intention to ignore potential risk and take on more risk, introducing more risk into the financial system and increasing the level of bank riskiness. A bank’s efficiency can be improved because securitization introduces a higher flexibility for banks to allocate their resources.

Chapter seven discusses the limitations and possible future studies, as well as the conclusion of the thesis.

Chapter 2
Introduction of securitization

2.1 The development of securitization

2.1.1 Background history

Securitization refers to packaging and selling of a bank's illiquid assets backed by securities. Specifically, securitization is the financial practice of pooling various types of contractual debt, such as residential mortgages, commercial mortgages, auto loans, or credit card debt obligations, and selling said consolidated debt as pass-through securities, or collateralized mortgage obligations (CMOs) to various outside investors. The cash collected from the financial instruments underlying the security is paid to the various investors who had advanced money for that right. There are mainly two different types of securities, residential-mortgage-backed securities (RMBS) and asset-backed securities (ABS). RMBS are the securities which backed by residential mortgage receivables, while ABS are backed by other types of receivables.

Securitizing practice can be found, at least, as far back as the 18th century in Netherland (Frehen et al., 2014). Early examples of mortgage-backed securities (MBS) in the U.S. were the farm railroad mortgage bonds of the mid-19th century, which contributed to the panic of 1857 (Riddiough and Thompson, 2012). Regards to the first modern residential mortgage-backed securities, the U.S. Department of Housing and Urban Development created it in February, 1970 (Deutsche Bundesbank Monthly Report, 1997). Starting in the 1990s with some earlier private transactions, securitization was applied to a number of sectors of the reinsurance and insurance markets, including life and catastrophe. This activity grew to nearly 15 billion U.S. Dollar of issuance in 2006.

Modern securitization took off in the late 1990s and early 2000s, thanks to the innovative structures implemented across the asset classes, such as UK Mortgage Master Trusts (a concept imported from US credit cards), insurance-backed transactions, and more esoteric asset classes like the securitization of lottery receivables. The Bond Market Association (BMA) in the United States estimates that, the total amount outstanding at the end of 2004 was $1.8 trillion. This amount represented about 8% of total outstanding bond market debt ($23.6 trillion), about 33% of mortgage-related debt ($5.5 trillion), and about 39% of corporate debt ($4.7 trillion) in the U.S. In nominal terms, the ABS amount outstanding grew, between 1995 and 2004, by about 19% annually, with mortgage-related debt and corporate debt growing at about 9%. According to the data of Security Industry and Financial Market Association (SIFMA), the outstanding ABS in the U.S. has risen from $520 billion to $2972 billion between 1997 and 2007, an increase of nearly 500 percent. (see Figure 2-1)

<Insert Figure 2-1 Here>

Between the early 1990s and 2008, the scale of securitization market enjoyed a tremendous expansion around the world. In the U.S., the outstanding volume of mortgage-backed securities increased from $2.49 trillion in 1996 to $8.9 trillion by the end of 2008, while the market for asset-backed securities reached $2.67 trillion by the end of 2008 compared with $0.4 trillion in 1996. In Europe, the outstanding volume of mortgage-backed securities reached €1.21 trillion at the end of 2008, while the market for asset-backed securities reached €0.19 trillion (Securities Industry and Financial Markets Association (SIFMA)). According to the International Monetary Fund (IMF), between 20% and 60% of the funding for new residential mortgage loans originated in mature economies before the credit crisis of 2008. After this extended period of rapid expansion, securitization markets froze in late 2008 following the collapse of Lehman Brothers. The impact of the crisis on securitization markets has since been well documented (see, for example, Brunnermeier, 2009; Gorton, 2010; BIS, 2011).

2.1.2 The securitization transaction

2.1.2.1 The off-balance-sheet activities

Traditionally, banks are not closely linked with financial securities which can be easily transferred to liquidity. Those securities, e.g., stocks and bonds, are marketable because they are anonymous, in the sense that the identity of the holder is irrelevant. Banks usually deal with specific financial contracts, e.g., loans and deposits, which cannot easily be resold. Therefore, banks typically must hold these contracts in their balance sheets until the contracts expire. Since granting only fully collateralized projects is not efficient, banks have to screen borrowers and monitor loans to control the credit risk. Also, when transforming maturities or when issuing liquid deposits guaranteed by illiquid loans, a bank takes a risk combined by interest rate risk and liquidity risk. Interest rate risk is due to the difference in maturity. Bank's cost of funds depends on the level of short-term interest rates, which is determined by the contractual interest rates of the loans granted by the bank. It is reasonable that this predetermined interest rate may rise above the interest income. Even when no interest is paid on deposits, the bank still has the possibility to face unexpected withdrawals, which will force it to seek more expensive sources of funds. Thus, this difference between the marketability of the claims issued and that of the claims held creates the liquidity risk.

Due to the disadvantages above of the traditional banking model, as well as the increased competition from financial markets, it is necessary for banks to shift to more value-added products, which were better adapted to the needs of customers. From the 1980s, banks started operating sophisticated contracts, such as loan commitments, credit lines, and guarantees. They also developed their offer of swaps, hedging contracts, and securities underwriting. From an accounting viewpoint, none of these operations corresponds to a genuine liability (or asset) for the bank but only to a conditional commitment. Those activities hence are classified as off-balance-sheet (OBS) operations. One of those off-balance-sheet financial innovations is loan securitization.

2.1.2.2 The "originate-to-distribute" model

Traditionally, banks use deposits to fund loans that they will keep on their balance sheets until maturity. However, the development of securitization changes this traditional banking model from "originate-to-hold" to "originate-to-distribute". That is, banks are granting loans to securitize them in the market later on. In fact, the origination of loans is now just the first step in a longer sequence.

Securitization involves the following steps: (1) a sponsor or originator of receivables sets up the bankruptcy-remote special purpose vehicle (SPV), pools the receivables, and transfers them to the SPV as a true sale; (2) the cash flows are tranched into asset-backed securities, the most senior of which are rated and issued in the market; (3) the proceeds are used to purchase the receivables from the sponsor; (4) the pool revolves, in that over a period of time the principal received on the underlying receivables is used to purchase new receivables; and (5) there is a final amortization period, during which all payments received from the receivables are used to pay down tranche principal amounts.

It is notable that credit card receivables are different from other pools of underlying loans because the underlying loan to the consumer is a revolving credit. For example, unlike automobile or student loans, credit card receivables have no natural maturity. Consequently, the maturity of the SPV debt is determined arbitrarily by stating that receivable payments after a certain date are "principal" payments.

Figure 2-2 shows a schematic process of a typical securitization transaction (from Gorton and Souleles, 2007). The diagram shows the two key steps in the securitization process: pooling and tranching. Pooling and tranching correspond to different types of risk. Pooling minimizes the potential adverse selection problem associated with the selection of the assets to be sold to the SPV. Conditional on selection of the assets, tranching divides the risk of loss due to default based on seniority. Since tranching is based on seniority, the risk of loss due to default of the underlying assets is stratified, with the residual risks borne by the sponsor.

<Insert Figure 2-2 Here>

2.1.3 The role of banks in securitization

To better understand securitization and the possible problems stem from this financial innovation, this section presents the specific structure of a securitization transaction and introduces the key players as well.

2.1.3.1 Types of asset securitization

A. Agency Mortgage-Backed Securities

Securitization market started from the agency mortgage market, which began in the early 1970s when the Government National Mortgage Association (Ginnie Mae) used structured finance techniques to pool government-sponsored mortgage loans. These structures were later embraced by the Federal Home Loan Mortgage Corporation (Freddie Mac) and the Federal National Mortgage Association (Fannie Mae), which forms the agency securitization market. This agency securitization market provides a convenient platform for mortgage-backed securities to be passed through, which makes it possible for a seamless transfer of cash flows from the originators to security investors.

In order to satisfy investors' needs of more diversified mortgage securities with different maturities or interest rate characteristics, more complicated securitization products, such as collateralized mortgage obligations (CMOs), are invented. Such collateralized mortgage obligations are used to transform or resecuritize existing agency mortgage-back securities. Simply speaking, they are the securitization on securitized assets. These financial innovations greatly expand the role of Freddie Mac and Fannie Mae to the secondary market and enhance the credit availability in the housing market (Fabozzi and Dunlevy 2001).

B. Nonagency Asset-Backed Securities

Apart from the traditional agency securitization structures, the nonagency securitization market began to become popular from the Tax Reform Act of 1986. This act legally consents the creation of real estate mortgage investment conduits (REMICs), which is a watershed in the development of securitization market. Since this accounting vehicle, the REMICs, essentially allows originators to transfer their assets into a bankruptcy-remote trust that is insulated from the performance of the asset issuer, the development of the nonagency securitization market has been spurred from then. For example, benefited from alternative credit enhancement structures, the growth in the securitization of nonconforming mortgage-backed securities enjoyed an explosive jump. The nonconforming mortgage market, or the private-label securities market, consists of loans that are too large to meet the agencies' size limits. In 1995, the longstanding Community Reinvestment Act was modified to encourage the securitization of lower-credit-quality loans. An environment of lower interest rates also made homeownership affordable, allowing borrowers to refinance and consolidate their debt.

Other than policy change, technological innovations and advanced credit-scoring systems also played a critical role in automating underwriting procedures and lowering borrowing costs. These financial innovations and lower underwriting standards spurred the rapid growth of the subprime mortgage market. According to the Inside Mortgage Finance, for example, the size of the subprime market increased from nearly $65 billion in 1995 to around $1.3 trillion in 2007 before the crisis.

Of course, to decrease the potential risk, the construction of a REMIC requires the underlying collateral assets must be static. That is, the collateral of REMIC should be a real property or a real property derivative, which means the REMIC structure cannot be applied to a large subset of cash-flow-producing assets, such as car loans, revolving credit card receivables, lease receivables, student loans, corporate debt, and commercial real estate loans. To fill this gap, asset securitization has relied on several alternative bankruptcy-remote structures. The primary mechanisms for securitizing nonmortgage assets are provided by a variety of common-law trusts and revolving special-purpose entities such as master trusts and commercial paper conduits.

C. Classification of Nonagency Securities

The development of securitization creates a large amount of complicated structured derivatives. Therefore, it is helpful to clearly classify such financial tools in securitization market, especially those nonagency securities. The classification and terminology for nonagency asset-backed securities will follow the Securities Industry and Financial Markets Association (SIFMA).

First, though it is true that the term asset-backed security (ABS) is used to describe any structured security that is backed by an asset's cash flows, SIFMA uses this definition more narrowly to refer to such asset receivables other than direct mortgage loans. Securities backed by mortgage loans are commonly described as mortgage-backed securities. Therefore, the class of asset-backed securities represents a wide variety of consumer finance assets, including home equity loan, home equity lines of credit products, automobile loans, credit card receivables, student loans, consumer loans, and other lease financing receivable structures which can be more exotic.

Within the category of mortgage-backed securities, there are two majorities of subgroups. The first subgroup is called the private-label MBS, which is based on prime or Alt-A nonagency mortgage products, while the second subgroup is the subprime MBS which derived from subprime mortgages. Also, there is another category named as commercial mortgage-backed securities (CMBS), which are structures backed by commercial real estate loans.

Last, another important asset-backed class is the collateralized debt obligation (CDO). CDOs backed by corporate loans are referred to as the collateralized loan obligations (CLOs), while CDOs backed by corporate bonds are referred to as the collateralized bond obligations (CBOs). Many of the recent and complex multiclass CDO securities that are based on existing nonagency MBS are often referred to as “the CDO squared.” Over the last few years, an important category to emerge is synthetic CDOs. This class of CDOs relies on credit derivatives which are typically the credit default swaps to transfer asset risks and cash flow payments between investors and issuers.

Arguably, CDO securities represent some of the most unique and intricate securitization structures. The typical MBS derives its cash flow from a large pool of homogenous mortgage loans. In contrast, the most basic CDO comprises a small number of corporate debt obligations. The CDO collateral may include business loans, e.g., leveraged loans, revolving credit facilities, and term loans, corporate bonds, and even other asset-backed securities.

In addition to the usual benefits of securitization outlined previously, CDO sponsors may be motivated by arbitrage incentives, aiming to profit from purchasing and securitizing corporate debt or other assets at favourable prices. Such a CDO security is typically referred to as an arbitrage CDO. If the originator securitizes its own assets (corporate loans, bonds, and other large receivables), then the CDO is known as a balance sheet CDO (see Bond Market Association, 2004). Most of the earlier CDOs were static, meaning that the underlying collateral was held over the life of the security. Concerned by the rise in corporate distress during the 2000s, some investors preferred a managed CDO structure, in which the issuer was more proactive in managing credit exposure.

2.1.3.2 Key players in securitization

Although bank loan securitization is simply referred to an originator selling their loans to security buyers, the securitization process includes five main participants in the process, that is, the issuer, the underwriter, the rating agency, the servicer, and the trustee. A representative securitization deal is showed in Figure 2-3, according to Cetorelli and Peristiani (2012).

<Insert Figure 2-3 Here>

In a typical securitization process represented in the exhibit, all of the securitized assets are pooled together and sold to an external legal entity, often referred to as a special-purpose vehicle (SPV). The SPV buys the assets from the issuer with funds raised from the buyers of the security tranches issued by the SPV. The transfer of the assets to the SPV has the legal implication of obtaining a true sale opinion that removes issuer ownership and insulates asset-backed investors in the event of an issuer bankruptcy. The SPV often transfers the assets to another special-purpose entity, which typically a trust. This second entity actually issues the security shares backed by those assets under GAAP sale rules outlined in the Financial Accounting Standards Board’s Statement No. 125.

It is notable that the securitization methods used in CMBS are similar to those employed in MBS, but with the difference that the underlying collateral consists of commercial mortgages that derive their principal and interest cash flows from property assets. However, there are some distinct operational and structural features in CMBS. First, CMBS do not burden the investor with significant interest rate risks because commercial mortgages do not generally have a prepayment feature. Commercial real estate lending is dominated by banks and life insurance companies. Banks typically lend shorter-term financing; in comparison, life insurance firms, motivated by the long-dated structure of their liabilities, prefer to provide longer-term real estate loans. Although investment banks are not typically large providers of commercial real estate credit, they are important in the credit intermediation process of real estate finance as lead underwriters in the syndicated loan market. However, in any securitization process, such complicated process requires the collaborations of other institutions. The following paragraphs introduce those financial institutions.

A. The issuer

The first step in the securitization process is issuance, the process of assembling the underlying collateral creating the asset-backed security. The issuer, which is also referred to as the sponsor or originator, is the beginning of the entire process. The issuer brings together the collateral assets for the asset-backed security. Issuers are often the loan originators of the portfolio of securitized assets because structured finance offers a convenient outlet for financial firms like banks, finance companies, and mortgage companies to sell their assets.

The issuer is closely linked with the lender, and sometimes these two functions overlap. The structure therefore depends on the type of collateral. Consumer auto finance lenders and large retail banks would be expected to dominate auto securitizations, while banks, nonbank mortgage lenders, and thrifts would compete more effectively in the private-label and MBS sectors.

Another important innovation in structured finance is the synthetic CDO, in which the cash flows stem from a credit default swap (CDS) derivative contract written on a reference portfolio of corporate bonds, loans, and CDS indexes. The role of the issuing SPV in a synthetic CDO is very different. In contrast to the more traditional asset-backed structure, in which the SPV draws cash flows from a pool of underlying assets, in a synthetic CDO the entity sells protection on the reference portfolio. The SPV and its investors derive cash flows from the premiums paid by the CDS protection buyers (typically a commercial or investment bank), but are liable for all credit events.

These more complex managed or synthetic CDO structures are more demanding on issuers. Managed CDOs require expertise in corporate debt markets in order to deal with credit exposures. Issuers of synthetic CDOs need to properly price the CDS protection of the reference portfolio. Providing such additional responsibilities, the role of the issuer in CDOs is typically referred to as collateral manager.

B. The servicer

The servicer is responsible for processing payments and interacting with borrowers, implementing the collection measures prescribed by the pooling and servicing agreements and, if needed, liquidating the collateral in the event of default. In cases in which the issuer is also the lender of the underlying assets, there is a greater likelihood that the issuer would retain these servicing rights. In addition to managing payment flows, servicers are expected to provide administrative help to the trustee.

Throughout the life-span of the structured securities, the servicer has several fiduciary responsibilities. First, the servicer is responsible to collect payments generated from the underlying assets. Second, the servicer has to transfer payments to accounts managed by the trustee. Last, the servicer should to manage deposits and investments of the revenue streams on behalf of the trustee. All functions above are referred to as primary or master servicer. In addition to the traditional servicer function, some ABS transactions may involve variations of these responsibilities. Sometimes the primary or master servicer responsibility may be transferred to a special or backup servicer if the loan or other asset in the security defaults.

Such specialized role requires the servicer to retain all loan or security-specific information in order to collect and divert cash flows as well as track performance. These duties are therefore easier to perform for an entity associated with the lender of the asset- backed-security collateral. The close links between servicing, issuing, and lending suggest that these roles are often combined.

C. The underwriter

The underwriter is the entity that assumes responsibility for structuring the asset-backed security (for example, designing the composition of tranches, and the size and type of credit and liquidity enhancements) based on the characteristics of the collateral and existing market conditions. The role of underwriters in structured finance is similar to that in other methods of securities issuance. Asset-backed- security underwriters fulfil traditional arranger roles of representing the issuer (here, the SPV or trust). The primary job of the underwriter is to analyze investor demand and design the structure of the security tranches accordingly.

Underwriters are also in charge of the actual securities sales, typically acquiring the securities from the special-purpose entities and therefore bearing some of the initial risks associated with the transactions. Consistent with traditional, negotiated cash-offer practices, underwriters of asset-backed bonds would buy at a discount a specified amount of the offer before reselling to investors. In addition to marketing and selling these securities, underwriters provide liquidity support in the secondary trading market. Because asset-backed securities trade in over-the-counter markets, the willingness of underwriters to participate as broker-dealers by maintaining an inventory and making a market enhances the issuance process. Working closely with the rating agencies, the underwriter helps design the tranche structure of the SPV to accommodate investors' risk preferences.

Investment banks have traditionally fulfilled this role in bond and equity financing, arranging and selling the offering for issuing firms. Commercial banks bring an additional dimension to the underwriting process by enhancing certification stemming from joint-production informational advantages (gathered primarily from screening and monitoring borrowers) that can be shared with investors. These certification benefits also are present in asset-backed securities such as CMBS or collateralized loan obligations, where the bank has private information on the credit quality of the borrower. Essentially, a bank is an information specialist that can bridge the certification gap between issuers and investors.

D. The rating agency

Rating agencies provide certification services to investors who need to carry out a due-diligence investigation of the underlying assets and evaluate the structure of the security. Ratings are necessary because many large institutional investors and regulated financial firms are required to hold mostly investment-grade assets. Under the guidance of rating agencies, the expected cash flows from securitized assets are redirected by the underwriter into multiple tranches. The rating agencies played a critical role in the rapid growth of structured finance in the United States over the past two decades.

Although asset-backed-security ratings of subordination structures vary across product types, most of them rely on a common blueprint. These securities are typically structured notes, meaning that the collateral cash flows are distributed into several separate tranches. Asset-backed tranches usually have different risk ratings and different maturities derived from the same pool of assets. The diversity in tranches makes them more appealing to a heterogeneous pool of investors with various risk preferences and investment objectives. The core components of each security include a number of senior tranches rated AAA, a class of subordinate tranches with a rating below AAA, and an unrated residual equity tranche. The senior tranches receive overcollateralization protection, meaning that credit losses would initially be absorbed by these subordinate classes. Sometimes junior (mezzanine) below- AAA classes that are subordinate to senior classes may also have a buffer of protection from the residual tranche or receive other credit enhancements. The remaining cash flows are distributed to the residual (equity) certificateholders. The residual investors receive any leftover cash flows, but have no claim on the collateral until all obligations to the more senior classes of securities are fully met.

In addition to overcollateralization cushions, several other ancillary enhancements are put in place to further protect investors from default and other risks (such as liquidity risk, currency fluctuation risk, and interest rate risk). In contrast to overcollateralization buffers that are built into the security internally, these credit enhancements are provided for a fee from a third party. For example, it was a common practice in the early years of nonagency mortgage securitization to buy credit bond insurance (often referred to as a wrap) from independent insurance providers. Foreign exchange and interest rate swaps are sometimes used to improve the overall risk profile of the security, making it more attractive and easier to price for investors. In addition, the SPV may lower risk exposures by obtaining a letter of credit or an asset-swap agreement.

Although a bank in the traditional model of intermediation performs all these roles, its compensation is determined implicitly by the asset-liability contracts. With asset securitization, however, the same roles can be played by multiple entities, each compensated separately for its services. This proliferation of markets and entities involved in the securitization process is perhaps the main reason why the modern system of intermediation seems so hard to decipher. We hope this study contributes to enhanced understanding of its main dynamics.

E. The trustee

The transactions of the special-purpose entity that buys the loans are typically handled by a trustee. The trustee is an independent firm with the fiduciary responsibility for managing the SPV/trust and representing the rights of the investors. The primary role of the trustee is to disperse payments to investors and to oversee the security on behalf of the investors by collecting information from the servicer and issuer while validating the performance of the underlying collateral.

The trustee guarantees that the transactions are administered in accordance with the related documentation and, in a cost-effective manner, takes care of the physical delivery of the securities, follows compliance and performance-related matters, and handles cash and information processing for the noteholders. Significantly, a trustee must work closely with the issuer and servicer to protect the welfare of the investors. In contrast to the roles of issuer or servicer, which can be combined, a trustee should be an independent entity whose sole purpose is to represent the investor and thus eliminate any conflict-of- interest problems. Given the administrative nature of the trustee business, this service is best suited to large custodian banks with a cost-effective back-office infrastructure to process the information.

Based on the arguments above, banks are the predominant force in the securitization market. For example, Cetorelli and Peristiani (2012) highlight the fact that trustee business in securitization is dominated by a small group of custodian banks. Banks' market share remained well over 90% before 2008. These trustee banks are best suited to processing information and acting on behalf of investors. Also, banks have issued about half of the nonagency asset-backed securities.

2.1.3.3 Credit enhancements

It is notable that in the securitization process at a number of stages, the provision of credit enhancements is of crucial importance, especially to attract institutional investors (Pagano and Volpin, 2010). Credit enhancements are protection, in the form of financial support, to cover losses on securitized assets in adverse conditions (Standard and Poor's, 2008). Thus, credit enhancements enable banks to convert pools of even poorly rated loans or mortgages into highly rated securities. Some enhancements, such as standby letters of credit, are very much in the spirit of traditional banking and are thus far from the world of shadow banking. The level of credit enhancements necessary to achieve a given rating is determined by a fairly mechanical procedure that reflects a rater's estimated loss function on the underlying collateral in the securitization (Ashcraft and Schuermann 2008). If estimated losses are high, then more enhancements are called for to achieve a given rating.

Credit enhancements might also be used to solve part of the asymmetric information problems that may plague the securitization process. If banks are better informed than outside investors about the quality of the assets they are securitizing, as they almost certainly are, banks that are securitizing higher-quality assets may use enhancements as a signal of their quality. In other words, by their willingness to keep "skin in the game" to retain some risk, banks can signal their faith in the quality of their assets.

Such signalling implies a positive relationship between the level of enhancements and the performance of securitized assets, just the opposite of the buffer explanation. Obviously, enhancements could, and probably do, serve both as a buffer against observable risk and a signal against unobservable (to outsiders) quality. However, since the buffer role is almost self-evidently true, we are interested in whether we can detect any evidence for the role of securitization enhancements as a signal. Others have also considered the hypothesis that enhancements might play a signalling role. Downing, Jaffee, and Wallace (2009) observe that asymmetric information about prepayment risk in the government-sponsored-enterprise (GSE) mortgage-backed-security market should motivate the use of signalling devices. Albertazzi et al. (2011) note the potential centrality of asymmetric information to the securitization process and conjecture that a securitizing sponsor can keep a junior (equity) tranche “as a signalling” device of its (unobservable) quality or as an expression of a commitment to continue monitoring. James (2010) comments that if asset-backed securities include a moral hazard (or “lemons”) discount due to asymmetric information, issuers have an incentive to retain some risk “as a way of demonstrating higher underwriting standards.”

A variant of the question we are asking about credit enhancements showed up in earlier literature on the role of collateral in traditional (on-the-books) bank lending. A theoretical literature in the 1980s predicted that in the context of asymmetric information, safer borrowers were more likely to pledge collateral to distinguish themselves from riskier ones (Besanko and Thakor 1987; Chan and Kanatas 1985). However, an empirical study by Berger and Udell (1990) found strong evidence against the signalling hypothesis: that is, collateral was associated with riskier borrowers and loans. In other words, when it comes to loans on the books, collateral seems to serve more as a buffer against observable risk than as a signal of unobservable quality.

While credit enhancements can take many forms, this research refers to the Schedule HC-S from FR-Y-9C report. Schedule HC-S is a sector of FR-Y-9C form reporting activities of “Servicing, Securitization, and Asset Sale Activities”. Three types of credit enhancements are provided.

The first type of credit enhancement is credit-enhancing, interest-only strips. Schedule HC-S instructions define these strips as: an on-balance-sheet asset that, in form or in substance, a) represents the contractual right to receive some or all of the interests due on the transferred assets; and b) exposes the bank to credit risk that exceeds its pro-rata share claim on the underlying assets whether through subordination provisions or other credit-enhancing techniques.

The HC-S instructions also note that the field for credit-enhancing, interest-only strips can include excess spread accounts. Excess spread is the monthly revenue remaining on a securitization after all payments to investors, servicing fees, and charge-offs. As such, excess spread—a measure of how profitable the securitization is—provides assurance to investors in the deal that they will be paid as promised. Excess spread accounts are the first line of defence against losses to investors, as the accounts must be exhausted before even the most subordinated investors incur losses.

The second class of credit enhancements is subordinated securities and other residual interest, which is a standard-form credit enhancement. By holding a subordinated or junior claim, the bank that securitized the assets is in the position of being a first- loss bearer, thereby providing protection to more senior claimants. In that sense, subordination serves basically as a buffer or collateral. However, in the asymmetric information context, holding a subordinate claim gives the bank the stake that can motivate it to screen the loans carefully before it securitizes them and to continue monitoring the loans after it securitizes them. The bank's willingness to keep some risk may serve as a signal that it has screened loans adequately and plans to monitor diligently.

The last form of credit enhancements is standby letters of credit, which obligates the bank to provide funding to a securitization structure to ensure that investors receive timely payment on the issued securities (e.g., by smoothing timing differences in the receipt of interest and principal payments) or to ensure that investors receive payment in the event of market disruptions. The facility is counted as an enhancement if and only if advances through the facility are subordinate to other claims on the cash flow from the securitized assets. Although not technically classified as an enhancement, a fourth item on Schedule HC-S that we consider is unused commitments to provide liquidity. Unused commitments represent the undrawn balance on previous commitments.

2.1.4 The impact of securitization

A comprehensive literature review on the impact of securitization is provided in this section, including the pros and cons, determinants and restrictions of securitization.

2.1.4.1 The advantage of securitization

The reason why securitization has enjoyed a dramatic growth before the 2007-09 financial crisis is due to the following benefits. First, securitization improves bank's liquidity by transforming the illiquid loans into marketable securities. Traditionally, banks tend to hold their loan portfolios until maturity. Since liquid funds and loans are two core components of bank assets, the increase in loan proportions indicates a decrease in the liquid funds holdings. In this case, the insufficient liquidity may prevent banks from pursuing other profitable investment opportunities or finance new credit based on their own willingness. Although loan sale can be considered as an alternative option for banks requiring additional liquidity, loan portfolios are identified as too cumbersome and expensive to sell by traditional literature (Diamond and Dybvig, 1983; Holmstrom and Tirole, 1998; Kashyap, Rajan, and Stein, 2002). With securitization, banks are able to liquidate loans to finance their liquidity need by removing some of the illiquid assets off their balance sheets (Pennacchi, 1988; Jiangli et al., 2007; Jiangli and Pritsker, 2008; Affinito and Tagliaferri, 2010; Martin-Oliver and Saurina, 2007), making themselves less dependent on the traditional sources of funds (e.g., deposits).

Second, by removing some of the risky assets off the balance sheet, a securitized bank is able to transfer the credit risk associated with the securitized assets to outside security investors. Under the *risk transfer hypothesis*, banks can use securitization to shed undesirable risks and rebalance their credit portfolios and achieve a different combination of risk and return. Moreover, the risk transfer of securitization may also lower the capital requirements. Banks are required to maintain a certain proportion of capital to absorb potential risk they are facing due to the regulations. Higher bank risk thus is associated with higher regulatory capital requirements, which in turn restricts banks' abilities to optimize their investment portfolios by holding a higher amount of liquidity. With securitization, banks are able to adjust their capital level by securitizing some risky assets.

Third, securitization could positively impact on bank's balance sheet. On one hand, the liability book or the funding comes from borrowing in most banks and financial sectors, which often at a high cost. Securitization allows these institutions to create a self-funded asset book, which in turn lower the funding costs. On the other hand, securitization could help banks to lock in profits on the balance sheet. Although holding the loans until maturity generates streams of interest income, the total profits are not yet known, and also, remain uncertain due to the possibility of borrowers' default. However, securitization allows issuers to record an earning bounce as soon as the loans have been securitized without any real additional burden to the banks.

2.1.4.2 The disadvantage of securitization

Although securitization could provide originators with many benefits, the costs of securitization means that not all banks are active securitizers, based on the following arguments. On the one hand, securitizations involve substantial one-off costs, including consultancy and organizational costs related to the bundling and tranching of loan portfolios, payments to the agencies responsible for assigning a rating to the different tranches, underwriting fees, and legal expenses. According to Davidson et al. (2003), the upfront costs of a typical securitization can easily exceed $1 million U.S. dollars, mainly from legal fees and from those responsible for structuring and arranging the operation. Thus, the *fixed-costs hypothesis* suggests small banks are not likely to be active securitizers, because the fixed costs of setting up securitization transactions could be a heavy burden for those banks.

On the other hand, since banks have private information on the quality of their loan portfolios, this information equality leads to a lemon discount that is required by the outside security investors (Gorton and Pennacchi, 1995). Under this *lemon discount hypothesis*, the securitized assets are likely to be underpriced during the transactions. Hence, banks that pay a lower lemon discount are more likely to securitize their loans. Previous studies show that the lemon discount is likely to be lower if: (i) the bank can credibly certify the quality of the assets it is selling (Focarelli et al., 2008); (ii) private information is less relevant because the loans are less opaque or more standardized; (iii) the loss given default is lower, for example because the loans are collateralized.

According to this hypothesis, banks with higher reputations built up in previous years had a lower level of charge-offs and problem loans are more likely to be active securitizers. Since mortgage loans, credit card receivables, and automobile loans enjoy a higher degree of standardization in practice, those loans are less subject to asymmetric information. Thus, banks with larger proportions of such loans are more likely to be active securitizers. Listed banks might also pay a lower lemon discount and are more likely to securitize their assets, due to the fact that, their balance sheets are typically under close scrutiny by external analysts.

Most importantly, the 2007-09 financial crisis highlights that securitization could encourage securitizers to take on more risk and lower the credit standards. The idea of securitization to reduce bank risk is to share the potential credit risk with a large number of security investors. Since securitizers realize that the potential losses are able to be diversified, they become more aggressive to grant loans without sufficient screening and monitoring efforts. Loan quality is in turn decreased.

2.1.5 Loan sales vs. securitization

Both loan sales and securitization are active and popular off-balance-sheet activities in practice. It would be useful and informative to distinguish between securitization and loan sales. First, although loan sales also enjoy rapid growth which is similar to securitization, this off-balance-sheet practice is actually a traditional banking activity (see Gorton and Haubrich, 1990). Loan sale involves the sale of a participation, or the totality of an originated loan, and the sale is usually affected without recourse. In those transactions, the originating bank serves as a pure broker. However, securitization involves qualitative asset transformation. The pooling process allows the originating bank to provide investors with diversification benefits. The asset pools, in practice, are often enhanced with augmented collaterals or other recourses. The credit enhancement, provided by the originating bank or a third party, is usually pivotal in obtaining an investment-grade rating for the new claim. Therefore, securitization may enhance originator's liquidity, reduces credit risk, and restructures the cash flows. Loan sales can merely separate funding from originator and the asset originated is to all intents and purposes identical to the asset purchased by the investor. Moreover, the sold loans are no more tradeable than the originated loan.

2.2 Empirical issues on securitization

2.2.1 Sample selection issue

An important issue that should be considered when estimating the effect of securitization is the choice to securitize may be endogenous. Banks determine whether and when they should access the securitization realm, which will then impact the available samples in the real world, that is, those non-securitized banks are the "missing samples" in the dataset of securitized banks. Although it is possible to add those "missing samples" simply into the dataset, the unobserved influences of this decision factor still exist (Heckman, 1979).

There are two common approaches in the previous literature to address the endogeneity problem of the decision to securitize, the instrument variables (IV) and Heckman selection estimators. The former method requires the existence of at least one instrumental variable that determines the treatment and is unrelated to unobserved heterogeneity, but this choice of instrument might create new potential issues. Therefore, the Heckman self-selection model will be a better choice as it is more robust than the instrument variables method (Casu et al., 2013). However, few of the prior literatures consider this selection bias, and none of them employed Heckman self-selection model to the author's best knowledge.

Among the few studies which considered sample selection issue is Casu et al. (2013), who in their working paper, use a propensity score matching approach to analyze whether individual banks did improve their performance through securitization. This methodology is known as a difference-in-difference matching strategy, which contains a two-step difference method. The first difference removes the unobserved heterogeneity and restoring conditional independence and the second difference produces the impact estimate.

2.2.2 Heckman self-selection model

As discussed before, Heckman Self-Selection Model could be a cure for the self-selection bias, which had been employed already in the economic field to investigate the wage issue in previous literature. However, it is not that popular in the financial realm, so a short review and explanation of this methodology should be necessary.

Theoretically, this methodology contains two equations, where, $\boldsymbol{i} = \mathbf{1}, \dots, \boldsymbol{I}$:

$$\boldsymbol{Y_{1i} = X_{1i}\beta_1 + U_{1i}} \tag{2.1}$$

$$\boldsymbol{Y_{2i} = X_{2i}\beta_2 + U_{2i}} \tag{2.2}$$

In this couple-equation, $\boldsymbol{X_{ji}}$ is a $\mathbf{1} \times \boldsymbol{K_j}$ vector of exogenous regressors, while $\boldsymbol{\beta_j}$ is a $\boldsymbol{K_j} \times \mathbf{1}$ vector of parameters. In the general case, suppose that data are available on $\boldsymbol{Y_{1i}}$ if $\boldsymbol{Y_{2i}} \geq \mathbf{0}$, while if $\boldsymbol{Y_{2i}} < \mathbf{0}$, there are no observations on $\boldsymbol{Y_{1i}}$. To be simplified, Equation (2.1) is the equation or regression of interest, and Euqation (2.2) is the selection equation or selection rule which impacts on Equation (2.1) and causes the bias. Therefore, considering the selection bias, the expected regression model is now as follows:

$$\boldsymbol{E(U_{1i}|X_{1i}, sample\ selection\ rule) = E(U_{1i}|X_{1i}, Y_{2i} \geq 0) =}$$
$$\boldsymbol{E(U_{1i}|X_{1i}, U_{2i} \geq -X_{2i}\beta_2)} \tag{2.3}$$

In the case of independence between $\boldsymbol{U_{1i}}$ and $\boldsymbol{U_{2i}}$, so that the data on $\boldsymbol{Y_{1i}}$ are missing randomly, the conditional mean of $\boldsymbol{U_{1i}}$ is zero, which means the subsample regression function is then:

$$\boldsymbol{E(Y_{1i}|X_{1i}, Y_{2i} \geq 0) = X_{1i}\beta_1 + E(U_{1i}|\ U_{2i} \geq -X_{2i}\beta_2)} \tag{2.4}$$

As a result, the selected sample regression function depends on X_{1i} and X_{2i}, which means those unobserved samples should have impact on the equation of interest.

To address this selection bias issue, a Heckman Self-Selection methodology is introduced (Heckman, 1979), which based on several assumptions (Wooldridge, 2002):

Assumption 1: (X_{1i}, Y_i) **are always observed, but** Y_{1i} **is only observed when** $Y_{2i} = 1$.
Assumption 2 (U_{1i}, U_{2i}) **is dependent of** X_{1i} **with zero mean.**
Assumption 3 $U_{2i} \sim N(0, 1)$.
Assumption 4 $E(U_{1i}|U_{2i}) = v_2 U_{2i}$.

Then from the Equation (2.4), using the well-known results from Johnson (1972):

$$E(U_{1i}|U_{2i} \geq -X_{2i}\beta_2) = \frac{\sigma_{12}}{\sigma_{22}^{1/2}}\lambda_i \tag{2.5}$$

$$E(U_{2i}|U_{2i} \geq -X_{2i}\beta_2) = \frac{\sigma_{22}}{\sigma_{22}^{1/2}}\lambda_i \tag{2.6}$$

where,

$$\lambda_i = \frac{\phi(Z_i)}{1-\Phi(Z_i)} = \frac{\phi(Z_i)}{\Phi(-Z_i)} \tag{2.7}$$

$$Z_i = -\frac{X_{2i}\beta_2}{\sigma_{22}^{1/2}} \tag{2.8}$$

λ_i is the inverse of Mill's ratio, while ϕ and Φ are the density and distribution function for a standard normal variable, respectively.

Then the full statistical model for normal population disturbances can now be developed, as the conditional regression function for selected samples may be written as:

$$E(Y_{1i}|X_{1i}, Y_{2i} \geq 0) = X_{1i}\beta_1 + \frac{\sigma_{12}}{\sigma_{22}^{1/2}}\lambda_i \tag{2.9}$$

$$E(Y_{2i}|X_{2i}, Y_{2i} \geq 0) = X_{2i}\beta_2 + \frac{\sigma_{22}}{\sigma_{22}^{1/2}}\lambda_i \qquad \textbf{(2.10)}$$

Therefore,

$$Y_{1i} = E(Y_{1i}|X_{1i}, Y_{2i} \geq 0) + V_{1i} \qquad \textbf{(2.11)}$$

$$Y_{2i} = E(Y_{2i}|X_{2i}, Y_{2i} \geq 0) + V_{2i} \qquad \textbf{(2.12)}$$

where,

$$E(V_{1i}|X_{1i}, \lambda_i, U_{2i} \geq -X_{2i}\beta_2) = 0 \qquad \textbf{(2.13)}$$

$$E(V_{2i}|X_{2i}, \lambda_i, U_{2i} \geq -X_{2i}\beta_2) = 0 \qquad \textbf{(2.14)}$$

$$E\left(V_{ji}V_{j'i'}|X_{1i}, X_{2i}, \lambda_i, U_{2i} \geq -X_{2i}\beta_2\right) = 0 \qquad \textbf{(2.15)}$$

Further, for $i \neq i'$,

$$E\left(V_{1i}^2|X_{1i}, \lambda_i, U_{2i} \geq -X_{2i}\beta_2\right) = \sigma_{11}[(1-\rho^2) + \rho^2(1 + Z_i\lambda_i - \lambda_i^2)] \qquad \textbf{(2.16)}$$

$$E(V_{1i}V_{2i}|X_{1i}, X_{2i}, \lambda_i, U_{2i} \geq -X_{2i}\beta_2) = \sigma_{12}(1 + Z_i\lambda_i - \lambda_i^2) \qquad \textbf{(2.17)}$$

$$E\left(V_{2i}^2|X_{2i}, \lambda_i, U_{2i} \geq -X_{2i}\beta_2\right) = \sigma_{22}(1 + Z_i\lambda_i - \lambda_i^2) \qquad \textbf{(2.18)}$$

where,

$$\rho^2 = \frac{\sigma_{12}^2}{\sigma_{11}\sigma_{22}} \qquad \textbf{(2.19)}$$

$$0 \leq 1 + Z_i\lambda_i - \lambda_i^2 \leq 1 \qquad \textbf{(2.20)}$$

All the results above indicate that, if one knew Z_i hence the inverse Mill's ratio, then λ_i could be added as a regressor in Equation 2.11, which could overcome the selection bias. In practice, it is notable that there should exist variables in X_{2i} but not in X_{1i}, which is also important for this methodology.

2.2.3 Heckman self-selection model applied in panel data

Unfortunately, the classic Heckman methodology fails when applied in panel data case, as it cannot address the individual effects in the samples (Kyriazidou, 1997). Therefore, several researchers address this failure theoretically. Wooldridge (1995) proposed the use of first estimator to address the sample selection bias in panel data, which then generates the Mundlak-Chamberlain approach that will be used in this paper. This methodology relies on a full parameterization of the sample selection mechanism, and requires specifying the functional form of the conditional mean of the individual effects in the equation of interest. However, this methodology does not impose distributional assumptions about the error terms and the individual effects in the equation of interest. Another group of researches mainly followed Kyriazidou (1997), which is more similar to difference-in-difference method. The idea of this estimator is to match observations within individuals that have the same selection effect in two periods, and to difference out both the individual heterogeneity term, and the selection term. Another estimator proposed by Rochina-Barrachina (1999) is similar to Kyriazidou, but with distributional assumptions to derive an explicit expression for the selectivity correction term. The following paragraphs will briefly review these methodologies.

2.2.3.1 Methodolgy from Kyriazidou

Kyriazidou (1997)'s methodology follows the familiar two-step approach of Heckman. In the first step, the unknown coefficients of the selection equation are consistently estimated, while in the second step, these estimates are used to estimate the equation of interest by a weighted least squares regression. Moreover, the fixed effect from panel data will be eliminated by taking time differences on the observed selected variables, and the weights come from the first step.

Specifically, Kyriazidou considers the following model similar to Heckman, where $\boldsymbol{i = 1, \ldots, I;\ t = 1, 2}$:

$$\boldsymbol{y_{it} = d_{it} \cdot y_{it}^{*} = d_{it} \cdot (x_{it}^{*}\beta + \alpha_{i}^{*} + u_{it}^{*}) = x_{it}\beta + \alpha_{it} + u_{it}} \qquad \textbf{(2.21)}$$

And,

$$d_{it} = 1\{\, z_{it}\gamma + \eta_i - \delta_{it} \geq 0\} \qquad (2.22)$$

Here, $\beta \in \Re^k$ and $\gamma \in \Re^q$ are unknown parameter vectors aiming to estimate, x_{it}^* and z_{it} are vectors of explanatory variables, α_i^* and η_i are unobserved time-invariant individual-specific effects, u_{it}^* and δ_{it} are unobserved disturbances, while $y_{it}^* \in \Re$ is a latent variable whose observability depends on the outcome of the indicator variable $d_{it} \in \{0, 1\}$. In particular, it is assumed that, while (d_{it}, z_{it}) is always observed, (y_{it}^*, x_{it}^*) is observed only if $d_{it} = 1$. Therefore, the problem is to estimate β and γ from a sample consisting of quadruples $(d_{it}, z_{it}, y_{it}, x_{it})$. The vector of explanatory variables is denoted by $\varsigma_i \equiv (z_{i1}, z_{i2}, x_{i1}^*, x_{i2}^*, \alpha_i^*, \eta_i)$.

In this two-period twin-equation, when $d_{i1} = d_{i2} = 1$, the time differences can be eliminated by a "fixed-effects" approach, using a first-differenced subsample:

$$E(y_{i1} - y_{i2} | d_{i1} = 1, d_{i2} = 1, \varsigma_i) = (x_{i1}^* - x_{i2}^*)\beta + E(u_{i1}^* - u_{i2}^* | d_{i1} = 1, d_{i2} = 1, \varsigma_i) \qquad (2.23)$$

In general, there is no reason to expect $E(u_{it}^* | d_{i1} = 1, d_{i2} = 1, \varsigma_i) = 0$, which means the sample selection effect λ_{it}, similar in Heckman (1997), also depends on the unknown joint conditional distribution of $(u_{it}^*, \delta_{i1}, \delta_{i2})$. Therefore, this effect may differ across individuals, as well as over time for the same individuals, based on an unknown function Λ:

$$\lambda_{it} \equiv E(u_{it}^* | d_{i1} = 1, d_{i2} = 1, \varsigma_i) = E(u_{it}^* | \delta_{i1} \leq z_{i1}\gamma + \eta_i, \delta_{i2} \leq z_{i2}\gamma + \eta_i, \varsigma_i) = \Lambda(z_{i1}\gamma + \eta_i, z_{i2}\gamma + \eta_i; F_{it}(u_{it}^*, \delta_{i1}, \delta_{i2} | \varsigma_i)) = \Lambda(z_{i1}\gamma + \eta_i, z_{i2}\gamma + \eta_i, \varsigma_i)) \qquad (2.24)$$

Then, the main equation of interest can be re-wrote as a "partially linear regression" as below, where $\nu_{it} \equiv u_{it} - \lambda_{it}$ is a new error term, which by construction satisfies:$E(\nu_{it} | d_{i1} = 1, d_{i2} = 1, \varsigma_i) = 0$:

$$y_{it} = x_{it}\beta + \alpha_{it} + \lambda_{it} + \nu_{it} \qquad (2.25)$$

Then the idea of this methodology is to "difference out" the nuisance term α_{it} and λ_{it} in this equation.

An advantage of the "difference out" methodology comes from much weaker distributional assumptions, since it is not required $(u_{it}^{*}, \delta_{it})$ to be i.i.d. across individuals not that it be independent of the individual-specific vector ς_i. In other word, this methodology allows the functional form of the unknown function Λ to vary across individuals, and it is also possible to allow for serial correlation in the errors.

From this point, under a conditional exchange ability assumption, $F(u_{i1}^{*}, u_{i2}^{*}, \delta_{i1}, \delta_{i2} | \varsigma_i) = F(u_{i2}^{*}, u_{i1}^{*}, \delta_{i2}, \delta_{i1} | \varsigma_i)$, it is easy to see that for an individual i that has $z_{i1}\gamma = z_{i2}\gamma$, which means,

$$\lambda_{i1} = E(u_{i1}^{*} | \delta_{i1} \leq z_{i1}\gamma + \eta_i, \delta_{i2} \leq z_{i2}\gamma + \eta_i, \varsigma_i) = E(u_{i2}^{*} | \delta_{i2} \leq z_{i1}\gamma + \eta_i, \delta_{i1} \leq z_{i2}\gamma + \eta_i, \varsigma_i) = \lambda_{i2} \qquad \textbf{(2.26)}$$

The above discussion presents a possibility of estimating β by OLS from a subsample that consists of those observations that have $z_{i1}\gamma = z_{i2}\gamma$ and $d_{i1} = d_{i2} = 1$. Defining $\Psi_i \equiv 1\{z_{i1}\gamma = z_{i2}\gamma\}$ and $\Phi_i \equiv \{d_{i1} = d_{i2} = 1\} \equiv d_{i1}d_{i2}$, with Δ denoting first differences, the estimator form is as follows:

$$\beta_n' = [\textstyle\sum_{i=1}^{n} \Delta x_i' \Delta x_i \Psi_i \Phi_i]^{-1} [\textstyle\sum_{i=1}^{n} \Delta x_i' \Delta y_i \Psi_i \Phi_i] \qquad \textbf{(2.27)}$$

However, this estimation scheme cannot be implemented directly in practice as γ is unknown. Therefore, Kyriazidou (1997) proposes a two-step estimation procedure. In the first step, γ will be estimated consistently based on the selection equation alone. In the second step, the estimate γ_n' will be used to estimate β, relying on the pairs of observations for which $z_{i1}\gamma_n'$ and $z_{i2}\gamma_n'$are "close". Specifically, in this method, β is proposed as:

$$\beta_n' = [\textstyle\sum_{i=1}^{n} \Psi_{in}' \Delta \mathrm{x}_i' \Delta x_i \Phi_i]^{-1} [\textstyle\sum_{i=1}^{n} \Psi_{in}' \Delta \mathrm{x}_i' \Delta y_i \Phi_i] \qquad \textbf{(2.28)}$$

where Ψ_{in}' is a weight that declines to zero as the magnitude of the difference $|z_{i1}\gamma = z_{i2}\gamma|$ increases. Here they choose "kernel" weights of the form of $\boldsymbol{\Psi}'_{in} \equiv \frac{1}{h_n}\boldsymbol{K}\left(\frac{\Delta z_i \gamma'_n}{h_n}\right)$, and $\boldsymbol{K}$ is a “kernel density” function, while $\boldsymbol{h}$ is a sequence of “bandwidths” which tends to zero as $\boldsymbol{n} \to \infty$. Thus, for a fixed nonzero magnitude of difference, the weight shrinks as the sample size increases, while for a fixed $\boldsymbol{n}$, a larger magnitude corresponds to a smaller weight.

This result could be extended to a longer panel easily, as when $\boldsymbol{T} \geq \boldsymbol{2}$,

$$\boldsymbol{\beta}'_n = \left[\sum_{i=1}^{n} \frac{1}{T_i - 1} \sum_{s<t} \boldsymbol{\Psi}'_{in} \, (\boldsymbol{x}_{it} - \boldsymbol{x}_{is})'(\boldsymbol{x}_{it} - \boldsymbol{x}_{is}) \boldsymbol{d}_{it} \boldsymbol{d}_{is}\right]^{-1} \times$$
$$\left[\sum_{i=1}^{n} \frac{1}{T_i - 1} \sum_{s<t} \boldsymbol{\Psi}'_{in} \, (\boldsymbol{x}_{it} - \boldsymbol{x}_{is})'(\boldsymbol{y}_{it} - \boldsymbol{x}_{is}) \boldsymbol{d}_{it} \boldsymbol{d}_{is}\right] \qquad \textbf{(2.29)}$$

where,

$$\boldsymbol{\Psi}'_{in} \equiv \frac{1}{h_n}\boldsymbol{K}\left(\frac{(z_{it} - z_{is})\gamma'_n}{h_n}\right) \qquad \textbf{(2.30)}$$

Then, define scalar index $\boldsymbol{Z}_i \equiv \Delta \boldsymbol{z}_i \boldsymbol{\gamma}$ and its estimated counterpart $\boldsymbol{Z}'_i \equiv \Delta \boldsymbol{z}_i \boldsymbol{\gamma}'_n$, along with the following quantities:

$$\begin{cases} \begin{cases} \boldsymbol{S}_{xx} \equiv \frac{1}{n}\sum_{i=1}^{n} \frac{1}{h_n}\boldsymbol{K}\left(\frac{Z_i}{h_n}\right) \Delta \boldsymbol{x}'_i \Delta \boldsymbol{x}_i \boldsymbol{\Phi}_i \\ \boldsymbol{S}'_{xx} \equiv \frac{1}{n}\sum_{i=1}^{n} \frac{1}{h_n}\boldsymbol{K}\left(\frac{Z'_i}{h_n}\right) \Delta \boldsymbol{x}'_i \Delta \boldsymbol{x}_i \boldsymbol{\Phi}_i \end{cases} \\ \begin{cases} \boldsymbol{S}_{xv} \equiv \frac{1}{n}\sum_{i=1}^{n} \frac{1}{h_n}\boldsymbol{K}\left(\frac{Z_i}{h_n}\right) \Delta \boldsymbol{x}'_i \Delta \boldsymbol{v}_i \boldsymbol{\Phi}_i \\ \boldsymbol{S}'_{xv} \equiv \frac{1}{n}\sum_{i=1}^{n} \frac{1}{h_n}\boldsymbol{K}\left(\frac{Z'_i}{h_n}\right) \Delta \boldsymbol{x}'_i \Delta \boldsymbol{v}_i \boldsymbol{\Phi}_i \end{cases} \\ \begin{cases} \boldsymbol{S}_{x\lambda} \equiv \frac{1}{n}\sum_{i=1}^{n} \frac{1}{h_n}\boldsymbol{K}\left(\frac{Z_i}{h_n}\right) \Delta \boldsymbol{x}'_i \Delta \boldsymbol{\lambda}_i \boldsymbol{\Phi}_i \\ \boldsymbol{S}'_{x\lambda} \equiv \frac{1}{n}\sum_{i=1}^{n} \frac{1}{h_n}\boldsymbol{K}\left(\frac{Z'_i}{h_n}\right) \Delta \boldsymbol{x}'_i \Delta \boldsymbol{\lambda}_i \boldsymbol{\Phi}_i \end{cases} \end{cases} \qquad \textbf{(2.31)}$$

The first difference of estimator could be written as:

$$\begin{cases} \widetilde{\boldsymbol{\beta}}_n - \boldsymbol{\beta} = \boldsymbol{S}_{xx}^{-1}(\boldsymbol{S}_{xv} + \boldsymbol{S}_{x\lambda}) \\ \boldsymbol{\beta}'_n - \boldsymbol{\beta} = \boldsymbol{S}'^{-1}_{xx}(\boldsymbol{S}'_{xv} + \boldsymbol{S}'_{x\lambda}) \end{cases} \qquad \textbf{(2.32)}$$

where $\widetilde{\boldsymbol{\beta}}_n$ is the denotian of the construction of the kernel weights of $\boldsymbol{\gamma}$.

From this point, under the following assumptions, the real estimator which overcoming the sample selection bias and individual effect of panel data can be presented.

The assumptions are:

Assumption 1: $(u_{i1}^*, u_{i2}^*, \delta_{i1}, \delta_{i2})$ and $(u_{i2}^*, u_{i1}^*, \delta_{i2}, \delta_{i1})$ are identically distributed conditional on ς_i, which is $F(u_{i1}^*, u_{i2}^*, \delta_{i1}, \delta_{i2} | \varsigma_i) = F(u_{i2}^*, u_{i1}^*, \delta_{i2}, \delta_{i1} | \varsigma_i)$.

Assumption 2: An i.i.d sample, $\{(x_{it}^*, u_{it}^*, \alpha_i^*, z_{it}, \delta_{it}, \eta_i); \mathrm{t} = 1, 2\}_{i=1}^{n}$ is drawn from the population. That is, for each i=1, …, n, and each t=1, 2, we observe $(d_{it}, z_{it}, y_{it}, x_{it})$.

Assumption 3: $E(\Delta x' \Delta \mathrm{x} \Phi | Z = 0)$ is finite and non-sigular.

Assumption 4: The marginal distribution of the index function $Z_i \equiv \Delta z_i \gamma$ is absolutely continuous, with density function $f_z(0) > 0$. In addition, f_z is almost everywhere r times continuously differentiable and has bounded derivatives.

Assumption 5: The unknown function satisfies: $\Lambda(s_t, s_\tau, \varsigma) - \Lambda(s_\tau, s_t, \varsigma) = \widetilde{\Lambda}(s_t - s_\tau)$ for t, τ=1, 2, where $\widetilde{\Lambda}$ is a function of (s_t, s_τ, ς).

Assumption 6.a: x_t^* and u_t^* have bounded 4+2m moments conditional on Z, for any 0<m<1;

Assumption 6.b: $E(\Delta x' \Delta \mathrm{x} \Phi | Z)$ and $E(\Delta x' \Delta \mathrm{x} \Delta v^2 \Phi | Z)$ are continuously at Z=0 and do not vanish;

Assumption 6.c: $E(\Delta x' \widetilde{\Lambda} \Phi | Z)$ is almost everywhere r times continousle differentiable as a function of Z, and has bounded derivatives.

Assumption 7: $hn \to \infty$ and $nhn \to \infty$ as $n \to \infty$.

The estimated parameter of interest, where β' is the weighted estimated parameter of equation of interest:

$$\beta'' \equiv \frac{\beta_n' - n^{-(1-\delta)(r+1)/(2(r+1)+1)} \beta_{n,\delta}'}{1 - n^{-(1-\delta)(r+1)/(2(r+1)+1)}} \qquad \textbf{(2.33)}$$

However, although this methodology is direct, it provides only a calculation methodology of the real estimator that interested, which means it help little in empirical field. Specifically, as empirical researches encounter missing variables inevitably, and the empirical models cannot be perfect as in theory, it is unreasonable just using dataset in hand to calculate the estimator directly. Therefore, other methodology should be employed.

2.2.3.2 Mundlak-Chamberlain Approach

In practice, previous methodologies are divided mainly in two branches to address selection bias and calculate inverse Mill's ratio, the traditional random effects probit/logit model and the fixed effects logit model. However, the former one requires strict exogeneity and zero correlation between the explanatory variables and $\boldsymbol{u_i}$, while it is impossible to obtain consistant estimates of $\boldsymbol{u_i}$ in the latter one. Therefore, a middle way to address this issue named Mundlak-Chamberlain Approach is more useful and convenient.

To be distinguished from the equations before, we can rewrite the equation of interest as:

$$\boldsymbol{y_{it}^{*} = x_{it}\beta + \varepsilon_i + e_{it}} \tag{2.34}$$

where $\boldsymbol{c_i}$ stands for an explicit function of the unobserved sample selection bias:

$$\boldsymbol{c_i = \varphi + \overline{x}_i\mu + v_i} \tag{2.35}$$

In this equation, $\boldsymbol{\overline{x}_i}$ is an average of $\boldsymbol{x_{it}}$ over time for individual $\boldsymbol{i}$, while $\boldsymbol{v_i}$ is assumed uncorrelated with $\boldsymbol{\overline{x}_i}$.

Under the assumption of $\boldsymbol{var(v_i) = \sigma_v^2}$ is constant and $\boldsymbol{e_i}$ is normally distributed, this model could then result in Chamberlain's random effects probit model, that is:

$$\boldsymbol{\Pr(y_{it} = 1|x_{it}, c_i) = \Pr(y_{it} = 1|x_{it}, \overline{x}_i, v_i) = \Phi(x_{it}\beta + \varphi + \overline{x}_i\mu + v_i)} \tag{2.36}$$

After adding the mean variables, this probit model then becomes a traditional random effects probit model:

$$\boldsymbol{L_i(y_{i1}, \cdots, y_{iT}|x_{i1}, \cdots, x_{iT}; \beta, \sigma_v^2) = \int \prod_{t=1}^{T}[\Phi(x_{it}\beta + \varphi + \overline{x}_i\mu + v)]^{y_{it}} \times [1 - \Phi(x_{it}\beta + \varphi + \overline{x}_i\mu + v)]^{(1-y_{it})}\,(1/\sigma_v)\phi(v/\sigma_v)dv} \tag{2.37}$$

Simply speaking, adding $\boldsymbol{\overline{x}_i}$ as control variables allows for some correlation between the random effect and the regressors. In sample selection issue when employing in Heckman model, we should estimate T different selection probits and compute T different inverse Mill's ratios. Then estimate the following equation on the selected sample:

$$y_{it} = x_{it}\beta + \overline{x}_i\varphi + \rho_t\hat{\lambda}_t + e_{it} \tag{2.38}$$

This yields consistant estimates of β, which will be the methodology this research following.

2.2.3 Propensity score matching

Apart from Heckman self-selection model, the propensity score matching (PSM) is an alternative method to address the selection bias. The matching idea and methodology can be applied in any study where it is possible to identify: (i) a treatment; (ii) a group of treated units; and (iii) a group of untreated units (Caliendo and Kopeinig, 2008). In this study, securitization is considered as the treatment, securitizers as the treatment group, and non-securitizers as the non-treatment group. A brief review of the PSM methodology is described below.

To estimate the causal effect of the treatment, i.e., securitization, the main aim is to estimate the outcomes if the securitizers chose not to securitize their loans. Let $S_{i,t}$ to be a variable indicating securitization activity, which equals to one if bank i conducts a securitization transaction for the first time in year t. Let $\Delta y^1_{i,t+1}$ to be the performance gain achieved by bank i at time $t+1$ after having securitized assets in period t and let $\Delta y^0_{i,t+1}$ be the hypothetical performance gain of the same bank i at the same time $t+1$ had it not securitized assets in period t. The effect of securitization on bank i's performance, which is also well-known as the average treatment effect on the treated (ATT), can be specified as:

$$\hat{\tau} = E(\Delta y^1_{i,t+1}|S_{i,t} = 1) - E(\Delta y^0_{i,t+1}|S_{i,t} = 1) \tag{2.39}$$

In Equation 2.39, $E(\Delta y^0_{i,t+1}|S_{i,t} = 1)$ represents the counterfactual mean or the hypothetical performance gain of a securitizer had it not securitized, which in practice is unobservable.

Therefore, we need to find a proxy for this counterfactual mean. Let the mean outcome for non-securitizers, $\boldsymbol{E}\left(\Delta \boldsymbol{y}_{i,t+1}^{\mathbf{0}} | \boldsymbol{S}_{i,t}=\mathbf{0}\right)$, as a proxy for the counterfactual mean. Equation 2.39 becomes to:

$$\hat{\boldsymbol{\tau}}=\boldsymbol{E}\left(\Delta \boldsymbol{y}_{i,t+1}^{\mathbf{1}} | \boldsymbol{S}_{i,t}=\mathbf{1}\right)-\boldsymbol{E}\left(\Delta \boldsymbol{y}_{i,t+1}^{\mathbf{0}} | \boldsymbol{S}_{i,t}=\mathbf{0}\right) \tag{2.40}$$

Equation 2.40 yields biased estimation unless $\boldsymbol{E}\left(\Delta \boldsymbol{y}_{i,t+1}^{\mathbf{0}} | \boldsymbol{S}_{i,t}=\mathbf{1}\right)= \boldsymbol{E}\left(\Delta \boldsymbol{y}_{i,t+1}^{\mathbf{0}} | \boldsymbol{S}_{i,t}=\mathbf{0}\right)$. To apply PSM approach to the case of securitization, we build a control group from non-securitizers that are similar to the securitizers in all relevant pre-securitization characteristics. Thus, the causal effect of securitization could be presented as:

$$\hat{\boldsymbol{\tau}}=\boldsymbol{E}\left(\Delta \boldsymbol{y}_{i,t+1}^{\mathbf{1}} | \boldsymbol{S}_{i,t}=\mathbf{1}, \boldsymbol{X}_{i,t-\mathbf{1}}\right)-\boldsymbol{E}\left(\Delta \boldsymbol{y}_{i,t+1}^{\mathbf{0}} | \boldsymbol{S}_{i,t}=\mathbf{0}, \boldsymbol{X}_{i,t-\mathbf{1}}\right) \tag{2.41}$$

Where $\boldsymbol{E}\left(\Delta \boldsymbol{y}_{i,t+1}^{\mathbf{1}} | \boldsymbol{S}_{i,t}=\mathbf{1}, \boldsymbol{X}_{i,t-\mathbf{1}}\right)$ is the mean performance change of a bank choose to securitize assets, $\left(\Delta \boldsymbol{y}_{i,t+1}^{\mathbf{0}} | \boldsymbol{S}_{i,t}=\mathbf{0}, \boldsymbol{X}_{i,t-\mathbf{1}}\right)$ is the weighted mean performance change of the control group at the same time, and $\boldsymbol{X}_{i,t-\mathbf{1}}$ is a vector of conditioning covariates observed.

A propensity score is the probability of a unit being assigned to a particular treatment given a set of observed covariates. Propensity scores are used to reduce selection bias by equating groups based on these covariates. Using propensity score, the equation for the average securitization effect becomes:

$$\hat{\boldsymbol{\tau}}=\boldsymbol{E}\left(\Delta \boldsymbol{y}_{i,t+1}^{\mathbf{1}} | \boldsymbol{S}_{i,t}=\mathbf{1}, \boldsymbol{p}(\boldsymbol{X}_{i,t-\mathbf{1}})\right)-\boldsymbol{E}\left(\Delta \boldsymbol{y}_{i,t+1}^{\mathbf{0}} | \boldsymbol{S}_{i,t}=\mathbf{0}, \boldsymbol{p}(\boldsymbol{X}_{i,t-\mathbf{1}})\right) \tag{2.42}$$

Where p is a propensity score conditional on $\boldsymbol{X}_{i,t-\mathbf{1}}$. Therefore, the average securitization effect is estimated as the difference between the mean performance change of securitizers and non-securitizers.

For consistent estimates of the securitization effect, two key assumptions must hold: the unconfoundedness assumption and the common support assumption. The unconfoundedness assumption, also referred to as the “conditional independence assumption” or “selection on observables,” requires the mean outcomes to be independent of the treatment after conditioning on a set of observable covariates (Imbens 2004, Smith and Todd 2005) and can be formally stated as:

$$(\Delta \boldsymbol{y}^{0}_{i,t+1}, \Delta \boldsymbol{y}^{1}_{i,t+1}) \perp \boldsymbol{S}_{i,t} | \boldsymbol{X}_{i,t-1} \;\; \boldsymbol{or} \;\; (\Delta \boldsymbol{y}^{0}_{i,t+1}, \Delta \boldsymbol{y}^{1}_{i,t+1}) \perp \boldsymbol{S}_{i,t} | \boldsymbol{p}(\boldsymbol{X}_{i,t-1}) \qquad \textbf{(2.43)}$$

In other words, it assumes that there are no unobservable differences between securitizers and non-securitizers after conditioning on $\boldsymbol{X}_{i,t-1}$, so that any systematic differences in outcomes can be attributed to the securitization effect. The unconfoundedness thus assumes away the potential bias arising from the selection on observables (Sianesi, 2004). To link the unconfoundedness assumption with standard exogeneity assumptions, it could be written as:

$$\Delta \boldsymbol{y}_i = \boldsymbol{\alpha} + \hat{\boldsymbol{\tau}} \boldsymbol{S}_i + \boldsymbol{\beta} \boldsymbol{X}'_i + \boldsymbol{\varepsilon}_i \qquad \textbf{(2.44)}$$

2.2.4 Instrumental variable approach

Another important empirical strategy is the instrumental variable approach, or the two-stage least squares (2SLS) approach. The advantages of using 2SLS over the more conventional maximum likelihood (ML) method for structural equation models (SEM). First, the 2SLS approach does not require any distributional assumptions for RHS independent variables, which means they can be non-normal, binary, etc. Second, in the context of a multi-equation non-recursive SEM it isolates specification errors to single equations, see Bollen (2001). Third, it is computationally simple and does not require the use of numerical optimisation algorithms. Fourth, it easily caters for non-linear and interactions effects, see Bollen and Paxton (1998). Last, it permits the routine use of often ignored diagnostic testing procedures for problems such as heteroscedasticity and specification error, see Pesaran and Taylor (1999).

To understand the 2SLS estimation, let us start with a simple regression model:

$$\boldsymbol{y} = \boldsymbol{\alpha} + \boldsymbol{\beta} \boldsymbol{x} + \boldsymbol{u} \qquad \textbf{(2.45)}$$

Where, y is the dependent variable x is the independent variable, α and β are estimable parameters u is the error term.

If x and u are correlated then this violates an assumption of the regression framework. Applying standard ordinary least squares (OLS) to Equation (2.45) under these circumstances results in inconsistent estimates. That is, even as the sample size approaches infinity the estimates of the parameters on average will not equal the population estimates. To remedy this problem one can apply 2SLS, also called the instrumental variables (IV) procedure.

To implement 2SLS we need to identify one or more instruments for x. These instruments (call them z) must satisfy two conditions: 1) z must be uncorrelated with u; and 2) z must be correlated with x. To get the parameter estimates is to run two OLS regressions: 1) OLS regression x on z and get predictions for x, say $\hat{x}$; 2) OLS regression y on $\hat{x}$.

The rationale is presented as follows. Consider the following latent variable model:

$$\eta_1 = \beta_0 + \beta_1\xi_1 + u_1 \tag{2.46}$$

Where, η_1 is the latent dependent variable with three indicators (y_1, y_2, y_3), ξ_1 is the latent independent variable with three indicators (x_1, x_2, x_3), β_0 and β_1 are the estimated parameters, u_1 is the disturbance error term.

Assume that the measurement models for η_1 and ξ_1 are:

$$\begin{cases} y_1 = \lambda_{y1}\eta_1 + \varepsilon_1 \\ y_2 = \lambda_{y2}\eta_1 + \varepsilon_2 \\ y_3 = \lambda_{y3}\eta_1 + \varepsilon_3 \end{cases} \tag{2.47}$$

$$\begin{cases} x_1 = \lambda_{x1}\xi_1 + \delta_1 \\ x_2 = \lambda_{x2}\xi_1 + \delta_2 \\ x_3 = \lambda_{x3}\xi_1 + \delta_3 \end{cases} \tag{2.48}$$

Where λ are factor loadings, ε and δ are measurement errors.

Bollen (1996) suggests the following procedure. Choose a scaling or reference variable for each latent variable, say $\boldsymbol{y_1}$ for $\boldsymbol{\eta_1}$ and $\boldsymbol{x_1}$ for $\boldsymbol{\xi_1}$, this implies the corresponding loadings are set to unity. These scaling variables should be those that best reflect the constructs theoretically or empirically. This allows us to write:

$$\boldsymbol{y_1 = \eta_1 + \varepsilon_1} \tag{2.49}$$

$$\boldsymbol{x_1 = \xi_1 + \delta_1} \tag{2.50}$$

Combining the two equations together allows us to write the basic equation in observable variables terms only:

$$\boldsymbol{y_1 = \beta_0 + \beta_1 x_1 + u} \tag{2.51}$$

Where $\boldsymbol{u = u_1 + \varepsilon_1 - \delta_1 \beta_1}$, and $\boldsymbol{u}$ is the new composite error term.

Clearly $\boldsymbol{x_1}$ is correlated with $\boldsymbol{u}$ since both and $\boldsymbol{u}$ and $\boldsymbol{x_1}$ depend upon $\boldsymbol{\delta_1}$. This mimics the basic equation and therefore OLS cannot be applied to the equation above, so instead a 2SLS procedure is needed. To identify suitable instruments we need to find variables which are not correlated with $\boldsymbol{u}$, but are highly correlated with $\boldsymbol{x_1}$. The non-scaling items for $\xi_1(x_2, x_3)$ are suitable as they are expected to be highly correlated with $\boldsymbol{x_1}$ given that they are all indicators of the same construct and they are not correlated with $\boldsymbol{u}$ (as we assume that measurement errors are uncorrelated.). Note, $\boldsymbol{y_2, y_3}$ are not suitable instruments as they are correlated with $\boldsymbol{u}$, since $\boldsymbol{u, y_2, y_3}$ all depend upon $\boldsymbol{u_1}$.

Therefore, the general principle is that non-scaling item indicators of the independent variable can be used as instruments, but not non-scaling items of the dependent variable as they correlate with the composite error term. Effectively, any variable that has either a direct or indirect effect on the dependent variable is not a candidate as an instrumental variable as it will be correlated with the composite error term. That is, if a causal chain exists between the composite error term and a variable then that variable is not a valid instrument.

In some situations, it is difficult to determine whether an instrument is valid. To ascertain the validity of an instrument you need to explicitly determine if the covariance between the instrument and composite error is zero.

2.2.5 Difference-in-difference analysis

Apart from the empirical strategies above, another popular estimation method is called the Difference-in-Difference analysis. The simplest set up is one where outcomes are observed for two groups for two periods. One of the groups is exposed to a treatment in the second period but not in the first period. The second group is not exposed to the treatment during either period. In the case where the same units within a group are observed in each time period, the average gain in the second (control) group is substracted from the average gain in the first (treatment) group. This removes biases in second period comparisons between the treatment and control group that could be the result from permanent differences between those groups, as well as biases from comparisons over time in the treatment group that could be the result of trends. To understand the Difference-in-Difference analysis, it would be better to start from the basic fixed-effects model. In the fixed effects models, if a researcher is interested whether $\boldsymbol{Y}_{\boldsymbol{it}}$ is affected by $\boldsymbol{D}_{it}$ which is assumed to be randomly assigned. There are also time varying covariates $\boldsymbol{X}_{it}$ and unobserved but fixed confounders $\boldsymbol{A}_{\boldsymbol{i}}$. Therefore,

$$\boldsymbol{E}[\boldsymbol{Y}_{\boldsymbol{0it}}|\boldsymbol{A}_i,\boldsymbol{X}_{it},\boldsymbol{t}] = \boldsymbol{\alpha} + \boldsymbol{\lambda}_{\boldsymbol{t}} + \boldsymbol{A}_i'\boldsymbol{\gamma} + \boldsymbol{X}_{it}'\boldsymbol{\beta}. \tag{2.52}$$

Assuming that the causal effect of individuals is additive and constant so the following equation is also true:

$$\boldsymbol{E}[\boldsymbol{Y}_{\boldsymbol{1it}}|\boldsymbol{A}_i,\boldsymbol{X}_{it},\boldsymbol{t}] = \boldsymbol{E}[\boldsymbol{Y}_{\boldsymbol{0it}}|\boldsymbol{A}_i,\boldsymbol{X}_{it},\boldsymbol{t}] + \boldsymbol{\rho} \tag{2.53}$$

Taken together, we will have:

$$\boldsymbol{E}[\boldsymbol{Y}_{\boldsymbol{1it}}|\boldsymbol{A}_i,\boldsymbol{X}_{it},\boldsymbol{t}] = \boldsymbol{\alpha} + \boldsymbol{\lambda}_{\boldsymbol{t}} + \boldsymbol{\rho}\boldsymbol{D}_{it} + \boldsymbol{A}_i'\boldsymbol{\gamma} + \boldsymbol{X}_{it}'\boldsymbol{\beta} \tag{2.54}$$

This equation implies the following regression equation:

$$\boldsymbol{Y_{it} = \alpha_i + \lambda_t + \rho D_{it} + X'_{it}\beta + \varepsilon_{it}} \tag{2.55}$$

Where $\boldsymbol{\varepsilon_{it} = Y_{0it} - E[Y_{0it}|A_i, X_{it}, t]}$, and $\boldsymbol{\alpha_i = \alpha + A'_i\gamma}$.

Suppose we simply estimate this model with OLS without fixed effects, then the estimation is:

$$\boldsymbol{Y_{it} = constant + \lambda_t + \rho D_{it} + X'_{it}\beta + \alpha_i + \varepsilon_{it}} \tag{2.56}$$

As $\boldsymbol{\alpha_i}$ is correlated with the individual status $\boldsymbol{D_{it}}$, there is a correlation of $\boldsymbol{D_{it}}$ with error term. This will lead to biased OLS estimations. A fixed effect model would address this problem because $\boldsymbol{\alpha_i}$ would be included in the regression. $\boldsymbol{D_{it}}$ with error term would therefore be uncorrelated and the regression would obtain an unbiased estimator $\boldsymbol{\rho}$.

In practice, there are two ways of estimating the fixed effects model: i) demeaning, or the within estimator, and ii) first differencing. With demeaning we should first calculate individual averages of the dependent variable and all explanatory variables. The we should substract the averages from the regression to obtain:

$$\boldsymbol{Y_{it} - \bar{Y}_i = \lambda_t - \bar{\lambda} + \rho(D_{it} - \bar{D}_i) + (X_{it} - \bar{X}_i)'\beta + \alpha_i + (\varepsilon_{it} - \bar{\varepsilon}_i)} \tag{2.57}$$

Thus $\boldsymbol{\alpha_i}$ drops out and therefore the error and the regressor would no longer be correlated.

In the first differencing way, we can also get rid of the $\boldsymbol{\alpha_i}$ by:

$$\boldsymbol{\Delta Y_{it} = \Delta\lambda_t + \rho\Delta D_{it} + \Delta X'_{it}\beta + \Delta\varepsilon_{it}} \tag{2.58}$$

The Difference-in-Difference method is first introduced by Card and Krueger (1994) who analyse the effect of a minimum wage increase in New Jersey. Taken securitization as an example, we can obtain a bank securitizes loans or not. We can only observe one situation or the other, that is, at a time point, a bank can only be a securitizer or a non-securitizer, but cannot be both.

If we assume that: 1) $\boldsymbol{Y_{1ist}}$ is the performance indicator of bank $\boldsymbol{i}$ which has securitized assets at state $\boldsymbol{s}$ and time $\boldsymbol{t}$, and 2) $\boldsymbol{Y_{0ist}}$ is the performance indicator of bank $\boldsymbol{i}$ which does not have securitized assets at state $\boldsymbol{s}$ and time $\boldsymbol{t}$. We the assume that:

$$\boldsymbol{E[Y_{0ist}|s,t] = \gamma_s + \lambda_t} \tag{2.59}$$

In the absence of the securitization activities, a bank's performance is determined by the sum of a time-invariant state effect $\boldsymbol{\gamma_s}$ and a time effect $\boldsymbol{\lambda_t}$. Let $\boldsymbol{D_{st}}$ be a dummy for securitized banks after an endogenous shock, e.g., the bankruptcy of Lehman Brothers in 2008. Assuming $\boldsymbol{E[Y_{1ist} - Y_{0ist}|s,t] = \delta}$ is the treatment effect, observed bank performance thus can be written as:

$$\boldsymbol{Y_{ist} = \gamma_s + \lambda_t + \delta D_{st} + \varepsilon_{ist}} \tag{2.60}$$

For example, for banks with securitization activities, the performance before the bankruptcy of Lehman Brothers in 2008 is:

$$\boldsymbol{E[Y_{ist}|s = securitizer, t = before\ 2008] = \gamma_{securitizer} + \lambda_{pre08}} \tag{2.61}$$

And the performance after the bankruptcy of Lehman Brothers in 2008 is:

$$\boldsymbol{E[Y_{ist}|s = securitizer, t = after\ 2008] = \gamma_{securitizer} + \lambda_{post08}} \tag{2.62}$$

Therefore, the difference between the securitizers' performance before and after 2008 is:

$$\boldsymbol{E[Y_{ist}|s = securitizer, t = after\ 2008] - E[Y_{ist}|s = securitizer, t = before\ 2008] = \lambda_{post08} - \lambda_{pre08} + \delta} \tag{2.63}$$

Similarly, for non-securitized banks, the performance before the bankruptcy of Lehman Brothers in 2008 is:

$$\boldsymbol{E[Y_{ist}|s = nonsecuritizer, t = before\ 2008] = \gamma_{nonsecuritizer} + \lambda_{pre08}} \tag{2.64}$$

And the performance after the bankruptcy of Lehman Brothers in 2008 is:

$$\boldsymbol{E[Y_{ist}|s = nonsecuritizer, t = after\ 2008] = \gamma_{nonsecuritizer} + \lambda_{post08}} \quad \textbf{(2.65)}$$

Therefore, the difference between the securitizers' performance before and after 2008 is:

$$\boldsymbol{E[Y_{ist}|s = nonsecuritizer, t = after\ 2008] - E[Y_{ist}|s = nonsecuritizer, t = before\ 2008] = \lambda_{post08} - \lambda_{pre08}} \quad \textbf{(2.66)}$$

Finally, the Difference-in-Difference strategy allows us to compare the change in the performance of securitizers with the change in the performance of non-securitizers. The population Difference-in-Difference is:

$$\boldsymbol{\{E[Y_{ist}|s = securitizer, t = after\ 2008] - E[Y_{ist}|s = securitizer, t = before\ 2008]\} - \{E[Y_{ist}|s = nonsecuritizer, t = after\ 2008] - E[Y_{ist}|s = nonsecuritizer, t = before\ 2008]\} = \delta} \quad \textbf{(2.67)}$$

The advantages of the Difference-in-Difference method are stated as follows. First, it is easy to calculate standard errors under this framework. Second, it allows researchers to control for other variables which may reduce the residual variance, which could also lead to smaller standard errors. Third, it is also easy to include multiple periods. Last, researchers can study treatments with different treatment intensity.

A typical regression model that can be estimated under the Difference-in-Difference framework is presented as follows:

$$\boldsymbol{Outcome_{it} = \beta_0 + \beta_1 Treatment_i + \beta_2 PostShock_t + \beta_3 (Treatment \times PostShock)_{it} + \varepsilon} \quad \textbf{(2.68)}$$

Where $\boldsymbol{Treatment}$ is the dummy if a bank confirmed as a securitizer, while $\boldsymbol{PostShock}$ is the post shock dummy.

Chapter 3
Securitization and bank risk

3.1 Introduction

There are conflicting arguments regarding the impact of securitization on bank risk. Classic theories suggest that securitization could decrease bank risk. On one hand, the risk transfer and diversification effects of securitization allow banks to substitute large potential risk exposures to direct borrowers with smaller and more diversified exposures, smooth out the risk among many investors (Duffie, 2007), and, absorb potential losses through the tranching process (Fender and Mitchell, 2005). The liquidity increase effect provides originators with the ability to face potential shocks (Gorton and Souleles, 2007) and income shocks (DeYoung and Rice, 2004). However, commentators cite the remarkable growth of securitization in recent years as a major contributor to the rise of the real estate bubble and the ensuing crisis. Part of the argument is that securitization creates additional layers of agency problems in loan origination. It leads to lax underwriting and thus higher default rates (Rajan, Seru, and Vig, 2011), or inefficiency in screening borrower and monitoring loans (Keys et al., 2010), which in turn can contribute to a lowering of lending standards and a gradual deterioration in the credit quality of assets (Demyanyk and Hemert, 2011). This chapter thus intend to study the impact of bank loan securitization on bank risk.

Using data from commercial banks in the U.S. during the period from 2002 to 2012, this chapter reports that the involvement of securitizations by commercial banks (measured as the ratio of total securitized assets over total assets) is positively associated with bank's $\boldsymbol{Zscore}$. The results show that an average of 10.99% standard deviation increase of $\boldsymbol{Zscore}$ due for each one-standard-deviation increase in total securitization ratio. The explanations are as follows. Securitization provide originators with the opportunity to share potential risk, because it permits a bank to originate loans and then transfer their interest rate and credit risks to outside investors (Benveniste and Berger, 1987; Franke, Herrmann and Webber, 2012). Creating a separate SPV isolates the cash flow generating assets and/or collateral so that securities issued by the SPV are not a general claim against the issuer, just against those assets. This effect then increases bank's ability to face the possible liquidity shock (Calomiris and Kahn, 1991). Securitization also provides a safety net for originators to confront the potential shocks from a more stable income stream (DeYoung and Rice, 2004), and a more diversified portfolio combination (Cebenoyan and Strahan, 2002). Bank risk is in turn decreased.

This study first uses OLS as the baseline framework to estimate the impact of loan securitization on bank risk. There is a concern that the relationship identified by the baseline framework could be endogenous. On the one hand, small banks may not prefer securitizing loans due to substantial large amount of upfront fixed costs. On the other hand, banks with higher reputation are more likely to be frequent securitizers because of a lower lemon discounts (Campbell and Kracaw, 1980; Diamond, 1984; Boyd and Prescott, 1986). This study utilizes several methods to address this issue. First, the Heckman self-selection model is used to estimate the causal effect of securitization on $\boldsymbol{Zscore}$, using three exogenous instruments. The first instrument is the *state-level corporate tax rate*. On the one hand, the corporate-tax-exempt benefit of securitization may increase banks' incentive to securitize assets (Han, Park, and Pennacchi, 2015), and on the other hand, *state-level corporate tax* itself is not directly related to bank risk. Secondly, a *peer liquidity index* based on Loutskina's (2011) liquidity index is constructed, which captures banks' incentive to securitize. It is also unlikely that a bank's industry peers' securitizing behaviour can directly affect its own risk (other than through the channel of securitization). The third instrument is the interaction of the two above mentioned instruments, which captures both instruments' characteristics.

A two-stage least squares (2SLS) estimation is implemented to check the robustness of the Heckman self-selection results by introducing the same sets of instruments. Finally, a propensity score matching based on weighted-least-squares estimation method, where the weights are inversely proportional to the probability of a bank being a securitizer is implemented. A propensity scores (represented by $\hat{\boldsymbol{p}}$) estimated by a probit regression using the following control variables: *bank size*, *diversification ratio*, *liquidity ratio*, *non-interest expense ratio*, *non-performing loans ratio*, *local market power index*, *bank holding* *company (BHC) dummy*, and *metropolitan statistical area (MSA) dummy* is then assigned. A securitizer receives a weight of $\mathbf{1}/\widehat{\boldsymbol{p}}$, while a non-securitizer receives a weight of $\mathbf{1}/(\mathbf{1}-\widehat{\boldsymbol{p}})$. A matched subsample including unique pairs of securitizer and non-securitizer with a difference of propensity score within 1% is used. All the results are consistent with the main results.

The 2007-09 financial crisis suddenly dried out the liquidity in the market. Securitization activities significantly rely on the liquidity in the market, so the withdrawal of repurchase agreements may trigger a securitized-banking run (Gorton and Metrick, 2012). Thus, there is the expectation that the impact of securitization will decrease because of a significant shrunk in the scale of securitization in the market. The sample period is divided into pre- and post-crisis subsamples in all estimations above. The pre-crisis period covers years from 2002 to 2007, while post-crisis period starts from 2007 to 2012. The reported results show that the impact of securitization on bank's Z-scores is positive and statistically significant in both periods, but the economic significance decreases after the breakout of the financial crisis. Overall, the sub-sample results still support the main findings.

Main transmission mechanisms from securitization to bank riskiness are through capital relief, favourable liquidity and risk transfer. To shed some more light on risk transfer, the possible differences between mortgage and non-mortgage securitizations are examined. Mortgage loans are widely considered to be safer than non-mortgage loans because the collaterals (i.e., real estates) of mortgage loan are not easily depreciated (Campbell and Cocco, 2015). Mortgage securitization is in turn not significantly related to risk transferring (Martín-Oliver and Saurina, 2007). Securitizing risky assets (e.g., non-mortgage loans), however, is found to be a more efficient risk transferring to decrease expected losses (Minton et al., 2004; Bannier and Hansel, 2008). Thus, non-mortgage securitization ratios are expected to be more significantly related to the increase of bank's Z-scores. To test the hypothesis, securitization is partitioned into mortgage and non-mortgage groups. The results show that while the increase of non-mortgage securitization ratios responds to higher Z-scores, mortgage securitization ratios are not significantly related to changes in Z-scores.

In practice, banks may choose loan sales rather than securitization because of a lower level of fixed upfront costs (Carlstrom and Samolyk, 1995). The final test thus focuses on loan sales. Loan sales involve the totality of an originated loan (Gorton and Haubrich, 1987) and are affected without recourse (Greenbaum and Thakor, 1987). Loan sellers can also reduce their risk by separating the ownership of riskier assets from their balance sheet (Berger and Udell, 1993). Thus, it is expected that loan sale ratios are positively related to bank's Z-scores. Following Bedendo and Bruno (2012), loan sales are partitioned by the difference between: 1) the outstanding principal balance of assets owned by others, with servicing retained by the bank, and, 2) the outstanding principal balance of assets sold and securitized by the bank. Using similar estimating methods in the present study the results show that loan sales also reduce bank risk.

This study provides direct empirical evidence on the impact of securitization on bank risk. Previous studies on securitization and bank risk pay more attention on the theoretical basis, providing both risk reduction (Benveniste and Berger, 1987; Pennacchi, 1988) and risk increase theories (Kobayashi and Osano, 2012; van Oordt, 2014). Empirical examinations of securitization provide evidence on the impact of bank performance (Guner, 2006; Casu et al., 2012), or specific on the impact of CMBS (Titman and Tsyplakov, 2010; An, Deng, and Gabriel, 2011), CLOs (Benmelech, Dlugosz, and Ivashina, 2012), subprime mortgage loans (Keys, Seru, and Vig, 2012), and ABCPs (Acharya, Schnabl, and Suarez, 2013) on bank performance and managerial efforts. To my best knowledge, there is no direct empirical evidence regarding the impact of securitization on bank risk. This study provides such direct evidence.

3.2 Hypothesis development

Bank loan securitization may lead to risk reduction through several channels. According to the risk sharing theory, securitization permits a bank to originate loans and then transfer their interest rate and credit risks to mortgage- and asset-backed security investors (Affinito and Tagliaferri, 2010; Franke, Herrmann, and Webber; 2011). In this case, securitization could reduce the burden on the balance sheet (Cumming, 1987; Flannery, 1994; Dell'Ariccia et al., 2008), or decrease expected losses that related to the potential default of borrowers

(Dahiya et al., 2003; Marsh, 2006). The tranching process of securitization creates classes of securities with different levels of credit quality from the underlying collateral asset pool, which could absorb potential losses of the underlying assets. This is accomplished through the use of credit support specified within the transaction structure, with the priority ordering of payments being a key example. Equity/first-loss tranche absorbs initial losses up to the level where it is depleted, followed by mezzanine tranches which absorb some additional losses, again followed by more senior tranches (see Fender and Mitchell; 2005 for details).

Securitization helps originators to confront the potential liquidity shocks caused by the riskiness of demandable-debt. The mismatch between the maturity of assets and liabilities of demandable-debt leave banks exposed to the possibility that depositors would attempt to withdraw more funds than they could supply on short notice. When this occurs, the consequences are dangerous and costly. Individual banks that do not meet their obligations are forced into expensive procedures, such as liquidation or receivership (Calomiris and Kahn, 1991).

Securitization decreases this riskiness by isolating the assets from the originators and improving originators' liquidity situation. On the one hand, securitization typically involves pooling the cash flows from a number of similar assets and selling the pool to a separate legal entity known as a special purpose vehicle (SPV). Creating this separate SPV isolates the cash flow generating assets and/or collateral so that securities issued by the SPV are not a general claim against the issuer, just against those assets. This process may reduce financial distress costs and thus increase debt capacity (Gorton and Souleles, 2005).

On the other hand, Calomiris and Kahn (1991) argue that higher liquidity level could partially ease the liquidity shock. The liquidity improving theory suggests securitization could improve the liquidity of bank's balance sheet (Greenbuam and Thakor, 1987; Pennacchi, 1988), reducing financing frictions. This effect could help bank's asset liability management, and increases bank's ability to effectively respond to negative economic environment (Stein, 1998; Kashyap and Stein, 2000; Schuermann, 2004; Diamond and Rajan, 2006), such as the case in demandable-debt.

Securitization could also provide a safety net for originators to face the income and undiversified portfolio shocks. It decreases the possibility of bank's income shock through capital relief effect. This theory suggests that securitization allows banks to adjust their capital ratios, as they may securitize loans instead of raising deposits. It allows issuers to hold less non-performing assets in the portfolios, and the fee-based income structure after securitization provides a more stable income stream (e.g., DeYoung and Rice, 2004). In practice, loan originators are often not best loan holders, since they end up being over-concentrated in certain industries and certain obligors because of the pressure to maintain client relationships (Berndt and Gupta, 2008). It could lead to higher undiversified risk which related to the rate of fluctuation or change that takes place in a given investment market. With securitization, issuers could restructure loan portfolios effectively to reduce such risk (Cebenoyan and Strahan, 2002).

Empirical evidence also supports the negative impact of securitization on bank risk. Based on the quarterly data between June 1988 and June 1993 of commercial banks in the U.S., Cebonoyan and Strahan (2004) suggest that securitization helps banks to manage their credit risk. Jiangli, Pritsker and Raupach (2007) conduct analysis of how asset securitization affects bank's insolvency and risk profile by testing U.S. bank holding company data from second quarter of 2001 to the third quarter of 2006. They develop a stylized model of a bank that originates and finances loans, and report that securitization can serve as an insurance against bank's insolvency in the real world. Jiangli and Pritsker (2008) also examine the effect of mortgage loan securitizations and other forms of asset securitizations on insolvency risk, profitability and leverage, using U.S. bank holding company data from 2001 to 2007. The empirical results also show that securitization could play a positive role by reducing insolvency risk. Therefore, my hypothesis is as follows:

Bank loan securitization could decrease bank risk.

3.3 Data and methodology

3.3.1 Data

Securitization and bank-specific data are obtained from the Reports of Income and Condition for commercial banks (the Call Report). Because U.S. banks are only required to provide detailed information on their securitization activities from June 2001, the annual data used in this study covers the period from 2002 to 2012. The final sample is an unbalanced panel including 342 banks with securitized loans and 8,483 banks without, accounting for 77,598 total bank-year observations.

3.3.2 Variables

While the following paragraphs provide detailed discussion on the variables used in this chapter in terms of variable construction, expectations on the regressions signs, and etc., a summary of variable definitions is presented in Appendix 1.A. The correlation matrix is reported in Appendix 1.B.

3.3.2.1 Dependent variable: LnZ

It is widely accepted that $Zscore$ could be employed to measure a bank's overall risk, the theory discussion of which can rely on Boyd and Graham (1986).

Theoretically, $Zscore$ is an indicator that measures the probability of banks or bank holding companies to fail. The $Zscore$ comes from a profitability indicator (r) and another risk indicator (S), the standard deviation of r, which measures the variability of profit. Let i denote an individual bank, j denote a year, and n denote the length (in years) of the sample period, then the empirical mean rate of return can be specified as:

$$\bar{r}_i = \sum_{j=1}^{n} \left(\tilde{r}_{ij} / n \right) \qquad \textbf{(3.1)}$$

Thus, $\bar{r}_i$ is a sample estimate of the true mean of $\tilde{r}_{ij}$ distribution.

Therefore, the estimated standard deviation of $\boldsymbol{r}$ for the $\boldsymbol{i}$th bank is:

$$\boldsymbol{S_i = \left\{\sum_{j=1}^{n}\left[\left(\tilde{r}_{ij} - \bar{r}_i\right)^2/(n-1)\right]\right\}^{1/2}} \tag{3.2}$$

Finally, for $\boldsymbol{Zscore}$, which measures the probability of a consolidated bankruptcy, should be:

$$\boldsymbol{p(\tilde{\pi} < -E) = p(\tilde{r} < k) = \int_{-\infty}^{k}\phi(r)dr} \tag{3.3}$$

where $\boldsymbol{\phi}$ is the probability density function of $\boldsymbol{\tilde{r}}$, $\boldsymbol{\pi}$ is the consolidated profits, $\boldsymbol{E}$ is consolidated equity, and $\boldsymbol{k = -E/A}$, in which $\boldsymbol{A}$ is the consolidated asset. Normal distributions are completely characterized by a location and a dispersion parameter, which means Euqation (3.3) may be simplified by changing coordinates. Therefore, if $\boldsymbol{\tilde{r}}$ is normally distributed, then

$$\boldsymbol{p(\tilde{r} < k) = \int_{-\infty}^{Z} N(0,1)dz} \quad \textbf{and} \quad \boldsymbol{z = (k - \rho)/\sigma} \tag{3.4}$$

where $\boldsymbol{\sigma}$ is the standard deviation of rate of return on assets. Here $\boldsymbol{z}$ is the principal risk measure, except that the sample estimate $\boldsymbol{S}$ is substituted for $\boldsymbol{\sigma}$ and the sample estimate $\boldsymbol{\tilde{r}}$ is substituted for $\boldsymbol{\rho}$, and $\boldsymbol{-z}$ is the risk variable that stands for overall risk, $\boldsymbol{Zscore}$. This $\boldsymbol{Zscore}$ is an estimate of the number of standard deviations below the mean that consolidated profits would have to fall to make consolidated equity negative, which means it is an indicator of the probability of a consolidated bankruptcy.

To be simplified, the specific calculation of z-score could then could be transferred into:

$$\boldsymbol{Zscore = \frac{ROA + E/A}{sdROA}} \tag{3.5}$$

where $\boldsymbol{ROA}$ is bank's net income after tax as a percentage of average assets, $\boldsymbol{E/A}$ is equity capital and minority interests to total assets, and $\boldsymbol{sdROA}$ is the standard deviation of $\boldsymbol{ROA}$. A higher level of $\boldsymbol{Zscore}$ corresponds to a lower upper bound of insolvency, which means a lower probability of default.

$Zscore$ has been widely employed in banking literature because it reflects many parts of the potential risk. Firstly, Boyd and Graham (1986) indicate that $Zscore$ is strongly associated with commercial paper ratings as reported by Moody's Investors Service. Secondly, this measurement contains bank profitability (ROA, return on assets), bank risk (standard deviation of ROA) and bank safety (E/A, equity to assets ratio), which has a synthetic explanation of the overall risk. In the research of exploring the relationship between ownership structure and overall risk, Barry et al. (2011) employ $Zscore$ and find a significant association between them. (More empirical literatures about z-score can refer to: Boyd et al., 1993; Altman and Saunders, 1997; Konishi and Yasuda, 2004; Demirguc-Kunt et al., 2008; Garcia-Marco and Robles-Fernandez, 2008; Graham et al., 2008; Lepetit et al., 2008; Santos and Winton, 2008; Laeven and Levine, 2009; Pathan, 2009; Uhde and Heimeshoff, 2009; Demirguc-Kunt and Huizinga, 2010; Houston et al., 2010)

Theoretically, the distribution of dependent variable should follow the normality assumption, which means a new dependent variable LnZ will be employed here. According to the basic mathematics knowledge, considering the feature of natural logarithm, the trends of LnZ should follow $Zscore$, which means a higher LnZ value still stands for a lower probability of default, or to say, overall risk. Following the methodology of Beck, De Jonghe and Schepens (2011), Michalak and Uhde (2012), as well as Anginer, Demirguc-Kunt and Zhu (2013), this study also employs a three- and five-year rolling LnZ.[1]

3.3.2.2 Securitization measures

Researches on securitization so far can be categorized in the following groups. Some researchers prefer to discuss the general influence of securitization, where they mainly define the regressor of securitization as total securitized assets to total assets, as in Mandel et al. (2012). Recently, more studies began to focus on the differences among securities. For example, Solano et al. (2006), when discussing the effects of securitization on the value of banking institutions, distinguish mortgage-backed securities (MBS) and asset-backed securities (ABS). Moreover, another group of researches classify detailed categories of securitization. For example, Cheng et al. (2008) employ four different securitization variables, ABS$_t$ (total securitized assets divided by total assets), MBS$_t$ (securitized 1-4 family residential mortgages scaled by total assets), CONSBS$_t$ (securitized consumer loans scaled by total assets) and COMMBS$_t$ (securitized commercial loans scaled by total assets) to study the relationship between securitization and opacity of banks. The key independent variable in this research is ***Securitization ratio***, which is defined as the ratio of the outstanding principal balance of assets securitized over total assets for a given type (i.e., mortgage or non-mortgage loans).

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[1] The results are robust with different rolling windows, from four to six years, when calculating the standard deviation of ROA.

3.3.2.3 Control variables

This study controls for several bank specific characteristics. ***Retained interest ratio*** is defined as the total amount of retained interest divided by the total amount of securitization assets of a given type, including the aggregate retained interests into credit enhancements, liquidity provisions, and seller's interest. The incentive of securitizers to carefully monitor loans could increase by providing enhancements which may decrease bank risk (Downing, Jaffee, and Wallace, 2009).

Bank size is the natural logarithm of total assets. DeMiguel et al. argue that size plays a significant role in the performance of banks. Haan and Poghosyan (2012) prove bank size reduces return volatility. However, the factor of scale could have negative impacts, which means banks do better by reducing their size (Gennotte and Pyle, 1991). Recently, papers also support this point of view, that larger companies tend to have riskier portfolios, which could increase the overall risk (Demzets, 1999). The relationship between bank risk and bank size, Hakenes and Schnabel (2011), Haan and Poghosyan (2012), and DeMiguel et al. (2013) suggest a negative relationship, while Gennotte and Pyle (1991) support a positive relationship.

Diversification indicates the diversification level of banks, which is calculated as noninterest income divided by total operation income, following the approach of Stiroh (2004). Previous research on diversification of portfolios shows positive influence, as the investors are more likely to be better off when holding a large number of low quality stocks than a smaller number of high quality stocks, and the return on the former portfolio will be higher (Wagner and Lau, 1971). Recently, empirical research on large Austrian commercial banks over the period of 1997-2003 also provides a decline of banks' realized risk, as well as increases profit efficiency when regarding to diversification effects, though it may impact cost efficiency negatively.

Liquidity ratio is an indicator for banks' liquidity, specified as liquid assets divided by total assets. Liquidity impacting on banks is not a one-way method, in fact, it sometimes could help managers to weaken the potential risks. Bolton et al. (2011) propose a dynamic model of investment, financing and risk management for financial institutions, and then find that liquidity significantly associated with banks' performance. Meanwhile, this model also supports the opinion that liquidity management is one of the complementary risk management tools.

Non interest expense ratio is an indicator of banks' efficiency, defined as non-interest expenses divided by total assets. Non-interest expenses are usually not associated with targeting customers to deposit funds; therefore, they are more likely to increase risk level (Lepetit et al., 2008).

Non performing loans ratio, computed as the amount of loans past due 90 days divided by total assets, reflects the risk management situation. Because non-performing loans are either in default or close to being in default, bank risk level can be positively related to the proportion of non-performing loans. For example, Affinito and Tagliaferri (2010) define non-performing loans as "bad loans" in their research to estimate the motivations of banks to choose securitization in Italian banking industry. Other researches which employ this control variable could refer to Calomiris and Mason (2004), Cardone-Riportella et al. (2010), Jiangli and Prisker (2008), and Minton, Stulz and Williamson (2009) for examples.

Following Berger and Bouwman (2013), I also control for banks' ***local market power*** as the deposit concentration for the local markets in which the bank operates. The larger the local market power, the greater a bank's market power and concentration in its surroundings. This is a standard measure of competition used in antitrust analysis and research in the U.S. (Berger and

Bouwman, 2013). Moreover, using deposits for this purpose because it is the only vairbale for which location is known. Following Berger and Bouwman (2013), this research uses the new local market definitions based on Core Based Statistical Area (CBSA) and non-CBSA county.

This study uses a bank holding company dummy ($\boldsymbol{BHC\ dummy}$) to control for whether it belongs to a bank holding company. $\boldsymbol{BHC\ dummy}$ equals one if the bank belongs to a bank holding company, and zero otherwise. Within a short-time window, banks belonging to a BHC are more likely to take more risk, as they have this “backup” (Jiang, Lee, and Yue, 2010).

Finally, a metropolitan statistical area dummy ($\boldsymbol{MSA\ dummy}$), which equals one if the bank is located in a metropolitan area, and zero otherwise, is used to identify individual banks’ locations. Competition may be fiercer in metropolitan areas, and banks in suburban areas are more likely to have a more stable environment.

3.3.3 Empirical strategy

In order to test the impact of bank loan securitization on bank risk, this chapter starts with the following OLS model:

$$\boldsymbol{Zscore_{i,t} = \beta_0 + \beta_1 Securitization\ Ratio_{i,t-1} + \beta_2 X_{i,t-1} + \alpha_i + \delta_t + \mu_{i,t}} \quad \textbf{(3.6)}$$

where $\boldsymbol{Zscore_{i,t}}$ is the dependent variable, $\boldsymbol{Securitization\ Ratio_{i,t-1}}$ is the vector of total securitization ratio, $\boldsymbol{X_{i,t-1}}$ is the vector of bank-specific control variables, $\boldsymbol{\alpha_i}$ is the individual difference, $\boldsymbol{\delta_t}$ is the time variation that not related to individual charateristics, and $\boldsymbol{\mu_{i,t}}$ is the disturbance term.

The relationship identified by the OLS model could be biased since self-selection problem exists in the decision of securitizing loans. First, securitization involves substantial upfront fixed costs including consultancy and organizational costs, payments to rating agencies, underwriting fees, and legal expenses. Small banks thus may not prefer securitizing loans. Second, the lemon discount required on the underlying assets suggests that securitized assets are likely to be underpriced (Campbell and Kracaw, 1980; Diamond, 1984; Boyd and Prescott, 1986). Thus, banks with higher reputation are more likely to enjoy a lower discount during securitization process. The existence of self-selection problem in securitization is, therefore, a rational conjecture.

This study uses three methods to address this endogeneity issue. First, a Heckman self-selection model using three instrument variables is implemented. The first instrument is the ***state-level corporate tax rate***[2], because higher corporate tax rates may increase a bank's incentive to securitize assets due to the corporate tax exemption of securitized assets (Han, Park, and Pennacchi, 2015). The second instrument is ***peer liquidity index***. Liquidity index is proposed by Loutskina (2011) to effectively capture banks' ability to sell loans. Following Loutskina (2011), a bank's loan portfolio is broken down into six groups: 1) home mortgages, 2) multi-family residential mortgages, 3) commercial mortgages, 4) agricultural loans, 5) commercial and industrial (C&I) loans, and 6) consumer credit.[3] Liquidity index is defined as:

$$\boldsymbol{Liquidity\ Index_{it}} = \sum_{j=1}^{6}\left(\frac{\boldsymbol{Economy\ Wide\ Securitization_{jt}}}{\boldsymbol{Economy\ Wide\ Total\ Loans_{jt}}}\right) \times (\boldsymbol{Loan\ Share_{j,it}}) \quad \textbf{(3.7)}$$

In this equation, $\boldsymbol{Economy\ Wide\ Securitization_{jt}}$ is the total securitized loans of type j at time t in the whole economy, $\boldsymbol{Economy\ Wide\ Total\ Loans_{jt}}$ is the total loans outstanding of type $\boldsymbol{j}$ at time $\boldsymbol{t}$ in the whole economy, and $\boldsymbol{Loan\ Share_{j,it}}$ is the share of type $\boldsymbol{j}$ loans in bank $\boldsymbol{i}$ at time $\boldsymbol{t}$ in the whole economy.

Finally, bank $\boldsymbol{i}$'s peer liquidity index is constructed by calculating the average liquidity index of bank $\boldsymbol{i}$'s peers.[4] The herd effect (Chari and Kehoe, 2004) implies that an individual bank's incentive to securitize loans can be stimulated by its industry peers, but it is unlikely that a bank's industry peers' securitizing behaviour can directly affect this bank's risk.

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[2] The data are available from the U.S. Tax Foundation website at: http://www.taxfoundation.org/taxdata/show/230.html.

[3] The data used to construct liquidity index comes from the "Financial Accounts of the United States" (Z.1) data release.

[4] Bank *i* itself is excluded.

State-level corporate tax rate only provides information on the impact of securitization incentives of a state's "average" bank, while peer liquidity index captures no state-level difference. A third instrument is constructed by interacting the above two instruments. After using the instruments to determine the incentives to securitize loans in the first-step regression, a self-selection control variable is added which is the inverse Mills ratio, into the following main regression:

$$\boldsymbol{Zscore_{i,t} = \beta_0 + \beta_1 Securitization\ Ratio_{i,t-1} + \beta_2 X_{i,t-1} + \beta_3 inverse\ Mills\ ratio + \alpha_i + \delta_t} \quad \mathbf{(3.8)}$$

Second, an instrumental variable approach is used, which is similar to the same set of instruments and control variables as the Heckman model.

Finally, there is a concern about potential biases caused by the unbalanced samples with the sample of securitizer (342) being significantly smaller than that of non-securitizers (8,483). Following Bortolotti, Fotak, and Megginson (2015), this study uses the propensity score matching based weighted square regression. First, propensity scores (represented by $\boldsymbol{\hat{p}}$) is assigned to banks using the following bank-specific characteristics: *bank size*, *diversification ratio*, *liquidity ratio*, *non-interest expense ratio*, *non-performing loans ratio*, *local market power index*, *bank holding company (BHC) dummy*, and *metropolitan statistical area (MSA) dummy*. A securitizer receives a weight of **1/** $\boldsymbol{\hat{p}}$, while a non-securitizer receives a weight of **1/(1-** $\boldsymbol{\hat{p}}$**)**. The sample is refined by constructing a subsample consisting of securitizers and their most similar non-securitizer counterparties. A 1:1 matching which imposes a 1% tolerance on the difference of propensity scores of each securitizer and matched non-securitizer is adopted. The sample is divided into pre- and post-crisis periods to check the differences between them. The reported results are also robust when a simple propensity score matching method is used.

The breakout of the 2007-09 financial crisis significantly changes the macroeconomic environment, e.g., it suddenly dried out the liquidity in the market. Securitization activities rely heavily on the liquidity in the market, so the withdrawal of repurchase agreements may trigger a securitized-banking run (Gorton and Metrick, 2012). The significant dive of the securitization market may in turn decrease the impact of securitization. Thus, it is expected that the impact of securitization on bank's risk may decrease after the 2007-09 financial crisis. Therefore, the hypothesis here is as follows:

The impact of securitization on bank risk before the breakout of the 2007-09 financial crisis is likely to be more significant.

The sample period is thus divided into pre- and post-crisis periods. Pre-crisis period start from 2002 to 2006, while post-crisis period covers the years from 2007 to 2012. All regressions are rerun using the before and after 2007 subsamples.

3.4 Empirical results

3.4.1 Preliminary analysis

Table 3.1 shows the summary statistics on all variables used in this study for both securitizers and non-securitizers. Panel A, Table 3.1 first reports the descriptive statistics of securitizers and non-securitizers.[5] It is also interesting to see the differences between pre- and post-crisis periods. Thus, statistics of mean, median, and standard deviation (SD) are reported under each subgroup. The average value of $\boldsymbol{Zscores}$ decreased from 1.05 before 2007 to 0.63 after 2007, and the standard deviations of $\boldsymbol{Zscores}$ for both securitizers and non-securitizers also increased significantly after 2007. These results reflect the severe impact of crisis on bank risk. Since values of securitization related variables for non-securitizers are all zero, only statistics for securitizers on variables of $\boldsymbol{total\ securitization\ ratio}\%$ and $\boldsymbol{total\ retained\ interest\ ratio}\%$ are reported. There was a significant dive of the securitization market scale after the breakout of crisis (average securitization of 13.24% before 2007 vs. 7.08% from 2007), which could be caused by a sudden erosion of liquidity in the capital market (Gorton and Metrick, 2012). The average credit enhancements level increases from 4.28% to 5.26%, suggesting investors become more cautious after realizing the crisis. Small banks are rare securitizers due to a large amount of upfront costs, and Table 3.1 shows that the average size of securitizers (nearly $596 million) in the sample is over four times than non-securitizers (nearly $134 million). Literature show that securitization allows banks to achieve more diversified portfolios (DeMarzo, 2005), and a lower liquidity level (Lourtskina, 2011). The costs of deposits are lower for bank holding companies that located in a metropolitan area with higher market power, so they are more likely to be able to maintain the “originate-to-distribute” funding model (Loutskina and Strahan, 2009). The empirical results support all theories above.

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[5] Percentage values of ratio variables are reported in Table 3.1.

<Insert Table 3.1 Panel A Here>

The differences between securitizers and non-securitizers and changes for the before and after the 2007-09 financial crisis sub-periods are presented in Panel B, Table 3.1. Student's t-test and Wilcoxon rank-sum test are applied for the means and medians of the differences, respectively. The 2007-09 financial crisis significantly decreases bank risk, since the average $\boldsymbol{Zscores}$ of securitizers and non-securitizers decreases by 0.42 and 0.43, respectively. However, $\boldsymbol{Zscores}$ of securitizers are higher than non-securitizers in both periods (i.e., before and after 2007), suggesting securitization could decrease bank risk. In the line with the previous findings, significant differences between securitizers and non-securitizers regarding to the rest of control variables are also reported.

<Insert Table 3.1 Panel B Here>

3.4.2 The impact of bank securitization on $\boldsymbol{Zscore}$

Results on the baseline model of the impact of loan securitization on bank’s $\boldsymbol{Zscores}$ using OLS are reported in Table 3.2. Results on $\boldsymbol{Zscores}$, 3-year rolling and 5-year rolling $\boldsymbol{Zscores}$ are reported in column (1), (2), and (3), respectively.

<Insert Table 3.2 Here>

Coefficients of key variable, $\boldsymbol{total\ securitization\ ratio}\%$, are all positive and significant, indicating that loan securitization is associated with a decrease in bank risk. Column (1) shows that a one-standard-deviation increase in total securitization ratio is associated with an increase of 10.99% of a standard deviation in bank's Z-scores. 10.99% is calculated by standardizing the coefficient, which is coefficient × SD_securitization ratio/SD_Zscore. Results are similar on economic impacts using 3-year rolling and 5-year rolling $\boldsymbol{Zscores}$, where a one-standard-deviation increase in total securitization ratio is associated with an average increase of 7.13% and 6.33% of a standard deviation in bank's $\boldsymbol{Zscores}$, respectively. These results are in line with the hypothesis that securitization could help banks to reduce their risk in the short run by substituting large potential exposures to direct borrowers with smaller and more diversified exposures and smoothing out the risks among many investors (Duffie, 2007). This diversification effect allows securitizers to share the large and entire risk exposure to a single possible shock with a large number of investors, which in turn decreases this exposure, leading to a risk reduction effect.

Results on the control variables are largely in the line with the expectations and previous literature. Literature suggests that providing credit enhancements could decrease bank risk by forcing securitizers to retain long-term economic exposure. The findings of the regressions support this argument by presenting a positive relationship between ***total retained interest ratio%*** and $\boldsymbol{Zscores}$. The negative correlation between ***bank size*** and $\boldsymbol{Zscores}$ can be explained by the *too-big-to-fail* theory that larger banks are more likely to take on more risk. As expected, a higher level of diversification and liquidity decreases bank risk, while less efficient banks are likely to be riskier.

To address the endogeneity problem, several identification strategies are applied in this chapter. Results using Heckman self-selection analysis are reported in Table 3.3. Coefficients and standard errors, using instrument of ***state-level corporate tax rate***, ***peer liquidity index***, and ***state-level corporate tax rate × peer liquidity index***, are reported in column (1), (2), and (3), respectively. ***Inverse Mills ratios*** are significant in all specifications, suggesting that self-selection bias is controlled by the empirical model. Similar economic impacts of loan securitization ratios on bank's $\boldsymbol{Zscores}$ are reported, where a one-standard-deviation increase in total securitization ratio is associated with an average increase of 6.49% of a standard deviation in bank's $\boldsymbol{Zscores}$, respectively. This result confirms the baseline findings.

<Insert Table 3.3 Here>

Second, a 2SLS estimation is employed to address the endogeneity problem, where the same set of instruments are used. Results again show a positive and significant association between securitization ratio and bank's $\boldsymbol{Zscores}$. The results are reported in Table 3.4. The findings are consistent using Heckman self-selection and 2SLS methods, confirming that the results are robust. More interestingly, the implements of Heckman self-selection and 2SLS estimation improve R-squares in both regressions, suggesting that those models are more accurate than the OLS estimation.

<Insert Table 3.4 >

Analysis so far ignores the presence of the 2007-09 financial crisis. Therefore, the sample is divided into pre- and post-crisis periods, in order to examine whether securitization activities impact differently on bank risk. The OLS, Heckman, and instrumental variable regressions are reviewed using the subsamples. Results are presented in Table 3.5, Panel A, B, and C, respectively.

<Insert Table 3.5 Panel A Here>

<Insert Table 3.5 Panel B Here>

<Insert Table 3.5 Panel C Here>

Consistent with the results on full sample, the coefficients of total securitization ratio are all significant and positive in all specifications. However, the split-sample results show a decreased economic impact of securitization ratio on Z-score after the breakout of the financial crisis. For example, in column (1), Panel A, a one-standard-deviation increase in total securitization ratio is associated with an increase of 13.48% of a standard deviation in bank's Z-scores before 2007 when estimated by OLS, while this economic impact significantly decreases to 8.06% (column (2)) after 2007. Similar declines of economic significance are also found in Heckman and instrumental variable estimations. The explanations are as follows. After June 2007, the securitization market suffered significant dive in total scale since insufficient information to price and quality of securities (Pagano and Volpin, 2012), which increased the overhang of illiquid assets on banks' balance sheets (Brunnermeier and Pedersen, 2009). Bank risk in turn cannot be sufficiently transferred through securitization process. Another explanation could be the motivation change after 2007. Bedendo and Bruno (2012) argue that the principal incentive behind credit risk transferring activities is to raise financial resources rather than transferring risk during severe times. In this case, securitizers are more likely to use securitization to address their funding shortage rather than transferring potential risk.

Another concern in this empirical study is the unbalanced observations between securitizers (3,132) and non-securitizers (74,466). Therefore, a propensity score matching based weighted-least-squares estimation is used to address this problem using a full sample and 1:1 matched sample. Results on full sample, 1:1 matched sample are reported in column (1) to (2), Table 3.6, respectively. Results again show a positive and significant association between securitization ratio and bank's Z-scores. After dividing the full sample into pre- and post-crisis periods, results in column (3) and (4) are consistent with the expectation and the main results. Taken together the results above, the results show that bank loan securitization could decrease bank risk measured by Z-score, which is in the line with the main hypothesis.

<Insert Table 3.6 Here>

3.5 Additional analysis

3.5.1 The impact of mortgage and non-mortgage securitization on bank's Z-score

Main transmission mechanisms from securitization to bank riskiness are through capital relief, favourable liquidity and risk transfer. To shed some more light on this risk transfer argument, this study focuses on mortgage securitization vs non-mortgage securitization. Mortgage loans are widely considered to be higher quality due to the underlying real estates are not easily depreciated (Campbell and Cocco, 2015). Mortgage securitization is in turn not significantly related to risk transferring (Martín-Oliver and Saurina, 2007). Non-mortgage securitization, however, allows banks to remove riskier asset out of their balance sheet and share potential risk with a larger number of investors, decreasing the expected losses

(Minton et al., 2004; Bannier and Hansel, 2008). Therefore, the hypothesis here is as follows:

The impact of non-mortgage securitization on bank risk is more significant than mortgage securitization.

To test this hypothesis, bank's total securitization is broken down securitization activities into mortgage and non-mortgage securitizations. Mortgage loans include 1-4 home mortgages, while non-mortgage loans contain all other types of loans, including home equity lines, credit card receivables, auto loans, commercial and industrial loans, other consumer loans, and all other loans. replace Then total securitization ratios are replaced by mortgage and non-mortgage securitization ratios in all specifications, respectively. The OLS results are reported in Panel A, Table 3.7, while results on mortgage and non-mortgage securitizations using Heckman self-selection model are reported in Panel B and C, Table 3.7, respectively.

<Insert Table 3.7 Here>

In the line with the hypothesis, mortgage securitization ratio is not significantly related to Z-score, while non-mortgage securitization is found to have a significant and positive impact on Z-score. A one-standard-deviation increase in non-mortgage securitization ratio is associated with an increase of 6.73% of a standard deviation in bank's Z-scores, and this economic impact is 11.93% and 2.88% before and after 2007, respectively. This finding is in the line with the evidence of no risk transfer in mortgage securitization (Acharya, Schnabl, and Suarez, 2013).

3.5.2 The impact of loan sales on bank Z-score

The final test focuses on loan sales. Similar to securitization, loan sales also allow sellers to transfer potential risk to the buyers. However, loan sales involve the totality of an originated loan (Gorton and Haubrich, 1987) and are affected without recourse and bank serves as a pure broker (Greenbaum and Thakor, 1987). In practice, banks may choose to use total loan sale rather than securitization as their funding strategy (Carlstrom and Samolyk, 1995). Loan sellers can also reduce potential risk by separating the ownership of riskier assets from their balance sheet (Berger and Udell, 1993), which in turn transfers the potential risk to the loan buyers. Following Bedendo and Bruno (2012), loan sales are defined by the difference between 1) the outstanding principal balance of assets owned by others, with servicing retained by the bank, and 2) the outstanding principal balance of assets sold and securitized by the bank. Loan sales data are collected from the Call Report, and the regression results are reported in Table 3.8.

<Insert Table 3.8 Here>

The results show a similar positive impact of loan sale on bank's Z-score. The coefficients of loan sale ratio are all positive and statistically significant at 1% level across all specifications. A one-standard-deviation increase in loan sale ratio is associated with an increase of 7.51% and an average increase of 7.47% of a standard deviation in bank's Z-scores when estimated by OLS and Heckman models, respectively. This finding holds after dividing the sample into pre- and post-2007 periods, where the economic impact is around 8% before 2007, and 6% after 2007.

3.6 Conclusion

This chapter studies how securitization affects bank risk measured by Z-score. To address the endogeneity problem in securitization, identifications such as a Heckman self-selection model and an instrumental variable approach, are employed. The empirical structure also includes three instruments, i) *state-level corporate tax rate*; ii) *peer liquidity index*; and, iii) *state-level corporate tax rate* × *peer liquidity index*; in both analyses. Among all specifications, empirical results are consistent and robust. Therefore, the findings show that the involvement of securitization decreases bank risk measured by Z-score.

Concerning the severe economic environmental change before and after the 2007-09 financial crisis, it is interesting to study the possible change. The sample period is thus divided into pre- and post-crisis periods. Although the results are generally consistent with the main findings, that securitization ratios are positively and significantly correlated to bank's Z-scores, a significant economic significance change after the breakout of the 2007-09 crisis is spotted. In addition, the additional tests show disparate impacts between mortgage and non-mortgage securitizations. Mortgage securitization is not likely to help banks to reduce bank risk, while non-mortgage securitization could provide efficient risk transferring. Finally, the empirical results suggest that loan sale activities respond to a similar positive impact on bank risk.

Table 3.1: Summary statistics

Table 3.1 shows the descriptive statistics of the dependent and independent variables. Statistics are based on the panel data including 342 secuiritizers and 8,483 non-securitizers during the period of 2002 to 2012, accounting for total bank-year observations of 77,598. Previous periods are not included because U.S. banks are only required to provide detailed information on their securitization activities from June 2001. Variable definitions are provided in Appendix 3.A. Concerning the impact of the 2007-2009 financial crisis, the time period is divided into before- and after-2007 to check the difference. Panel A reports the statistics of securitizers and non-securitizers, respectively. Statistics of mean, median, and standard deviation are reported. Panel B shows the comparative statistics of: 1.the difference between the pre- and post-crisis periods, where the difference is calculated by the value after 2007 minus the value before 2007; and, 2.the difference between securitizers and non-securitizers, where the difference is calculated by the value of securitizers minus the value of non-securitizers. Differences in the number and proportion of failed banks are showed with regards to variable of bank failure, while differences in means and medians are showed for the rest of variables. Information on t-test on means and medians are also showed in Panel B.

Panel A: Statistics for securitizers and non-securitizers

	Securitizers								Non-securitizers							
	before 2007				after 2007				before 2007				after 2007			
Dependent variable																
	mean	median	SD	Obs.	mean	median	SD	Obs.	mean	median	SD	Obs.	mean	median	SD	Obs.
Z-score	1.05	0.96	0.45	1,534	0.64	1.04	1.01	1,598	1.05	1.02	0.34	36,221	0.61	0.96	0.98	38,245
Securitization regressors																
Total securitization ratio%	13.24	4.00	56.54	1,534	7.08	1.46	30.78	1,598	-	-	-	-	-	-	-	-
Bank-specific control variables																
Total retained interest ratio%	4.28	1.75	14.33	1,534	5.26	0.00	20.00	1,598	-	-	-	-	-	-	-	-
Bank size	13.23	12.68	2.01	1,534	13.36	12.97	1.86	1,598	11.65	11.54	1.19	36,221	11.94	11.84	1.19	38,245
Diversification ratio%	25.55	14.24	25.56	1,534	24.44	14.04	25.28	1,598	12.55	10.56	10.10	36,221	11.97	9.99	10.78	38,245
Bank liquidity ratio%	22.60	21.01	12.84	1,534	20.65	18.77	12.15	1,598	23.33	21.06	14.63	36,221	22.15	19.46	14.92	38,245
Non-interest expense ratio%	3.38	2.86	1.96	1,534	3.34	2.93	1.69	1,598	3.07	2.88	1.20	36,221	3.13	2.93	1.23	38,245
Non-performing loans ratio%	1.89	0.48	3.58	1,534	2.55	0.36	4.63	1,598	1.53	0.23	3.02	36,221	1.54	0.09	3.30	38,245
Local-market power	2.29	0.02	5.42	1,534	2.47	0.03	5.82	1,598	0.46	0.01	2.40	36,221	0.51	0.01	2.50	38,245
Bank holding company dummy	0.86	1.00	0.34	1,534	0.90	1.00	0.30	1,598	0.82	1.00	0.39	36,221	0.83	1.00	0.38	38,245
Metropolitan statistical area dummy	0.79	1.00	0.41	1,534	0.78	1.00	0.41	1,598	0.61	1.00	0.49	36,221	0.61	1.00	0.49	38,245

Table 3.1: Summary statistics (continued)

Panel B: Difference between securitizers and non-securitizers

	Difference with the reference of 2007/2008 financial crisis difference = value after 2007 - value before 2007						Difference between securitizers and non-securitizers difference = value of securitizer - value of non-securitizer					
	Securitizers			Non-securitizers			Before 2007			After 2007		
Dependent variable												
statistic	Dif %		t-test on means	Dif %		t-test on means	Dif %		t-test on means	Dif %		t-test on means
Bank failure	4.84%		a*	6.21%		a	0.04%		a	-1.33%		a
statistic	Dif mean	Dif med.	t-test on mean and med.	Dif mean	Dif med.	t-test on mean and med.	Dif mean	Dif med.	t-test on mean and med.	Dif mean	Dif med.	t-test on mean and med.
Z-score	-0.42	0.08	a	-0.43	-0.05	a, b	0.01	-0.06	a, b	0.03	0.07	a
Securitization regressor												
Total securitization ratio%	-6.16	-2.54	a, b	-	-	-	-	-	-	-	-	-
Bank-specific control variables												
Total retained interest ratio%	0.98	-1.75	b	-	-	-	-	-	-	-	-	-
Bank size	0.14	0.29	a, b	0.29	0.29	a, b	1.58	1.14	a, b	1.42	1.13	a, b
Diversification ratio%	-1.10	-0.20	-	-0.58	-0.57	a, b	13.00	3.68	a, b	12.47	4.05	a, b
Bank liquidity ratio%	-1.95	-2.25	a, b	-1.18	-1.60	a, b	-0.73	-0.05	a	-1.49	-0.69	a, b
Non-interest expense ratio%	-0.04	0.07	b	0.06	0.05	a, b	0.31	-0.01	a	0.21	0.01	a
Non-performing loans ratio%	0.66	-0.12	a, b	0.01	-0.14	b	0.36	0.25	a, b	1.01	0.27	a, b
Local-market power	0.19	0.01	b	0.04	0.00	a, b	1.82	0.02	a, b	1.97	0.03	a, b
Bank holding company dummy	0.04	0.00	a	0.01	0.00	a	0.05	0.00	a	0.08	0.00	a
Metropolitan statistical area dummy	-0.01	0.00	-	0.00	0.00	-	0.17	0.00	a	0.17	0.00	a

NOTE: * the letter "a" and "b" indicate a significant difference of means and medians at 1% level, respectively.

Table 3.2: Baseline results – OLS estimation

Table 3.2 shows the baseline results on the impact of total loan securitization ratio on bank's Z-scores. The sample period is 2002-2012. Control variables include *retained interest ratio, bank size, diversification ratio, liquidity ratio, non-interest expense ratio, non-performing loans ratio, local-market power index, bank holding company dummy* and *metropolitan statistical area dummy*. All variable definitions are provided in Appendix 3.A. The baseline results based on *Z-score, three years rolling Z-score, and five years rolling Z-score* are reported in column (1) to (3), respectively. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Dependent Variable	*Z-score*	*3-year rolling Z-score*	*5-year rolling Z-score*
	(1)	(2)	(3)
Total securitization ratio%$_{t-1}$	0.066***	0.058**	0.035***
	(0.02)	(0.03)	(0.02)
Total retained interest ratio%$_{t-1}$	0.017	0.004	-0.009
	(0.04)	(0.04)	(0.03)
Bank size$_{t-1}$	-0.100***	-0.079***	-0.055***
	(0.01)	(0.01)	(0.01)
Diversification ratio%$_{t-1}$	0.140**	0.145***	0.137***
	(0.07)	(0.05)	(0.04)
Bank liquidity ratio%$_{t-1}$	-0.623**	-0.472**	-0.390**
	(0.29)	(0.20)	(0.16)
Non-interest expense ratio%$_{t-1}$	0.179	0.020	0.027
	(0.12)	(0.08)	(0.05)
Non-performing loans ratio%$_{t-1}$	0.145***	0.131***	0.120***
	(0.03)	(0.03)	(0.02)
Local-market power$_{t-1}$	0.022	0.027	0.024
	(0.03)	(0.02)	(0.02)
Bank holding company dummy$_{t-1}$	-0.043***	-0.038***	-0.030***
	(0.01)	(0.01)	(0.01)
Metropolitan statistical area dummy$_{t-1}$	-0.030	-0.013	-0.009
	(0.03)	(0.02)	(0.02)
Constant	1.571***	1.311***	1.020***
	(0.12)	(0.09)	(0.07)
Bank fixed effects	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes
Observations	69,258	69,258	69,258
Adjusted-R^2	0.2446	0.2534	0.2504

Table 3.3: Heckman self-selection estimation

Table 3.3 shows results on the impact of total loan securitization ratio on bank's Z-scores using Heckman self-selection model. The sample period is 2002-2012. Control variables include *retained interest ratio, bank size, diversification ratio, liquidity ratio, non-interest expense ratio, non-performing loans ratio, local-market power index, bank holding company dummy* and *metropolitan statistical area dummy*. All variable definitions are provided in Appendix 3.A. The regression introduces three instruments: 1) *state-level corporate tax rate*; 2) *peer liquidity index*; and 3) *state-level corporate tax rate × peer liquidity index*. Only the second-step results are reported in columns (1) to (3), respectively. The first-step results are reported in Appendix 3.C. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Dependent Variable	*5-year rolling Z-score*		
	Heckman self-selection model		
Instrument	(1) (Corporate tax rate)	(2) (Peer liquidity index)	(3) (Interaction term)
Total securitization ratio%$_{t-1}$	0.218***	0.213***	0.247**
	(0.03)	(0.03)	(0.09)
Total retained interest ratio%$_{t-1}$	0.280***	0.280***	0.322*
	(0.04)	(0.04)	(0.14)
Bank size$_{t-1}$	-0.055**	-0.129***	-0.356***
	(0.02)	(0.04)	(0.26)
Diversification ratio%$_{t-1}$	0.131	0.142***	0.502***
	(0.08)	(0.09)	(0.29)
Bank liquidity ratio%$_{t-1}$	-14.734	-1.335**	-0.351***
	(10.76)	(1.25)	(0.31)
Non-interest expense ratio%$_{t-1}$	0.221	0.052	-4.421***
	(0.31)	(0.29)	(2.52)
Non-performing loans ratio%$_{t-1}$	-0.006	-0.026**	-0.484***
	(0.05)	(0.07)	(0.86)
Local-market power$_{t-1}$	0.484***	-0.446***	-0.226**
	(0.12)	(0.12)	(0.11)
Bank holding company dummy$_{t-1}$	-0.067*	-0.075*	-3.238***
	(0.04)	(0.04)	(2.86)
Metropolitan statistical area dummy$_{t-1}$	-0.099***	-0.091***	-16.79*
	(0.03)	(0.03)	(8.69)
Constant	1.616***	3.204***	1.671***
	(0.48)	(0.80)	(1.34)
Inverse Mills Ratio	-0.235***	-0.243***	-0.488***
	(0.07)	(0.08)	(0.13)
Bank fixed effects	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes
Observations	69,258	69,258	69,258
Adjusted-R^2	0.4346	0.3446	0.3418

Table 3.4: 2SLS estimation

Table 3.4 shows results on the impact of total loan securitization ratio on bank's Z-scores using 2SLS estimation. The sample period is 2002-2012. Control variables include *retained interest ratio, bank size, diversification ratio, liquidity ratio, non-interest expense ratio, non-performing loans ratio, local-market power index, bank holding company dummy* and *metropolitan statistical area dummy*. All variable definitions are provided in Appendix 3.A. The regression introduces three instruments: 1) *state-level corporate tax rate*; 2) *peer liquidity index*; and 3) *state-level corporate tax rate* × *peer liquidity index*. Only the second-step results are reported in columns (1) to (3), respectively. The first-step results are reported in Appendix 3.C. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Dependent Variable	*5-year rolling Z-score*		
	2SLS model		
Instrument	(1) (Corporate tax rate)	(2) (Peer liquidity index)	(3) (Interaction term)
Total securitization ratio%$_{t-1}$	0.233***	0.202***	0.287***
	(0.08)	(0.27)	(0.10)
Total retained interest ratio%$_{t-1}$	1.674**	1.927***	3.047***
	(0.71)	(0.72)	(4.08)
Bank size$_{t-1}$	-0.054***	-0.058***	-0.074***
	(0.01)	(0.01)	(0.05)
Diversification ratio%$_{t-1}$	0.090***	0.096***	0.142***
	(0.03)	(0.14)	(0.04)
Bank liquidity ratio%$_{t-1}$	-0.344	-0.318	-0.212
	(0.30)	(0.31)	(0.54)
Non-interest expense ratio%$_{t-1}$	-1.273	-1.020**	-1.513**
	(0.86)	(1.89)	(0.97)
Non-performing loans ratio%$_{t-1}$	-0.304	-0.367**	-0.606**
	(0.32)	(0.34)	(1.10)
Local-market power$_{t-1}$	0.041	0.037	-0.126
	(0.08)	(0.09)	(0.30)
Bank holding company dummy$_{t-1}$	-0.056***	-0.024	-0.050***
	(0.01)	(0.08)	(0.01)
Metropolitan statistical area dummy$_{t-1}$	-0.017**	-0.015*	-0.007
	(0.01)	(0.01)	(0.03)
Constant	1.074***	1.284**	1.119***
	(0.09)	(0.63)	(0.08)
Bank fixed effects	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes
Observations	69,258	69,258	69,258
Adjusted-R^2	0.4579	0.4928	0.4579

Table 3.5: Split sample analysis

Table 3.5 shows the baseline results using split samples referring to the 2007-2009 financial crisis. The full sample is divided into before- and after-2007 periods. Control variables include *retained interest ratio, bank size, diversification ratio, liquidity ratio, non-interest expense ratio, non-performing loans ratio, local-market power index, bank holding company dummy* and *metropolitan statistical area dummy*. All variable definitions are provided in Appendix 3.A. Results on before and after 2007 subsamples using OLS estimators are reported in Panel A. Heckman self-selection model and 2SLS are employed as two additional identifications to address the endogeneity problem, where three instruments are introduced: 1) *state-level corporate tax rate*; 2) *peer liquidity index*; and 3) *state-level corporate tax rate* × *peer liquidity index*. The second-step results of Heckman model are reported in Panel B, while results using 2SLS estimations in Panel C, respectively. The first-step results are reported in Appendix 3.C. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Split sample analysis, OLS

Dependent Variable	*5-year rolling Z-score*	
	OLS	
	(1)	(2)
Time period	before 2007	after 2007
Total securitization ratio%$_{t-1}$	0.347**	0.442*
	(0.33)	(0.33)
Total retained interest ratio%$_{t-1}$	0.034	0.000
	(0.04)	(0.05)
Bank size$_{t-1}$	-0.007**	-0.112***
	(0.01)	(0.01)
Diversification ratio%$_{t-1}$	0.066	0.110*
	(0.06)	(0.07)
Bank liquidity ratio%$_{t-1}$	-0.446***	-1.025*
	(0.10)	(0.61)
Non-interest expense ratio%$_{t-1}$	0.012	-0.073
	(0.11)	(0.08)
Non-performing loans ratio%$_{t-1}$	0.762**	0.133***
	(0.49)	(0.04)
Local-market power$_{t-1}$	0.026	0.035
	(0.02)	(0.03)
Bank holding company dummy$_{t-1}$	-0.003**	-0.035*
	(0.01)	(0.02)
Metropolitan statistical area dummy$_{t-1}$	-0.012	-0.009
	(0.02)	(0.03)
Constant	0.404***	1.708***
	(0.12)	(0.15)
Bank fixed effects	Yes	Yes
Time Fixed Effect	Yes	Yes
Observations	29,638	39,620
Adjusted-R^2	0.2185	0.2781

Table 3.5: Split sample analysis (continued)

Panel B: Split sample analysis, Heckman model

Dependent Variable	*5-year rolling Z-score*					
	Heckman self-selection model					
Instrument	(1) (Corporate tax rate)	(2) (Peer liquidity index)	(3) (Interaction term)	(4) (Corporate tax rate)	(5) (Peer liquidity index)	(6) (Interaction term)
Time period		before 2007			after 2007	
Total securitization ratio%$_{t-1}$	0.182***	0.179***	0.194***	0.212***	0.208***	0.209***
	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)
Total retained interest ratio%$_{t-1}$	0.269***	0.275***	0.264***	0.278***	0.272***	0.276***
	(0.08)	(0.07)	(0.08)	(0.05)	(0.05)	(0.05)
Bank size$_{t-1}$	-0.149***	-0.188***	-0.118***	-0.005	-0.045	-0.023
	(0.04)	(0.05)	(0.04)	(0.03)	(0.03)	(0.03)
Diversification ratio%$_{t-1}$	0.268**	0.254*	0.287**	0.011	0.026	-0.017
	(0.13)	(0.13)	(0.12)	(0.11)	(0.11)	(0.11)
Bank liquidity ratio%$_{t-1}$	-4.143	-39.553	-18.738*	-14.110	-12.982	-13.476*
	(57.67)	(51.49)	(60.52)	(10.70)	(11.16)	(10.85)
Non-interest expense ratio%$_{t-1}$	0.362	0.283	0.366	0.160	0.113	0.116
	(0.35)	(0.31)	(0.36)	(0.50)	(0.50)	(0.50)
Non-performing loans ratio%$_{t-1}$	0.005	-0.187	0.078	-0.030	-0.061	-0.042
	(0.79)	(0.91)	(0.71)	(0.05)	(0.06)	(0.05)
Local-market power$_{t-1}$	0.598***	0.383*	0.596***	0.443***	0.462***	0.445***
	(0.19)	(0.20)	(0.19)	(0.15)	(0.16)	(0.15)
Bank holding company dummy$_{t-1}$	0.066	0.054	0.051	-0.145***	-0.159***	-0.150***
	(0.06)	(0.06)	(0.06)	(0.05)	(0.05)	(0.05)
Metropolitan statistical area dummy$_{t-1}$	-0.017	-0.024	-0.030	-0.119***	-0.116***	-0.117***
	(0.05)	(0.05)	(0.05)	(0.03)	(0.03)	(0.03)
Constant	3.182***	3.997***	2.591***	0.669	1.592**	1.080*
	(0.80)	(1.03)	(0.72)	(0.64)	(0.71)	(0.58)
Inverse Mills Ratio	-0.430***	-0.084**	-0.348***	-0.541***	-0.246**	-0.155**
	(0.11)	(0.11)	(0.10)	(0.14)	(0.12)	(0.10)
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	29,638	29,638	29,638	39,620	39,620	39,620
Adjusted-R^2	0.4374	0.3029	0.4444	0.3294	0.3712	0.3544

Table 3.5: Split sample analysis (continued)

Panel C: Split sample analysis, 2SLS estimation

Dependent Variable			*5-year rolling Z-score*			
			2SLS			
Instrument	(1) (Corporate tax rate)	(2) (Peer liquidity index)	(3) (Interaction term)	(4) (Corporate tax rate)	(5) (Peer liquidity index)	(6) (Interaction term)
Time period		before 2007			after 2007	
Total securitization ratio%$_{t-1}$	0.080**	0.078**	0.118**	0.265**	0.228**	0.285**
	(0.08)	(0.04)	(0.12)	(0.11)	(0.10)	(0.14)
Total retained interest ratio%$_{t-1}$	4.137**	3.497	3.532**	0.465	-10.883	0.045**
	(1.82)	(11.56)	(1.71)	(0.32)	(11.70)	(0.35)
Bank size$_{t-1}$	-0.092***	-0.083***	-0.059**	-0.025***	-0.128***	-0.030***
	(0.02)	(0.02)	(0.34)	(0.00)	(0.10)	(0.00)
Diversification ratio%$_{t-1}$	0.177**	0.164**	-0.053	-0.022	0.428	-0.009
	(0.07)	(0.06)	(0.56)	(0.03)	(0.46)	(0.03)
Bank liquidity ratio%$_{t-1}$	0.039	-0.123	-2.727*	-0.399*	-0.942*	-0.341**
	(1.50)	(1.39)	(6.63)	(0.22)	(1.53)	(0.21)
Non-interest expense ratio%$_{t-1}$	2.651*	-2.223	2.922	1.071***	0.434	-4.945
	(1.59)	(1.36)	(8.65)	(0.40)	(0.44)	(5.39)
Non-performing loans ratio%$_{t-1}$	-1.228	-1.035	2.180	2.588	-36.289	-0.673
	(0.94)	(0.84)	(8.03)	(1.89)	(46.85)	(1.60)
Local-market power$_{t-1}$	-0.020	0.204***	-0.012	0.121***	0.115***	0.723***
	(0.17)	(0.73)	(0.15)	(0.04)	(0.04)	(1.10)
Bank holding company dummy$_{t-1}$	-0.001***	-0.213***	-0.011	-0.107***	-0.100***	-0.098***
	(0.03)	(0.48)	(0.03)	(0.01)	(0.20)	(0.01)
Metropolitan statistical area dummy$_{t-1}$	-0.004	-0.077	-0.008	-0.024***	0.023	-0.021***
	(0.02)	(0.17)	(0.02)	(0.01)	(0.05)	(0.01)
Constant	1.505***	1.398***	1.228***	0.678***	1.856*	0.745***
	(0.17)	(0.19)	(3.84)	(0.05)	(1.12)	(0.06)
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	29,638	29,638	29,638	39,620	39,620	39,620
Adjusted-R^2	0.2719	0.3932	0.4754	0.4648	0.3022	0.4819

Table 3.6: Weighted least squares estimation

Table 3.6 reports the results of the impact of securitization ratios on bank's Z-scores using a propensity score matching based weighted-least-squares estimator. To test the consistency of the results, this regression uses a full sample and a 1:1 matched subsample including securitizers and non-securitizers with a propensity score distance within 1%. Within each sample, the propensity scores are used as the weights to conduct a least squares estimation. The sample period is from 2002 to 2012.The sample period is also divided into pre- and post-crisis subsamples. All variable definitions are presented in Appendix 3.A. Control variables include *retained interest ratio, bank size, diversification ratio, liquidity ratio, non-interest expense ratio, non-performing loans ratio, local-market power index, bank holding company dummy* and *metropolitan statistical area dummy*. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Dependent Variable	*5-year rolling Z-score*			
	(1) Full sample	(2) 1:1 sample	(3) before 2007	(4) after 2007
Total securitization ratio%$_t$	0.209***	0.196***	0.172***	0.220***
	(0.01)	(0.02)	(0.01)	(0.03)
Total retained interest ratio%$_t$	0.238***	0.126***	0.307***	0.163***
	(0.03)	(0.04)	(0.06)	(0.04)
Bank size$_t$	-0.033***	-0.016***	-0.046***	-0.030***
	(0.00)	(0.00)	(0.00)	(0.00)
Diversification ratio%$_t$	0.036***	0.112*	-0.014	0.085***
	(0.01)	(0.06)	(0.01)	(0.02)
Bank liquidity ratio%$_t$	-0.400	8.398	-0.651	0.969
	(0.54)	(8.73)	(0.61)	(1.38)
Non-interest expense ratio%$_t$	-0.600***	-0.394***	-0.675***	-0.562***
	(0.02)	(0.06)	(0.03)	(0.03)
Non-performing loans ratio%$_t$	-0.150***	-0.047***	6.109***	0.111***
	(0.02)	(0.01)	(0.87)	(0.01)
Local-market power$_t$	0.073***	0.292***	0.103***	0.024
	(0.01)	(0.08)	(0.02)	(0.02)
Bank holding company dummy$_t$	-0.116***	-0.159***	-0.125***	-0.105***
	(0.00)	(0.03)	(0.00)	(0.00)
Metropolitan statistical area dummy$_t$	-0.020***	-0.070***	-0.006*	-0.027***
	(0.00)	(0.02)	(0.00)	(0.00)
Constant	0.766***	0.225***	0.913***	0.725***
	(0.01)	(0.06)	(0.02)	(0.02)
Observations	77,598	6,264	37,755	39,843
Pseudo R-squared	0.2658	0.1726	0.2046	0.2429

Table 3.7: Mortgage and non-mortgage securitization

Table 3.7 presents regression results on the impact of mortgage and non-mortgage securitization on bank Z-scores, using OLS and Heckman self-selection estimations. Results using OLS are reported in Panel A. Second-step results using Heckman model on mortgage and non-mortgage are reported in Panel B and C, respectively. The first-step results are reported in Appendix 3.C. The sample period is 2002-2012. The full sample is also divided into before- and after-2007 periods to explore the differences referring to the 2007-2009 financial crisis. Control variables include *retained interest ratio, bank size, diversification ratio, liquidity ratio, non-interest expense ratio, non-performing loans ratio, local-market power index, bank holding company dummy* and *metropolitan statistical area dummy*. Instrumental variables include: 1) *state-level corporate tax rate*; 2) *peer liquidity index*; and, 3) *state-level corporate tax rate × peer liquidity index*. All independent variables are lagged in OLS regressions. Bank and year fixed effects are controlled in OLS regression. All variable definitions are presented in Appendix 3.A. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A: OLS estimation

Dependent Variable	*5-year rolling Z-score*					
	(1) Full Sample	(2) Before 2007	(3) After 2007	(4) Full Sample	(5) Before 2007	(6) After 2007
Mortgage securitization ratio%$_{t-1}$	0.109	-0.045	-0.206			
	(0.04)	(0.11)	(0.20)			
Mortgage retained interest ratio%$_{t-1}$	0.008	0.034	0.243***			
	(0.04)	(0.04)	(0.08)			
Non-mortgage securitization ratio%$_{t-1}$				0.247***	0.310***	0.198***
				(0.15)	(0.91)	(0.04)
Non-mortgage retained interest ratio%$_{t-1}$				0.007	0.007	-0.008
				(0.01)	(0.01)	(0.03)
Bank size$_{t-1}$	-0.079***	-0.007	-0.195***	-0.079***	-0.007	-0.146***
	(0.01)	(0.01)	(0.05)	(0.01)	(0.01)	(0.04)
Diversification ratio%$_{t-1}$	0.163***	0.180**	0.107	0.145***	0.066	0.284**
	(0.05)	(0.06)	(0.14)	(0.05)	(0.06)	(0.13)
Bank liquidity ratio%$_{t-1}$	-0.469**	-0.446***	8.222	-0.472**	-0.442***	5.414
	(0.20)	(0.10)	(53.37)	(0.20)	(0.10)	(58.03)
Non-interest expense ratio%$_{t-1}$	0.037	0.013	1.634***	0.024	0.011	0.273
	(0.08)	(0.11)	(0.25)	(0.08)	(0.11)	(0.35)
Non-performing loans ratio%$_{t-1}$	0.131***	0.757	0.263	0.128***	0.725	0.251
	(0.03)	(0.48)	(0.96)	(0.03)	(0.47)	(0.80)
Local-market power$_{t-1}$	0.027	0.026	0.543**	0.027	0.026	0.624***
	(0.02)	(0.02)	(0.22)	(0.02)	(0.02)	(0.19)
Bank holding company dummy$_{t-1}$	-0.038***	0.003	0.014	-0.038***	0.003	0.062
	(0.01)	(0.01)	(0.06)	(0.01)	(0.01)	(0.06)
Metropolitan statistical area dummy$_{t-1}$	-0.013	-0.012	-0.008	-0.013	-0.012	-0.024
	(0.02)	(0.02)	(0.05)	(0.02)	(0.02)	(0.05)
Constant	1.317***	0.404***	4.144***	1.312***	0.403***	3.189***
	(0.09)	(0.12)	(0.87)	(0.09)	(0.12)	(0.82)
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	69,258	29,638	39,620	69,258	29,638	39,620
Adjusted-R^2	0.4533	0.4781	0.4308	0.4120	0.4253	0.4187

Table 3.7: Mortgage and non-mortgage securitization

Panel B: second-step results on mortgage securitization

Dependent Variable	*5-year rolling Z-score*								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Instrument	(Corporate tax rate)	(Peer liquidity index)	(Interaction term)	(Corporate tax rate)	(Peer liquidity index)	(Interaction term)	(Corporate tax rate)	(Peer liquidity index)	(Interaction term)
Time period		full sample			before 2007			after 2007	
Mortgage securitization ratio%$_{t-1}$	0.154	0.149	0.151	0.115	0.102	0.089	0.178	0.177	0.178
	(0.05)	(0.05)	(0.05)	(0.11)	(0.12)	(0.12)	(0.06)	(0.06)	(0.06)
Mortgage retained interest ratio%$_{t-1}$	0.088*	0.083*	0.081*	0.079	0.081	0.070	0.107*	0.101	0.100
	(0.05)	(0.05)	(0.05)	(0.07)	(0.07)	(0.07)	(0.06)	(0.06)	(0.06)
Bank size$_{t-1}$	-0.063***	-0.085***	-0.081***	-0.061***	-0.100***	-0.102***	-0.051***	-0.051**	-0.064***
	(0.01)	(0.02)	(0.01)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)
Diversification ratio%$_{t-1}$	0.338***	0.347***	0.349***	0.407***	0.408***	0.421***	0.257***	0.266***	0.266***
	(0.07)	(0.07)	(0.07)	(0.08)	(0.08)	(0.08)	(0.10)	(0.10)	(0.10)
Bank liquidity ratio%$_{t-1}$	-13.167	-12.492	-12.538	-5.110	-5.709	-5.124	-13.372	-13.381	-12.608
	(8.16)	(8.49)	(8.39)	(13.63)	(13.40)	(13.32)	(10.31)	(10.32)	(10.54)
Non-interest expense ratio%$_{t-1}$	-0.891**	-0.924***	-0.858**	0.203	0.335	0.347	-2.572***	-2.741***	-2.564***
	(0.35)	(0.35)	(0.35)	(0.38)	(0.39)	(0.38)	(0.61)	(0.61)	(0.60)
Non-performing loans ratio%$_{t-1}$	0.058	0.025	0.035	0.612	0.308	0.429	-0.000	-0.004	-0.018
	(0.05)	(0.06)	(0.05)	(0.47)	(0.62)	(0.59)	(0.06)	(0.06)	(0.06)
Local-market power$_{t-1}$	-0.010	0.001	0.001	-0.001	0.015	0.018	-0.004	-0.017	0.005
	(0.10)	(0.10)	(0.10)	(0.13)	(0.13)	(0.13)	(0.14)	(0.14)	(0.14)
Bank holding company dummy$_{t-1}$	-0.095***	-0.116***	-0.102***	-0.099***	-0.121***	-0.114***	-0.094**	-0.101**	-0.098**
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)
Metropolitan statistical area dummy$_{t-1}$	-0.050***	-0.056***	-0.055***	-0.032	-0.042*	-0.042*	-0.054**	-0.052*	-0.059**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)
Constant	1.550***	2.101***	1.983***	1.250***	2.201***	2.218***	1.503***	1.511***	1.812***
	(0.32)	(0.49)	(0.30)	(0.44)	(0.79)	(0.45)	(0.43)	(0.57)	(0.40)
Inverse Mills Ratio	-0.190***	-0.301***	-0.279***	-0.091	-0.282*	-0.286***	-0.208**	-0.208*	-0.273***
	(0.06)	(0.10)	(0.06)	(0.09)	(0.16)	(0.09)	(0.09)	(0.12)	(0.08)
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	69,258	69,258	69,258	29,638	29,638	29,638	39,620	39,620	39,620
Adjusted-R²	0.2542	0.2643	0.2356	0.3343	0.3225	0.3214	0.3446	0.3645	0.3574

Table 3.7: Mortgage and non-mortgage securitization

Panel C: second-step results on non-mortgage securitization

Dependent Variable	5-year rolling Z-score								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Instrument	(Corporate tax rate)	(Peer liquidity index)	(Interaction term)	(Corporate tax rate)	(Peer liquidity index)	(Interaction term)	(Corporate tax rate)	(Peer liquidity index)	(Interaction term)
Time period		full sample			before 2007			after 2007	
Non-Mortgage securitization ratio%$_{t-1}$	0.137***	0.125***	0.134***	0.131***	0.122***	0.130***	0.082***	0.077***	0.079***
	(0.03)	(0.02)	(0.03)	(0.04)	(0.02)	(0.04)	(0.06)	(0.06)	(0.06)
Non-Mortgage retained interest ratio%$_{t-1}$	0.008	0.008	0.008	-0.010	-0.011	-0.010	0.106*	0.105	0.105
	(0.02)	(0.03)	(0.02)	(0.03)	(0.03)	(0.03)	(0.06)	(0.06)	(0.06)
Bank size$_{t-1}$	-0.049*	-0.055**	-0.048*	-0.094***	-0.094***	-0.092***	0.010	-0.014	0.006
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)	(0.04)
Diversification ratio%$_{t-1}$	-0.470***	-0.479***	-0.474***	-0.546***	-0.551***	-0.550***	-0.451***	-0.456***	-0.450***
	(0.08)	(0.08)	(0.08)	(0.12)	(0.12)	(0.12)	(0.11)	(0.11)	(0.11)
Bank liquidity ratio%$_{t-1}$	-0.427	-0.438	-0.415	-0.269	-0.274	-0.246	-9.996	-10.033	-9.910
	(0.76)	(0.75)	(0.76)	(0.63)	(0.63)	(0.63)	(12.06)	(12.28)	(12.10)
Non-interest expense ratio%$_{t-1}$	0.476	0.550***	0.475	0.612	0.568***	0.577	0.558	0.577	0.559
	(0.31)	(0.17)	(0.31)	(0.39)	(0.15)	(0.39)	(0.49)	(0.48)	(0.49)
Non-performing loans ratio%$_{t-1}$	-0.066	-0.066	-0.065	-0.562	-0.569	-0.545	-0.116**	-0.113*	-0.115**
	(0.06)	(0.06)	(0.06)	(0.78)	(0.79)	(0.78)	(0.06)	(0.06)	(0.06)
Local-market power$_{t-1}$	0.544***	0.520***	0.548***	0.764***	0.660***	0.775***	0.409***	0.412***	0.407***
	(0.11)	(0.11)	(0.11)	(0.17)	(0.16)	(0.17)	(0.15)	(0.15)	(0.15)
Bank holding company dummy$_{t-1}$	-0.239***	-0.239***	-0.241***	-0.100**	-0.107**	-0.102**	-0.357***	-0.355***	-0.358***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.06)	(0.06)	(0.06)
Metropolitan statistical area dummy$_{t-1}$	-0.103***	-0.105***	-0.102***	0.015	0.010	0.017	-0.192***	-0.192***	-0.192***
	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Constant	1.918***	2.064***	1.914***	2.474***	2.515***	2.450***	1.021	1.493**	1.101
	(0.54)	(0.51)	(0.53)	(0.64)	(0.63)	(0.64)	(0.73)	(0.67)	(0.72)
Inverse Mills Ratio	-0.306***	-0.330***	-0.305***	-0.376***	-0.383***	-0.372***	-0.185*	-0.257**	-0.197*
	(0.08)	(0.08)	(0.08)	(0.10)	(0.10)	(0.10)	(0.11)	(0.10)	(0.11)
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	69,258	69,258	69,258	29,638	29,638	29,638	39,620	39,620	39,620
Adjusted-R^2	0.2212	0.2173	0.2206	0.2965	0.3005	0.2964	0.3001	0.2964	0.3157

Table 3.8: Loan sale estimation, full sample

Table 3.8 presents regression results of the impact of loan sales on bank Z-scores, using OLS and Heckman self-selection models in Z-score regression. The sample period is 2002-2012. The full sample is also divided into before- and after-2007 periods to explore the differences referring to the 2007-2009 financial crisis. Results using full sample, sample before 2007 and after 2007 are reported in Panel A, B, and C, respectively. Control variables include *bank size, diversification ratio, liquidity ratio, non-interest expense ratio, non-performing loans ratio, local-market power index, bank holding company dummy* and *metropolitan statistical area dummy*. All independent variables are lagged in OLS and Heckman models. Bank and year fixed effects are controlled in OLS and Heckman models. All variable definitions are presented in Appendix 3.A. In Heckman regressions, only second-step results are reported in Table 3.8 and the first-step results in Appendix 3.C. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A: full sample

Dependent Variable	*5-year rolling Z-score*			
	(1)	(2)	(3)	(4)
	Full Sample			
	OLS	Heckman		
Loan sale ratio%$_{t-1}$	0.240***	0.171***	0.273***	0.272***
	(0.06)	(0.02)	(0.02)	(0.02)
Bank size$_{t-1}$	-0.079***	-0.022***	-0.016	-0.015**
	(0.01)	(0.01)	(0.01)	(0.01)
Diversification ratio%$_{t-1}$	0.146***	0.032	0.026	0.026
	(0.05)	(0.03)	(0.03)	(0.03)
Bank liquidity ratio%$_{t-1}$	-0.469**	-0.344	-0.371**	-0.359
	(0.20)	(0.60)	(0.60)	(0.60)
Non-interest expense ratio%$_{t-1}$	0.011	-0.215**	-0.214**	-0.205
	(0.08)	(0.15)	(0.15)	(0.15)
Non-performing loans ratio%$_{t-1}$	0.132***	0.058	0.055**	0.055**
	(0.03)	(0.04)	(0.04)	(0.04)
Local-market power$_{t-1}$	0.027	0.096**	0.090**	0.088*
	(0.02)	(0.05)	(0.05)	(0.05)
Bank holding company dummy$_{t-1}$	-0.038***	-0.120***	-0.113***	-0.110***
	(0.01)	(0.02)	(0.02)	(0.02)
Metropolitan statistical area dummy$_{t-1}$	-0.013	-0.019**	-0.020***	-0.021***
	(0.02)	(0.01)	(0.01)	(0.01)
Constant	1.309***	0.780***	0.659***	0.623***
	(0.09)	(0.13)	(0.21)	(0.13)
Inverse Mills Ratio		-0.086***	-0.060***	-0.053**
		(0.03)	(0.04)	(0.03)
Bank fixed effects	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes
Observations	69,258	69,258	69,258	69,258
Adjusted-R^2	0.4650	0.4506	0.4302	0.3968

Table 3.8: Loan sale estimation, before 2007

Panel B: before 2007

Dependent Variable	*5-year rolling Z-score*			
	(1)	(2)	(3)	(4)
	Before 2007			
	OLS	Heckman		
Loan sale ratio%$_{t-1}$	0.192***	0.179***	0.218***	0.217***
	(0.04)	(0.02)	(0.02)	(0.02)
Bank size$_{t-1}$	-0.120***	-0.022***	-0.050***	-0.038***
	(0.04)	(0.01)	(0.01)	(0.01)
Diversification ratio%$_{t-1}$	0.299**	0.084**	-0.049	-0.055
	(0.13)	(0.04)	(0.04)	(0.04)
Bank liquidity ratio%$_{t-1}$	-8.018	-5.379	-0.289	-0.252
	(60.77)	(6.64)	(0.54)	(0.54)
Non-interest expense ratio%$_{t-1}$	0.431	-0.710***	0.379*	0.454**
	(0.36)	(0.22)	(0.21)	(0.21)
Non-performing loans ratio%$_{t-1}$	0.119	0.046	0.877*	0.936**
	(0.73)	(0.04)	(0.46)	(0.43)
Local-market power$_{t-1}$	0.647***	0.066	0.139**	0.149**
	(0.19)	(0.06)	(0.07)	(0.07)
Bank holding company dummy$_{t-1}$	0.046	-0.141***	-0.114***	-0.106***
	(0.06)	(0.02)	(0.02)	(0.02)
Metropolitan statistical area dummy$_{t-1}$	-0.033	-0.024**	-0.000	-0.003
	(0.05)	(0.01)	(0.01)	(0.01)
Constant	2.687***	0.819***	1.277***	1.044***
	(0.74)	(0.17)	(0.26)	(0.18)
Inverse Mills Ratio		-0.088**	-0.182***	-0.139***
		(0.04)	(0.05)	(0.03)
Bank fixed effects	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes
Observations	29,638	29,638	29,638	29,638
Adjusted-R^2	0.4898	0.3548	0.3433	0.3295

Table 3.8: Loan sale estimation, after 2007

Panel C: after 2007

Dependent Variable	*5-year rolling Z-score*			
	(1)	(2)	(3)	(4)
	After 2007			
	OLS		Heckman	
Loan sale ratio%$_{t-1}$	0.201**	0.209***	0.276***	0.278***
	(0.61)	(0.02)	(0.02)	(0.02)
Bank size$_{t-1}$	-0.007	-0.059***	-0.037***	-0.020**
	(0.01)	(0.01)	(0.01)	(0.01)
Diversification ratio%$_{t-1}$	0.066	-0.043	0.086**	0.081**
	(0.06)	(0.05)	(0.04)	(0.04)
Bank liquidity ratio%$_{t-1}$	-0.439***	-0.199	-5.334	-5.508
	(0.10)	(0.53)	(6.76)	(6.62)
Non-interest expense ratio%$_{t-1}$	0.016	0.434**	-0.687***	-0.699***
	(0.11)	(0.22)	(0.22)	(0.22)
Non-performing loans ratio%$_{t-1}$	0.744	0.825*	0.044	0.046
	(0.48)	(0.48)	(0.04)	(0.04)
Local-market power$_{t-1}$	0.026	0.157**	0.087	0.062
	(0.02)	(0.07)	(0.06)	(0.06)
Bank holding company dummy$_{t-1}$	0.003	-0.118***	-0.173***	-0.136***
	(0.01)	(0.02)	(0.03)	(0.02)
Metropolitan statistical area dummy$_{t-1}$	-0.012	0.003	-0.019*	-0.024**
	(0.02)	(0.01)	(0.01)	(0.01)
Constant	0.405***	1.463***	1.147***	0.762***
	(0.12)	(0.20)	(0.24)	(0.17)
Inverse Mills Ratio		-0.221***	-0.164***	-0.076**
		(0.04)	(0.06)	(0.04)
Bank fixed effects	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes
Observations	39,620	39,620	39,620	39,620
Adjusted-R^2	0.5425	0.3606	0.3488	0.3344

Chapter 4
Bank securitization and the likelihood of failure

4.1 Introduction

Further to the evidence provided in Chapter 3 regarding bank risk reduction effect of securitization, this chapter is concerned with shedding further light as to whether the risk reduction effect is temporary. The 2007-09 financial crisis highlighted the gradual deterioration in the credit quality of assets (Demyanyk and Hemert, 2011) due to the lower standard in lending encouraged by securitization. Therefore, the question arises as to whether, securitization could decrease bank risk in the short term, but increase the long-term risk, or even leading to the likelihood of bank failure.

For example, the main argument of supporters of securitization is that it could increase a bank's potential risk due to information asymmetry (An, Deng and Gabriel, 2011). In the case of securitization, information asymmetry theory suggests that the issuers could hide or take advantage of their private information, bringing about moral hazard or adverse selection problems (Acharya, Schnabl and Suarez, 2013). In securitization, moral hazard problem refers to the situation where issuers lack the incentive to carefully monitor loans or screen borrowers (Kahn and Winton, 2004; Acharya and Viswanathan, 2011; Hartman-Glaser, Piskorski, and Tchistyi, 2012; Chemla and Hennessy, 2014), while adverse selection is the situation where issuers hideg hard or soft information, in order to earn higher reputations or ratings by ignoring the potential risk (An, Deng, and Gabriel, 2011; Agarwal, Chang, and Yavas, 2012; Benmelech, Dlugosz, and Ivashina, 2012). Both these problems would lead to the "illusion of risk transferring"; that is, the risk stays inside the institutions but are not transferred to outside investors. Therefore, securitization activities can in turn increase the likelihood of bank failure.

This chapter investigates the likelihood of bank failure using data on U.S. banking industry during the period 2002 to 2012. The dependent variable in the analysis is bank failure dummy and a logit regression is used to estimate the association between securitization ratio and the bank failure dummy. There is the concern that the relationship identified by the baseline framework could be endogenous. On the one hand, small banks may not prefer securitizing loans due to substantial large amount of upfront fixed costs. On the other hand, banks with higher reputation are more likely to be frequent securitizers because of a lower lemon discounts (Campbell and Kracaw, 1980; Diamond, 1984; Boyd and Prescott, 1986). Therefore, several methods are used to address this issue. First, a proportional hazards function is employed to estimate the relationship between bank loan securitization and the likelihood of bank failure. This method could provide the possibility of bank failure based on the estimated survival time through the entire sample period. The results suggest that bank loan securitization by commercial banks is positively associated with the likelihood of bank failure. A 1% increase in total securitization ratio increases the possibility of bank failure by an average of 0.57%. A propensity score matching based weighted-least-squares estimation method is also used in the investigation, where the weights are inversely proportional to the probability of a bank being a securitizer. An assigned propensity scores (represented by $\hat{p}$) estimated by a probit regression using the following control variables: bank size, diversification ratio, liquidity ratio, non-interest expense ratio, non-performing loans ratio, local market power index, bank holding company (BHC) dummy, and metropolitan statistical area (MSA) dummy is utilised in the study. A securitizer receives a weight of $1/\hat{p}$, while a non-securitizer receives a weight of $1/(1-\hat{p})$. A matched subsample including unique pairs of securitizer and non-securitizer with a difference of propensity score within 1% is also implemented in the study. All the results are consistent with the main results.

The 2007-09 financial crisis suddenly dried out the liquidity in the market, as well as the securitization activities (Gorton and Metrick, 2012). Thus, it is reasonable to expect the impact of securitization to decrease because of a significant reduction in scale of the securitization market. Therefore, the sample period is divided into pre- and post-crisis subsamples in all estimations. The pre-crisis period cover the years from 2002 to 2007, while the post-crisis period is from 2007 to 2012. The reported results show that the impact of securitization on the likelihood of bank failure are positive and statistically significant in both periods, but the economic significance decreases after the start of the financial crisis. Overall, the sub-sample results still support the main results.

This study also investigates the potential differences between mortgage and non-mortgage securitizations. Mortgage loans are also easier to be securitized thanks to the higher quality and stronger degree of commoditisation (Altunbas, Gambacorta, and Marques-Ibanez, 2009). Mortgage securitizers are expected to more aggressive to take on more risk and lower their lending standards considering their potential risk can be easily shifted to the third parties. Thus, mortgage securitization is criticized more severely for deteriorating loan qualities and leading to potential problems (Hakenes and Schnabel, 2010). Therefore, mortgage securitization is expected to be more strongly related to the likelihood of bank failure than non-mortgage securitization. To test the hypothesis, a breakdown of securitization into mortgage and non-mortgage groups is performed. The results show that mortgage securitization ratios are more significantly related to the likelihood of bank failure.

Finally, a test of the impact of loan sales on the likelihood of bank failure is investigated. Similar to securitization, loan sales without recourse also increase sellers' incentives to apply weaker managerial standards (Cebenoyan and Strahan, 2004). It is expected that loan sale ratios will significantly be related to the likelihood of bank failure. Following Bedendo and Bruno (2012), loan sales are defined by the difference between 1) the outstanding principal balance of assets owned by others, with servicing retained by the bank, and 2) the outstanding principal balance of assets sold and securitized by the bank. The reported results suggest that loan sales also increase the likelihood of bank failure in the long run.

The remainder of this chapter is organized as follows. Section 2 develops the empirical hypotheses. Section 3 explains the main methodologies used in the study and their theoretical underpinnings, the variables and samples, and provide summary statistics. Section 4 discusses the main results. Section 5 includes the robustness tests and section 6 provides the summary and conclusions.

4.2 Hypothesis development

Information asymmetry theory suggests that securitization could increase bank risk, as there naturally exists unequal information between issuers and investors in their transaction. Houston et al. (2010) argue that lower information sharing leads to higher riskiness of banks. In this case, demandable-debt has an important advantage as part of an incentive scheme for disciplining the banker. In effect, demandable-debt permits depositors to “vote with their feet” (Calomiris and Kahn, 1991): withdrawal of funds is a vote of no-confidence in the activities of the banker. However, securitization introduces moral hazard and adverse selection problems by hiding hard or soft information. Hard information is more likely to be made public, and difficult to cover up, while soft information, in most cases, is private and easily hidden.

Moral hazard problem refers to the situation where there is asymmetry in information between issues and investors and issuers can choose to hide their hard information advantage. In this case, issuers could securitize good assets as an indicator of the entire portfolio, and take advantage of it to retain the lower finance cost. As issuers’ rating is based on the characteristics that are reported to investors, in fact, they cover up the unreported, possibly negative, hard information of other tranches. It could result in a reduced incentive of issuers to carefully screen borrowers and monitor the loans. The logic here is straightforward: lenders that sell loans they originate to dispersed investors may bear less of the cost when they default, hence issuers may have less incentive to screen borrowers carefully.

Key et al. (2012) argue that lenders have an incentive to originate loans that rate high, but loans that are easier to securitize suffer from more relax screening. Wang and Xia (2014) suggest that banks exert less effort on ex post monitoring loans when they can securitize them. Ahn and Breton (2014) also argue that when securitized banks, or the issuers, retain only insufficient skin in the game, the incentives will get distorted along the securitization chain, leading to lax monitoring and screening, even intentional sales of low quality loans (similar ideas can refer: Morrison, 2005; Parlour and Plantin, 2008).

However, as the potential risk is not transferred, hiding hard information results in the “illusion of risk transferring” (Murray, 2001). Agarwal, Chang and Yavas (2012) find banks in prime mortgage market are more likely to sell low-default-risk loans while retaining higher-default-risk ones in their portfolio and argue that issuers could purchase better rating by doing this.

Adverse selection problem refers to the situation of asymmetry in information prior to the deal, which could happen if issuers took advantage of their private soft information. In this case, issuers choose to securitize those loans which would become worse as good ones. Duffee and Zhou (2001) find that issuers have an incentive to sell the loans of the borrowers whose private information is negative. Downing, Jaffee and Wallace (2009) also show that Freddie Mac sells lower-credit-quality mortgage-backed securities than it retains in its portfolio. Although securitizing bad loans out seems to reduce bank risk, it will increase bank risk eventually.

The explanations are as follows. Adverse selection theory suggests that as investors’ best guess for a given asset in securitization market is of average quality because of the possibility of private information, a lemon market exists. In this case, investors with insufficient information would be unwilling to pay high price. Lenders, in turn, would not willing sell their high-quality loans in the market. This effect could cause a market level bank risk, as the entire asset quality could deteriorate to a level that the market would cease to exist (Akerlof, 1970).

Apart from the individual effect of positive impact of securitization on bank risk, contagion theory considers this issue at an industrial level. A large number of studies investigate the contagion effect in banking, which suggests that the risk, initially an idiosyncratic shock on one entity, spills over to other entities (Rochet and Tirole, 1996; Allen and Gale, 2000; Freixas et al., 2000; Diamond and Rajan, 2005). Specifying on securitization, Baur and Joossens (2006) argue that securitization would increase systemic risk of the entire banking sector, though it may transfer potential risks of individual banks to others. They provide two explanations. First, if the risks are transferred to unregulated market participants, there is less capital in the economy to cover these risks. Second, if other banks invest in the asset-backed securities in the market, the transferred risk would cause interbank linkages to grow. Both these effects would eventually negatively impact on other individuals in the market.

Fiordelisi and Marques-Ibanez (2013) suggest that this systemic risk is related to contagion among banks due to securitization. Similarly, Nijskens and Wagner (2011) also argue that while securitized banks may individually look less risky because of the volatility declines, they pose more risk to other individuals and the entire system. Managerial and regulatory policies may improve this situation, but securitization could also weaken the benefits. Akhigbe and Madura (2001) argue that a bank's exposure to possible contagion effects due to bank failure can be partially controlled by those two types of policies, but securitization activities have been shown to soften the ability of authorities.

Another industrial level impact of securitization comes from the so-called "shadow banking system". Securitization has been suggested as one of the most significant contributors to this unregulated system (Gennaioli, Shleifer and Vishny (GSV), 2013). As intermediaries expand their balance sheets by buying risky projects, they increase the systematic risk of their portfolios, raise their leverage, and endogenously become interconnected by sharing each other's risks. Although the expansion of the shadow banking system may be Pareto-improving, as in standard models of risk sharing (Ross, 1976; Allen and Gale, 1994), GSV (2013) argue that things will change dramatically when investors and intermediaries neglect tail risk, because they may not believe in truly bad outcomes during quiet times. In this case, securitization activities could create extreme financial fragility, undermining the regulated banking sector and leading to the financial crisis. Therefore, my main hypothesis is as follows:

Bank loan securitization is likely to increase the likelihood of bank failure.

4.3 Data and methodology

4.3.1 Data

Securitization and bank-specific data were collected from the Reports of Income and Condition for commercial banks (the Call Report). Because U.S. banks are only required to provide detailed information on their securitization activities from June 2001, the annual data covers the period from 2002 to 2012. The final sample is an unbalanced panel made up of 342 banks with securitized loans and 8,483 banks without totalling 77,598 bank-year observations.

4.3.2 Variables

4.3.2.1 Bank failure dummy

Bank failure dummy is denoted as one if a bank failed or is acquired by another bank under government assistance and zero otherwise.

4.3.2.2 Securitization measures

Studies on securitization are based on several different perspectives of the various authors. Some researchers prefer to investigate the general influence of securitization, where they mainly define the regressor of securitization as total securitized assets over total assets, as in Mandel et al. (2012). Recently, more studies focus on the differences among securities. For example, Solano et al. (2006), when discussing the effects of securitization on the value of banking institutions, distinguish mortgage-backed securities (MBS) from asset-backed securities (ABS). Other group of researches classify detailed categories of securitization. For example, Cheng et al. (2008) employ four different securitization variables, ABS_t (total securitized assets divided by total assets), MBS_t (securitized 1-4 family residential mortgages scaled by total assets), $CONSBS_t$ (securitized consumer loans scaled by total assets) and $COMMBS_t$ (securitized commercial loans scaled by total assets) to study the relationship between securitization and opacity of banks. The key independent variable in this research is $\boldsymbol{Securitization\ ratio}$, which is defined as the ratio of the outstanding principal balance of assets securitized over total assets for a given type (i.e., mortgage or non-mortgage loans).

4.3.2.3 Control variables

$\boldsymbol{Retained\,interest\,ratio}$ is defined as the total amount of retained interest divided by the total amount of securitization assets of a given type. It includes the aggregate retained interests into credit enhancements, liquidity provisions, and seller’s interest (similar definition can refer Casu and Sarkisyan, 2014). A number of recent studies have considered the hypothesis that providing retained interests is a signalling mechanism which could partially solve information asymmetry problem when structuring securitization transactions (Downing, Jaffee and Wallace, 2009; Albertazzi et al., 2011). By the willingness to keep “skin in the game” to retain some risk, banks can signal their faith in the quality of their assets.

Such signalling implies a positive relationship between the level of enhancements and the performance of securitized assets. Offering this contractual design features could also influence issuers’ effort to carefully screen borrowers when they plan to securitize loans (Fender and Michell, 2009). Albertazzi et al. (2011) conjecture that a securitizing sponsor can keep a junior (equity) tranche as a signaling device of the unobservable quality or as an expression of a commitment to continue monitoring the assets. Therefore, retained interests should decrease bank risk. including the aggregate retained interests into credit enhancements, liquidity provisions, and seller’s interest. The incentive of securitizers to carefully monitor loans could increase by providing enhancements which may decrease bank risk (Downing, Jaffee, and Wallace, 2009).

$\boldsymbol{Bank\,size}$ is the natural logarithm of total assets. The scale of banks matters much in the issue of risk taking. Based on Basel II Capital Accord, Hakenes and Schnabel (2011) analyze particularly the relationship between bank size and risk-taking behaviours and then discovered significant association. Using a model with imperfect competition and moral hazard, the results indicate that the right for banks to choose between standardized and internal ratings based approach pushes smaller banks to take higher risks, while gives larger banks a competitive advantage. Therefore, the likelihood of bank failure can be higher for those larger banks.

$Diversification$ indicates the diversification level of banks, which calculated as noninterest income divided by total operation income, as the approach of Stiroh (2004). The impact of diversification seems to be complicated sometimes, and even better diversification may not ensure it could translate into reduction in risk (Demsetz and Stranhan, 1999). Wagner (2010), presenting a two-bank and three-period model, prove it theoretically that diversification is more likely to increase the crises, though it may reduce each institution's individual failure possibility. Because even full diversification helps little as systemic crises induce extra costs. This paper also shows the ability of extension, which can be employed in the insurance and securitization fields.

$Liquidity\ ratio$ is an indicator for banks' liquidity, specified as liquid assets divided by total asset. Higher liquidity could increase the chance of a bank to survive during liquidity shock but may also increase the likelihood of risk taking.

$Non\ interest\ expense\ ratio$ is an indicator of banks' efficiency, defined as non-interest expenses divided by total assets. Non-interest expenses are usually not associated with targeting customers to deposit funds, which means they are more likely to increase the likelihood of failure (Lepetit et al., 2008).

$Non\ performing\ loans\ ratio$, computed as the amount of loans past due 90 days divided by total assets, reflects the risk management situation. Because non-performing loans are either in default or close to being in default, bank's likelihood of failure can be positively related to the proportion of non-performing loans.

Following Berger and Bouwman (2013), this study controls for banks' $local\ market\ power$ which is defined as the deposit concentration for the local markets in which the bank operates. The larger the local market power, the greater a bank's market power and concentration in its surroundings. This is a standard measure of competition used in antitrust analysis and research in the U.S. (Berger and Bouwman, 2013).

A bank holding company dummy ($\boldsymbol{BHC\ dummy}$) is used to control for whether it belongs to a bank holding company. $\boldsymbol{BHC\ dummy}$ equals one if the bank belongs to a bank holding company, and zero otherwise. A bank belonging to a bank holding company is expected to be more likely to survive, because the holding company is required to act as a source of strength to all the banks it owns (Houston and James, 1998; Paligorova and Xu, 2012). Finally, this study uses a metropolitan statistical area dummy ($\boldsymbol{MSA\ dummy}$), which equals one if the bank is located in a metropolitan area, and zero otherwise, to identify individual banks' locations. Competition may be fiercer in metropolitan areas, and banks in suburban areas are more likely to have a more stable environment.

4.3.3 Empirical strategy

4.3.3.1 Baseline model

To estimate the impact of loan securitization on the likelihood of bank failure, the logit regression is used as the baseline model:

$$\boldsymbol{Pr(Bank\,failure_{i,t}) = \beta_0 + \beta_1 Securitization\,Ratio_{i,t-1} + \beta_2 X_{i,t-1} + \alpha_i + \delta_t + \mu_{i,t}} \quad \textbf{(4.1)}$$

where $\boldsymbol{Pr(Bank\,failure_{i,t})}$ is the probability of bank failure, $\boldsymbol{Securitization\,Ratio_{i,t-1}}$ is the vector of total securitization ratio, $\boldsymbol{X_{i,t-1}}$ is the vector of bank-specific control variables, $\boldsymbol{\alpha_i}$ is the individual difference, $\boldsymbol{\delta_t}$ is the time variation that not related to individual charateristics, and $\boldsymbol{\mu_{i,t}}$ is the disturbance term.

4.3.3.2 Survival function

In order to estimate the long-term effect of securitization, a survival function is employed. Theoretically, survival analysis is a branch of statistics which deals with analysis of time to events, such as death in biological organisms and failure in mechanical systems. This analysis attempts to find out: a) what proportion of a population will survive past a certain time; b) those that survive, at what percentage will they die or fail; c) whether multiple causes of death or failure be taken into account; and d) how particular circumstances or characteristics increase or decrease the probability of survival.

Assuming $\boldsymbol{T}$ is a continuous random variable with probability density function f(t) and cumulative distribution function $\boldsymbol{F(t) = Pr\{T <= t\}}$, giving the probability that the event has occurred by duration t, so the survival function is as follows:

$$\boldsymbol{S(t) = Pr\{T > t\} = 1 - F(t) = \int_t^{\infty} f(x)dx} \qquad \textbf{(4.2)}$$

This function gives the probability that the event of interest has not occurred by duration t.

An alternative characterization of the distribution of T is given by the hazard function, defined as:

$$\boldsymbol{\lambda(t) = \lim_{dt \to 0} \frac{\Pr\{t < T \le t + dt | T > t\}}{dt}} \qquad \textbf{(4.3)}$$

The numerator of this expression is the conditional probability that the event will occur in the interval $\boldsymbol{(t, t + dt)}$ given that it has not occurred before, and the denominator is the width of the interval. The conditional probability in the numerator may be written as the ratio of the joint probability that $\boldsymbol{T}$ is in the interval $\boldsymbol{(t, t + dt)}$ and $\boldsymbol{T > t}$, to the probability of the condition $\boldsymbol{T > t}$. The former may be written as $\boldsymbol{f(t)dt}$ for small $\boldsymbol{dt}$, while the latter is $\boldsymbol{S(t)}$ by definition:

$$\boldsymbol{\lambda(t) = \frac{f(t)}{S(t)}} \qquad \textbf{(4.4)}$$

Noted that $-\boldsymbol{f(t)}$ is the derivative of $\boldsymbol{S(t)}$, the equation above could be rewritten as:

$$\boldsymbol{\lambda(t) = -\frac{d}{dt} log[S(t)]} \qquad \textbf{(4.5)}$$

Therefore, if we can integrate from $\boldsymbol{0}$ to $\boldsymbol{t}$ and introduce the boundary condition $\boldsymbol{S(0) = 1}$ (because the event will not occur for sure by a duration of 0), a formula for the probability of surviving to duration t could be obtained as:

$$S(t) = exp\left\{-\int_0^t \lambda(x)dx\right\} \tag{4.6}$$

The integral in curly brackets is called the cumulative hazard, which might be considered as the sum of the risk a bank faces going from duration 0 to t.

In the following step, let μ denote the mean or expected value of T, then it can be calculated by the density function $f(t)$ by definition:

$$\mu = \int_0^\infty tf(t)dt \tag{4.7}$$

Considering that $-f(t)$ is the derivative of $S(t)$, and $S(0) = 1 \& S(\infty) = 0$, so:

$$\mu = \int_0^\infty S(t)dt \tag{4.8}$$

In other words, the mean is simply the integral of the survival function.

In practice, suppose we have n units with lifetimes governed by a survivor function $S(t)$ with associated density $f(t)$ and hazard $\lambda(t)$, and suppose unit i is observed for a time t. If the unit not survived at t_i, its contribution to the likelihood function is the density at that duration:

$$L_i = f(t_i) = S(t_i)\lambda(t_i) \tag{4.9}$$

If the unit is survived at t_i, the probability of this event is:

$$L_i = S(t_i) \tag{4.10}$$

Note that both types of contribution share the survivor function $S(t_i)$. Let d_i denote a non-survivor indicator, then the likelihood function could be written as:

$$L = \prod_{i=1}^{n} L_i = \prod_i \lambda(t_i)^{d_i} S(t_i) \tag{4.11}$$

After take log, we obtain the log-likelihood function for censored survival data:

$$\boldsymbol{logL} = \sum_{i=1}^{n}\{\boldsymbol{d_i log\lambda(t_i)} - \boldsymbol{\Lambda(t_i)}\} \tag{4.12}$$

where $\boldsymbol{\Lambda(t_i)}$ stands for the cumulative hazard.

4.3.3.3 Empirical model

Survival analysis is used to estimate the relationship between securitization ratio and the likelihood of bank failure. Survival analysis is concerned with studying the time between a treatment's initial application and a subsequent event (such as bank failure), so it is possible to test the long-term impact of securitization. The survival analysis technique has been widely applied in banking research. Cole and Gunther (1995) employ survival analysis to study the determinants of bank failure. Recently, Berger and Bouwman (2013) used survival analysis to estimate the relationship between a bank's capital and its likelihood of survival. The Cox proportional hazards model is specified as follows:

$$\boldsymbol{log\left(\frac{\lambda_i(t_i|Securitization)}{\lambda_0(t)}\right) = \beta_0 + \beta_1 Securitization\ Ratio_{i,t} + \beta_2 X_{i,t} + \mu_i + \varepsilon_{i,t}} \tag{4.13}$$

where $\boldsymbol{\lambda_i(t_i|Securitization)}$ is the hazard function for securitizers under the event of bank failure, $\boldsymbol{\lambda_0(t)}$ is the average survival time of the entire sample, $\boldsymbol{Securitization\ Ratio_{it}}$ is the vector of total securitization ratio, $\boldsymbol{X_{it}}$ is the vector of bank-specific control variables, $\boldsymbol{\mu_i}$ is the individual differences that not related to time variables, and $\boldsymbol{\varepsilon_{i,t}}$ is the disturbance term. This study also uses the logit model to check the robustness of the results of survival analysis.

The 2007-09 financial crisis significantly changed the macroeconomic environment, e.g., it suddenly dried out the liquidity in the market. The withdrawal of repurchase agreements may trigger a securitized-banking run (Gorton and Metrick, 2012). The significant reduction in securitization in the market, may in turn, decrease the impact of securitization. Thus, it is expected that the impact of securitization on a bank's likelihood of failure may be decreased after the 2007-09 financial crisis. The sample for the study is divided into pre- and post-crisis periods. Pre-crisis period covers the years from 2002 to 2006, while post-crisis period covers the period from 2007 to 2012. All regressions are rerun using the before and after 2007 subsamples.

4.4 Empirical results

4.4.1 Preliminary analysis

Table 4.1 shows the summary statistics on all variables used in this chapter for both securitizers and non-securitizers. Since the results on independent variables are the same as that of in Chapter 3, only the number and proportion of failed banks on securitizers and non-securitizers are reported in Panel A, Table 4.1, and the differences between securitizers and non-securitizers in terms of failed banks in Panel B. Within each group, the sample is also divided into pre- and post-crisis periods. Statistics show that 331 banks securitized their assets and 3 (0.91%) of them went failure before the breakout of the 2007-09 financial crisis. After the breakout of the crisis, there were 17 (5.74%) securitizers failed. A similar picture can be seen for non-securitizers. Before 2007, results show that 70 (0.87%) of 8,059 non-securitizers failed while this proportion surges to 7.08% (505 failed banks out of a sample of 7,137 non-securitizers) after 2007.

<Insert Table 4.1 Panel A Here>

In Panel B, Table 4.1, results also report Student's t-test and Wilcoxon rank-sum test for the means and medians of the differences, respectively. The breakout of the 2007-09 financial crisis witnessed a more significant increase in proportions of failed non-securitizers (6.21%) than securitizers (4.84%), and the proportion of failed non-securitizers exceeds that of securitizers (by 1.33%). The Student’s t-test shows that the difference between proportions of failed securitizers and non-securitizers is statistically significant at 1% level. This result links securitization with a higher likelihood of bank failure before 2007. This finding confirms that banks with high involvement in the OTD market during the pre-crisis period contribute more significantly to the loan quality deterioration (Purnanandam, 2011).

<Insert Table 4.1 Panel B Here>

4.4.2 A visual demonstration of the association between securitization and the likelihood of bank failure

To begin with the estimation, it is interesting to provide a visual estimation to make the hypothesis convincing, that is, bank loan securitization activities do have a positive impact on the likelihood of bank failure. A Nelson-Aalen estimator (details about this estimator can refer to: Nelson, 1969, 1972; Aalen, 1978) is employed to plot the estimated proportion of failed banks through the time period for banks with/without loan securitization. From a set of observed survival time period (including censored times) in a sample of individuals, Nelson-Aalen estimator allows researchers to estimate the proportion of the population of such banks which would suffer failure under the same circumstances. The disadvantage of this method is that it cannot be used to explore the effects of several variables, and this is the reason a Cox model is applied in the following section. The results of Nelson-Aalen estimation are reported in Figure 4-1 (1A for total loan securitization; 1B for mortgage loan securitization; 1C for non-mortgage loan securitization).

<Insert Figure 4-1A Here>

<Insert Figure 4-1B Here>

<Insert Figure 4-1C Here>

If banks do not choose to securitize loans, before 2006, over 0.5% of the population will go bankruptcy, while those banks with loan securitization enjoy a zero-failure benefit. From then, however, the proportion of failure in the second group dramatically increases to nearly 2.5% and reach to the peak of nearly 12%. During the same period, banks without loan securitization only have 8% of the observations go bankruptcy. The situation is even worse for banks only securitizing non-mortgage loan, the percentage of failed banks is nearly 15%. Securitizing mortgage loans seems to be safe, as the proportion of failed banks only exceed their comparable group during 2008 to 2010, peaking at 7% (lower than banks without mortgage securitization (over 8%)).

It provides visual evidence to show that bank loan securitization leads to a higher possibility of failure. After decomposing loan securitization into mortgage and non-mortgage activities, Figure 4-1B and 4-1C show that mortgage securitization seems to be safer, while non-mortgage loan securitization is much riskier, respectively.

4.4.3 The impact of loans securitization on the likelihood of bank failure

Table 4.2 reports the results of the impact of loan securitization on the likelihood of bank failure using logit regressions. Similar to chapter 3, the full sample is also divided into pre- and post-2007 periods. Bank fixed effects are controlled in the Cox model. Instead of coefficients, marginal effects (rounded to four decimals) are reported in logit regressions.

<Insert Table 4.2 Here>

Following Chava, Livdan, and Purnanandam (2009), this study uses the Cox proportional hazards model along with a logistic model to estimate the impact of securitization on the likelihood of bank failure. The Cox model is likely to capture long-term effect and statistically superior for bankruptcy prediction since it takes the time at risk into consideration (see Shumway, 2001; Chava and Jarrow, 2004). The full sample is then divided into pre- and post-2007 periods. Bank fixed effects are controlled in the Cox model. Instead of coefficients, marginal effects (rounded to four decimals) are reported in logit regressions.

<Insert Table 4.3 Here>

Total securitization ratio is found to have a positive and significant impact on the likelihood of bank failure, and the results are consistent among all regressions. A 1% increase of total securitization ratio leads to a 0.75% (exp(0.561) – 1) (column (1)) and 0.39% (column (4)) increase of possibility of bank failure, estimated by Cox and logit models, respectively. This finding is consistent with the main hypothesis that the involvement of securitization could lead to long-term risk. Securitization encourages banks to take on more risk, decrease their efforts on screening borrowers, lower borrowing standards, and grant more poor-quality loans (Hakenes and Schnabel, 2010). The possibility of bank failure in turn increases because the diversification mechanism of securitization may not enough to cover the potential losses in the long run (Wagner, 2010). That is, the diversification effect allows the linked institutions to share the large risk exposure but cannot eliminate the riskiness. Meanwhile, benefited from this benefit, securitizers become more aggressive in taking risk, which in turn introduces more risk into the system. When the riskiness reached to a certain threshold, the diversification of securitization cannot smooth out the potential riskiness to face the financial shock, leading to a higher likelihood of bank failure.

After dividing the sample into pre- and post-2007 periods, results show that securitization ratio is still positively related to the likelihood of bank failure for both sub-sample periods. According to column (2) to (5), an average 1.21% increase of possibility of bank failure caused by 1% increase in population means of total securitization ratio before 2007, while this marginal effect decreases to an average of 0.28% (column (3) and (6)) after 2007. The decreased impact of securitization on the likelihood of bank failure may also due to the significant decrease in the scale of securitization market caused by the liquidity shortage in the secondary market after the breakout of financial crisis.

In order to check the robustness of the results, a propensity score matching based weighted-least-squares estimation is employed for bank failure to address the endogeneity problem. It is because the correlations reported so far could be a reverse causality. The positive relationship found by the empirical model reports that securitization ratios are positively related to the likelihood of bank failure, but it can also because the banks realize their likelihoods of failure, and then choose to securitize risky assets to remove the riskiness off their balance sheet. Therefore, the following robustness checks are conducted. Marginal effects of each variable on the likelihood of bank failure are reported in Table 4.4. Results are consistent, showing positive and significant impact of securitization ratios on the likelihood of bank failure, which confirms the main findings on bank failure in Table 4.4.

<Insert Table 4.4 Here >

4.5 Additional analysis

4.5.1 The impact of mortgage and non-mortgage securitization on the likelihood of bank failure

Mortgage loans can be easily securitized due to the higher quality and stronger degree of commoditisation (e.g., mortgage loans enjoy a higher standardisation of credit assessment techniques) (Altunbas, Gambacorta, and Marques-Ibanez, 2009). The rapid development of the secondary market makes it even more convenient to banks to securitize mortgage loans (Frame and White, 2005). Mortgage securitizers are in turn encouraged to take on more risk and reduce their incentives to carefully monitoring loans (Hakenes and Schnabel, 2010). Non-mortgage securitization requires securitizers to provide higher retention of risk exposures[6] during the process in order to signal the quality of the underlying assets (Guo and Wu, 2014), which forces non-mortgage securitizers to keep monitoring loans (Kiff and Kisser, 2010) and be more cautious when granting loans (Hattori and Ohashi, 2011). The impact of mortgage securitization on the likelihood of bank failure is likely to be more significant than non-mortgage securitization. Thus, the hypothesis here is:

The impact of mortgage securitization on the likelihood of bank failure is likely to be more significant, compared with non-mortgage securitization.

To test this hypothesis, this study breaks down securitization activities into mortgage and non-mortgage securitizations. Mortgage loans include 1-4 home mortgages, while non-mortgage loans contain all other types of loans, including home equity lines, credit card receivables, auto loans, commercial and industrial loans, other consumer loans, and all other loans. Then, total securitization ratios in all specifications are replaced with mortgage and non-mortgage securitization ratios, respectively. The Cox survival analysis results are reported in Table 4.5.

<Insert Table 4.5 Here>

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[6] It is found in International Monetary Fund (2009) that a minimum retention requirement of 5% could be binding for almost all types of asset-backed securities (ABS), but this retention ratio for mortgage-backed securities (MBS) is below 1%.

From Table 4.5, mortgage and non-mortgage securitizations are both found to lead to a higher likelihood of bank failure. The marginal impact of mortgage securitization is significantly higher than non-mortgage securitization. A 1% increase of securitized mortgage loans ratio leads to a 1.04% increase in the possibility of bank failure, compare with that of non-mortgage securitization ratio is 0.20%. Mortgage securitization is more likely to encourage banks to take on more risk and lower the lending standards, which may contribute more significantly to the deteriorate of loan qualities in the market and the likelihood of bank failure.

4.5.2 The impact of loan sales on the likelihood of bank failure

The final test focuses on loan sales. Similar to securitizations, loan sales also allow sellers to transfer potential risk to the buyers. However, loan sales involve the totality of an originated loan (Gorton and Haubrich, 1987) and are affected without recourse and bank serves as a pure broker (Greenbaum and Thakor, 1987). Loan sales without recourse increase sellers' incentives to apply weaker managerial standards, leading to the deterioration of loan quality (Cebenoyan and Strahan, 2004). Thus, the impact of loans sales on the likelihood of failure is expected to be similar to that of securitization:

Loan sales are likely to increase the likelihood of bank failure.

Following Bedendo and Bruno (2012), loan sales activity is defined by the difference between: 1) the outstanding principal balance of assets owned by others, with servicing retained by the bank, and 2) the outstanding principal balance of assets sold and securitized by the bank. Loan sales data are collected from the Call Report, and the regression results are reported in Table 4.6.

<Insert Table 4.6 Here>

According to Table 4.6, the impact of loan sales on the likelihood of bank failure is also positive, which is similar to that of securitization. The coefficients of loan sale ratio are all positive and statistically significant at 1% level across all specifications. In terms of economic impact, a 1% increase of loan sale ratios leads to a 2.6% increase in the possibility of bank failure. This result holds after dividing the sample period into pre- and post-crisis periods. Overall, the involvement of loan sale activities increases the probability of bank failure.

4.6 Conclusion

This chapter studies how securitization affects the likelihood of bank failure. To address the endogeneity problem in securitization, both a Cox survival analysis and a propensity score matching based weighted least squares analysis are employed. The empirical results are consistent and robust results in all specifications, which suggests that loan securitization increases the likelihood of bank failure.

Concerning the severe economic environmental change before and after the 2007-09 financial crisis, the full sample is divided into pre- and post-crisis periods. Although the empirical regressions show consistent results in both periods, a significant economic significance change is spotted after the breakout of the 2007-09 crisis. Specifically, the marginal effects of securitization on the likelihood of bank failure are rather stable with a small increase.

In addition, this chapter shows disparate impacts between mortgage and non-mortgage securitizations. Both mortgage and non-mortgage securitizations significantly increase bank’s possibility of failure, between which the economic impact of mortgage securitization is more significant. Last, loan sale activities respond to a similar positive impact on the likelihood of bank failure.

Table 4.1: Summary statistics

Table 4.1 shows the descriptive statistics of the dependent and independent variables used in this paper. The statistics are based on the panel data including 342 securitizers and 8,483 non-securitizers during the period of 2002 to 2012, accounting for total bank-year observations of 3,983. Previous periods are not included because U.S. banks are only required to provide detailed information on their securitization activities from June 2001. Variable definitions are provided in Appendix A. Concerning the impact of the 2007-2009 financial crisis, the time period is divided into before- and after-2007 to check the difference. Panel A reports the statistics of bank failures in terms of number of failed banks (failed #) and the proportion of failed banks (failed %) in the total number of banks (bank #). Panel B reports the statistics of securitizers and non-securitizers, respectively. Statistics include mean, median, and standard deviation. Panel C shows the comparative statistics of: 1.the difference between the pre- and post-crisis periods, where the difference is calculated by the value after 2007 minus the value before 2007; and, 2.the difference between securitizers and non-securitizers, where the difference is calculated by the value of securitizers minus the value of non-securitizers. Differences in the number and proportion of failed banks are showed with regards to variable of bank failure, while differences in means and medians are showed for the rest of variables. Information on t-test on means and medians are also showed in Panel 4.C.

Panel A: Statistics for bank failure

	Securitizers								Non-securitizers							
	before 2007				after 2007				before 2007				after 2007			
statistic	bank #	failed #	failed %	Obs.	bank #	failed #	failed %	Obs.	bank #	failed #	failed %	Obs.	bank #	failed #	failed %	Obs.
Bank failure	331	3	0.91%	1,534	296	17	5.74%	1,598	8,059	70	0.87%	36,221	7,137	505	7.08%	38,245

Table 4.1: Summary statistics

Panel B: Difference between securitizers and non-securitizers

	Difference with the reference of 2007/2008 financial crisis difference = value after 2007 - value before 2007				Difference between securitizers and non-securitizers difference = value of securitizer - value of non-securitizer			
	Securitizers		Non-securitizers		Before 2007		After 2007	
Dependent variable								
statistic	Dif %	t-test on means	Dif %	t-test on means	Dif %	t-test on means	Dif %	t-test on means
Bank failure	4.84%	a*	6.21%	a	0.04%	a	-1.33%	a

NOTE: * the letter "a" and "b" indicate a significant difference of means and medians at 1% level, respectively.

Table 4.2: Baseline model, logit regression

Table 4.2 shows the results on the impact of bank loan securitization on the likelihood of bank failure, which employs the logit model. The sample period is from 2002 to 2012. Control variables include *retained interest ratio, bank size, diversification ratio, liquidity ratio, non-interest expense ratio, non-performing loans ratio, local-market power index, bank holding company dummy* and *metropolitan statistical area dummy*. All variable definitions are presented in Appendix 4.A. The sample period is also divided into before- and after-2007 to explore the difference referring to the 2007-09 financial crisis. Marginal effects are reported instead of coefficients. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Dependent Variable		*Bank failure*	
		Logit model	
	(1) full sample	(2) before 2007	(3) after 2007
Total securitization ratio%$_t$	0.0039***	0.0064***	0.0016**
	(0.001)	(0.003)	(0.000)
Total retained interest ratio%$_t$	-0.1270	-0.0740***	-0.1162
	(0.076)	(0.027)	(0.075)
Bank size$_t$	0.0015***	0.0005	0.0020***
	(0.000)	(0.000)	(0.000)
Diversification ratio%$_t$	-0.0077***	-0.0022	-0.0101**
	(0.003)	(0.002)	(0.005)
Bank liquidity ratio%$_t$	0.1078*	0.0579**	0.1304
	(0.060)	(0.026)	(0.118)
Non-interest expense ratio%$_t$	0.0075***	0.0018***	0.0108**
	(0.002)	(0.001)	(0.004)
Non-performing loans ratio%$_t$	-0.1815	-0.2605	-0.3410*
	(0.110)	(0.589)	(0.184)
Local-market power$_t$	0.0081**	-0.0009	0.0124**
	(0.003)	(0.002)	(0.005)
Bank holding company dummy$_t$	-0.0014*	-0.0020***	-0.0004
	(0.001)	(0.001)	(0.001)
Metropolitan statistical area dummy$_t$	0.0049***	0.0009**	0.0082***
	(0.001)	(0.000)	(0.001)
Constant	-7.722***	-6.039***	-7.090***
	(0.41)	(1.70)	(0.46)
Observations	77,598	37,755	39,843
Pseudo R-squared	0.2237	0.2478	0.2220

Table 4.3: Survival analysis

Table 4.3 shows the results on the impact of bank loan securitization on the likelihood of bank failure using survival analysis. The sample period is from 2002 to 2012. Control variables include *retained interest ratio, bank size, diversification ratio, liquidity ratio, non-interest expense ratio, non-performing loans ratio, local-market power index, bank holding company dummy* and *metropolitan statistical area dummy*. All variable definitions are presented in Appendix 4.A. The sample period is also divided into before- and after-2007 to explore the difference referring to the 2007-09 financial crisis. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Dependent Variable		*Bank Failure*	
		Cox model	
	(1) full sample	(2) before 2007	(3) after 2007
Total securitization ratio%$_t$	0.561***	1.019***	0.335**
	(0.23)	(0.15)	(0.32)
Total retained interest ratio%$_t$	-0.370	-48.354***	-0.161
	(0.93)	(13.43)	(0.86)
Bank size$_t$	0.108***	-0.038	0.148***
	(0.04)	(0.13)	(0.04)
Diversification ratio%$_t$	-0.806**	-1.363	-0.885**
	(0.40)	(1.23)	(0.42)
Bank liquidity ratio%$_t$	8.273**	16.555***	9.020
	(3.81)	(5.02)	(9.65)
Non-interest expense ratio%$_t$	1.185***	1.367***	0.951***
	(0.27)	(0.21)	(0.30)
Non-performing loans ratio%$_t$	-29.130**	1.935	-35.379**
	(14.25)	(4.21)	(17.46)
Local-market power$_t$	0.823*	1.076	0.974**
	(0.46)	(1.19)	(0.46)
Bank holding company dummy$_t$	-0.146	-0.910***	-0.024
	(0.11)	(0.25)	(0.12)
Metropolitan statistical area dummy$_t$	0.826***	0.661**	0.835***
	(0.11)	(0.29)	(0.11)
Observations	77,598	37,755	39,843
Pseudo R-squared	0.2119	0.2367	0.2112

Table 4.4: Weighted-least-squares analysis

Table 4.4 reports the results of the impact of securitization ratios on the likelihood of bank failure using a propensity score matching based weighted-least-squares estimator. The regression uses a full sample and a 1:1 matched subsample including securitizers and non-securitizers with a propensity score distance within 1%. Within each sample, the propensity scores are the weights to conduct a least squares estimation. The sample period is from 2002 to 2012. The sample period is also divided into pre- and post-crisis subsamples. All variable definitions are presented in Appendix 4.A. Control variables include *retained interest ratio, bank size, diversification ratio, liquidity ratio, non-interest expense ratio, non-performing loans ratio, local-market power index, bank holding company dummy* and *metropolitan statistical area dummy*. Marginal effects are reported instead of coefficients. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Dependent Variable		*Bank failure*		
	(1) Full sample	(2) 1:1 sample	(3) before 2007	(4) after 2007
Total securitization ratio%$_t$	0.0019***	0.0068***	0.0015**	0.0049**
	(0.004)	(0.003)	(0.002)	(0.009)
Total retained interest ratio%$_t$	-0.0070	-0.0000	-0.0086	-0.0060
	(0.010)	(0.006)	(0.010)	(0.014)
Bank size$_t$	0.0019***	0.0003	0.0000	0.0025***
	(0.000)	(0.001)	(0.000)	(0.001)
Diversification ratio%$_t$	-0.0107***	-0.0036	-0.0018	-0.0140***
	(0.003)	(0.006)	(0.002)	(0.005)
Bank liquidity ratio%$_t$	0.0867	0.0601	0.0487	0.0968
	(0.275)	(0.961)	(0.199)	(0.463)
Non-interest expense ratio%$_t$	0.0530***	0.0012	0.0464***	0.0581***
	(0.006)	(0.007)	(0.004)	(0.011)
Non-performing loans ratio%$_t$	-0.0449	-0.0129	-0.0421	-0.0553
	(0.038)	(0.020)	(0.093)	(0.048)
Local-market power$_t$	0.0128***	0.0045	-0.0022	0.0194***
	(0.004)	(0.009)	(0.003)	(0.007)
Bank holding company dummy$_t$	-0.0015	0.0001	-0.0023***	-0.0005
	(0.001)	(0.003)	(0.001)	(0.002)
Metropolitan statistical area dummy$_t$	0.0048***	0.0020	0.0011*	0.0082***
	(0.001)	(0.002)	(0.001)	(0.001)
Constant	-0.0178***	-0.0022	0.0018	-0.0236***
	(0.004)	(0.007)	(0.003)	(0.006)
Observations	77,598	6,264	37,755	39,843
Pseudo R-squared	0.2031	0.1121	0.2071	0.2032

Table 4.5: The analysis on mortgage and non-mortgage securitization

Table 4.5 presents regression results on the impact of mortgage and non-mortgage securitization on the likelihood of failure. The Cox model is used in survival analysis. The sample period is 2002-2012. The sample is also divided into before- and after-2007 periods to explore the differences referring to the 2007-2009 financial crisis. Control variables include *retained interest ratio, bank size, diversification ratio, liquidity ratio, non-interest expense ratio, non-performing loans ratio, local-market power index, bank holding company dummy* and *metropolitan statistical area dummy*. Bank fixed effects are controlled in Cox model. All variable definitions are presented in Appendix 4.A. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Dependent Variable	Bank failure					
	(7) Full Sample	(8) Before 2007	(9) After 2007	(10) Full Sample	(11) Before 2007	(12) After 2007
	Cox model					
Mortgage securitization ratio%$_t$	0.711***	0.974***	0.570*			
	(0.21)	(0.15)	(0.32)			
Mortgage retained interest ratio%$_t$	0.286	30.616	0.379			
	(1.14)	(10.345)	(1.13)			
Non-mortgage securitization ratio%$_t$				0.185**	0.223**	0.119**
				(0.52)	(0.50)	(0.45)
Non-mortgage retained interest ratio%$_t$				-1.503	-43.997***	-0.981
				(1.77)	(12.27)	(1.18)
Bank size$_t$	0.109***	-0.035	0.148***	0.108***	-0.039	0.148***
	(0.04)	(0.13)	(0.04)	(0.04)	(0.13)	(0.04)
Diversification ratio%$_t$	-0.813**	-1.428	-0.887**	-0.806**	-1.371	-0.886**
	(0.40)	(1.21)	(0.42)	(0.40)	(1.23)	(0.42)
Bank liquidity ratio%$_t$	8.155**	6.437**	8.974	8.321**	15.687***	8.886
	(3.85)	(2.92)	(9.64)	(4.01)	(4.73)	(9.61)
Non-interest expense ratio%$_t$	1.191***	1.377***	0.953***	1.181***	1.367***	0.949***
	(0.27)	(0.21)	(0.30)	(0.27)	(0.21)	(0.30)
Non-performing loans ratio%$_t$	-28.589**	3.942	-35.248**	-27.897**	3.620	-34.662**
	(14.02)	(8.49)	(17.36)	(13.92)	(3.95)	(17.17)
Local-market power$_t$	0.818*	1.246	0.973**	0.821*	1.090	0.975**
	(0.46)	(1.07)	(0.46)	(0.46)	(1.18)	(0.46)
Bank holding company dummy$_t$	-0.152	-0.926***	-0.025	-0.143	-0.909***	-0.023
	(0.11)	(0.25)	(0.12)	(0.11)	(0.25)	(0.12)
Metropolitan statistical area dummy$_t$	0.827***	0.667**	0.834***	0.828***	0.661**	0.835***
	(0.11)	(0.29)	(0.11)	(0.11)	(0.29)	(0.11)
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	No	No	No	No	No
Observations	77,598	37,755	39,843	77,598	37,755	39,843
Pseudo-R^2	0.2116	0.2347	0.2112	0.2120	0.2367	0.2113

Table 4.6: The analysis on loan sales

Table 4.6 presents regression results of the impact of loan sales on the likelihood of bank failure, which uses the Cox model in survival analysis. The sample period is 2002-2012. The sample is also divided into before- and after-2007 periods to explore the differences referring to the 2007-2009 financial crisis. Control variables include *bank size, diversification ratio, liquidity ratio, non-interest expense ratio, non-performing loans ratio, local-market power index, bank holding company dummy* and *metropolitan statistical area dummy*. Bank fixed effects are controlled in Cox models. All variable definitions are presented in Appendix 4.A. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Dependent variable	*Bank failure*		
	(1)	(2)	(3)
	Full Sample	Before 2007	After 2007
Loan sale ratio%$_t$	0.373**	0.913**	0.226**
	(0.48)	(1.36)	(0.20)
Bank size$_t$	0.109***	-0.056	0.149***
	(0.04)	(0.13)	(0.04)
Diversification ratio%$_t$	-0.810**	-1.400	-0.891**
	(0.40)	(1.23)	(0.42)
Bank liquidity ratio%$_t$	8.164**	6.524**	8.696
	(3.83)	(2.89)	(9.55)
Non-interest expense ratio%$_t$	1.190***	1.360***	0.957***
	(0.27)	(0.21)	(0.30)
Non-performing loans ratio%$_t$	-28.781**	-1.652	-33.887**
	(14.06)	(8.66)	(17.09)
Local-market power$_t$	0.820*	1.178	0.961**
	(0.46)	(1.09)	(0.46)
Bank holding company dummy$_t$	-0.152	-0.900***	-0.020
	(0.11)	(0.25)	(0.12)
Metropolitan statistical area dummy$_t$	0.827***	0.669**	0.835***
	(0.11)	(0.29)	(0.11)
Bank fixed effects	Yes	Yes	Yes
Time Fixed Effect	No	No	No
Observations	77,598	37,755	39,843
Pseudo-R^2	0.3233	0.3464	0.3229

Chapter 5
Bank Loan Securitization and Efficiency

5.1 Introduction

In the last two decades, securitization has dramatically changed the way banks provide liquidity. While it is still debatable on the role of securitization in contribution to the risk of financial markets, it is generally belief that as loans have become more liquid, the efficiency of the whole financial market has increased because the credit supply relies less on bank's financial conditions (Loutskina and Strahan, 2009). It is less clear, however, that this change of the special role of banks through securitization has any positive impact on bank's own efficiency or not. Examining the impact of securitization on bank efficiency is thus the central focus of this chapter.

Bank loan securitization is deemed to have two contradictory impact on banks (Gande and Saunders, 2012). On the one hand, securitization allows originators to transfer asset risks to investors and hence can hold a lower level of risk-adjusted capital ratios (Benveniste and Berger, 1987; Berger, Herring, and Szego, 1995). Securitization also creates a new source of liquidity by allowing banks to convert illiquid loans into marketable securities (Loutskina, 2011). In addition, a bank can use loan securitization to achieve optimal assets and geographic diversification (Hughes et al., 1999; Berger and DeYoung, 2001). These channels provide banks with better risk-management tools and are in turn less restricted to traditional sources of funds (Billet and Garfinkel, 2004). On the other hand, the existence of loan securitization can reduce securitizers' incentive to carefully screen borrowers (Keys et al., 2010). The long run effect of this moral hazard is decreased quality of loan and risk management.

It is unclear that the result of these competing forces can be efficiency gain or efficiency lose for a securitizing bank. The existing literature focus on the observable bank performance outcomes and find that securitization decreases bank risk (Cebenoyan and Strahan, 2004) and increases bank performance (Casu, et al., 2013; Jiang, Nelson, and Vytlacil, 2014), while bank's profitability may be decreased (Michalak and Uhde, 2010). The announcement of securitization is found to be positively associated with wealth gains for stronger banks, and wealth loss for weak banks (Lockwood, Rutherford, and Herrera, 1996).

The main results are summarized as follows. First, bank loan securitization is found to increase bank's efficiency. A one-standard-deviation increase of total securitization is associated with an 9.23% increase in the standard deviation of bank's efficiency scores.

Second, two approaches are used to identify the casual impact of securitization on bank efficiency. First, the Heckman self-selection model is employed to address the possible self-selection problem. Second, a Difference-in-Difference (DiD) approach is introduced to explore the association between the changes in securitization ratios and bank's efficiency scores. Following Brunnermeier, Dong, and Palia (2012), the bankruptcy of Lehman Brothers in September 2008 is used as a source of exogenous variation. The bankruptcy of Lehman Brothers triggered a sudden dried-up of secondary market liquidity, which impacts more significantly on securitized banks (Gorton and Metrick, 2012). The differences in bank efficiency between securitized and non-securitized banks are reduced in the post Lehman Brothers bankruptcy period.

Third, the key channels through which bank efficiency benefit from loan securitization are through capital relief, risk transferring, liquidity increase and diversification increase. The impact of loan securitization on bank efficiency is more significant for banks with higher capital ratios, higher level of risks, and lower level of liquidities and diversification. These results are consistent with previous literature (Loutskina and Strahan, 2009; Loutskina, 2011; Hartman-Glaser, Piskorski, and Tchistyi, 2012; Nadaulda and Weisbach, 2012; Jiang, Nelson, and Vytlacil, 2014).

Fourth, the impact of on-mortgage securitization ratio on bank efficiency is significant but not mortgage securitization. These results reflect the fact that mortgage loans are backed by real estates, the values of which are not easily to be depreciated (Campbell and Cocco, 2015), and are thus expected to be safer compared with non-mortgage loans. Securitizing non-mortgage loans is hence considered as a more efficient risk transferring.

Finally, a similar positive impact of loan sales on bank efficiency is documented. In practice, banks may choose loan sales rather than securitization to pursue higher flexibility and diversification. Loan sales involve the totality of an originated loan (Gorton and Haubrich, 1990) and are affected without recourse (Greenbaum and Thakor, 1987). Thus, loan sales can also reduce banks risk by separating the ownership of riskier assets from their balance sheet (Berger and Udell, 1993).

Overall, bank efficiency benefit from loan securitization. This result is especially true for banks with higher capital ratios, higher level of default risk, and lower level of diversification, who are more likely to benefit from the positive impact of bank securitization.

The results of have extensive implications for regulators and practitioners. The positive impact of securitization, particularly the impact of non-mortgage loan securitization on bank efficiency, provides evidence on the bright side of securitization. Securitization has been blamed for being one of the main triggers of the 2007-09 financial crisis, because it deteriorates loan quality in the subprime mortgage market (Piskorski, Seru, and Vig, 2010; Ghent, 2011). However, impeding the development of securitization may not be the right strategy to prevent a similar crisis in the future, because a less developed securitization market may not be able to supply sufficient credit to the market, and exacerbates real shocks in financial markets (Holmstrom and Tirole, 1997).

5.2 Hypothesis development

5.2.1 The positive impact of loan securitization on bank efficiency

Securitization increases bank's financial flexibility through two channels, flexibility increase and diversification increase. First, banks can use securitization vehicles such as asset-backed securities (ABSs), collateralized debt obligations (CDOs), or mortgage-backed securities (MBSs) to restructure their portfolios, and transfer asset risks to investors. It leads to capital relief effect because of the partially transferred credit risk. Originators are thus able to hold a lower level of risk-based capital. The regulatory reform in 1990s in the U.S. introduced a risk-based accord which requires banks to hold a minimum capital level according to the perceived risks (Avery and Berger, 1991; Carlstrom and Samolyk, 1995; Duffee and Zhou, 2001; Calomiris and Mason, 2004; Nicolo and Pelizzon, 2008; Acharya et al., 2013). By transferring potential credit risk to security investors, originators are able to hold a lower level of risk-based capital. For example, the capital adequacy rules developed by the Basel Committee on Banking Supervision (2006) permit a capital relief for institutions that are able to transfer such risk to others. It decreases the impact of capital restrictions on bank's activities and hence, which in turn increases financial flexibility. Traditionally, commercial banks have to hold the illiquid loans to maturity. Securitization creates a new source of liquidity by allowing banks to convert illiquid loans into marketable securities, leading to a liquidity increase effect (Loutskina, 2011). Financial flexibility is in turn increased because banks are less dependent on traditional sources of funds.

The increased financial flexibility may lead to a higher level of efficiency, since literature shows that less flexible banks tend to have lower efficiency. On one hand, restrictions on bank capital retention could result in additional cost, in the form of a higher barrier to entry and greater rent extraction by governments (Barth, Brumbaugh, and Wilcox, 2000; Laeven and Levine, 2007). On the other hand, restrictions on bank activities can limit the exploitation of economies of scope and scale in gathering and processing information about firms, building reputational capital and providing various types of services to customers (Barth et al., 2000; Laeven and Levine, 2007). Both restrictions could impede bank's ability to diversify income streams and reduce the franchise value of a bank, which might limit the incentive for efficient behavior (Barth et al., 2013).

Higher flexibility indicates a better reallocation of resources according to optimal mix, leading to higher efficiency (Parlour, Stanton, and Walden, 2012) by avoiding the underinvestment problem (Froot et al., 1993). Banks with financial flexibility can easily access to external capital markets to meet funding needs arising from unanticipated earnings shortfalls or new growth opportunities, and hence, avoid situations that may lead to suboptimal investment and poor performance (DeAngelo and DeAngelo, 2007; Gamba and Triantis, 2008; Byoun, 2008). Studies also emphasize the importance of obtaining financial flexibility through moderate or high liquidity balances (Opler et al., 1999; Billet and Garfinkel, 2004; Almeida et al., 2004; Acharya et al., 2007; Faulkender and Wang, 2006; Dittmar and Mahrt-Smith, 2007; Kalcheva and Lins, 2007; Harford et al., 2008; Riddick and Whited, 2008). Literature also shows that the additional internal (Kashyap and Stein, 2000) and external (Campello, 2002) sources of funds can partially alleviates the restrictions of funds on bank loan supply. Therefore, securitization may increase bank efficiency through the flexibility increase channel.

Second, securitization also provides originators with diversification benefits. The pooling process allows bank to construct a low-risk debt security from a large pool, creating a risk diversification effect (DeMarzo, 2005). Diversifying into other banks' asset reduces the probability of individual's failure, because it allows originators to diversify idiosyncratic risk carried by the assets (Wagner, 2010). Greenbaum and Thakor (1987) point out that the reduction of risks and diversification of portfolios is one of the main benefits of securitization. Securitization also leads to geographic diversification because originators are able to include a great amount of loans which come from different geographic locations where default risks are not expected to increase at the same time in the pool. In this case, securitization allows originators to smooth out the risk among many investors, where credit risk can be more easily and widely transferred across the financial system (Berger et al., 2005).

Diversification is positively related to bank efficiency because it leads to better resource allocation activities (Weston, 1970). Diamond (1984) argues that financial intermediation's cost control can be improved because portfolio diversification contributes to a higher asset quality (measured by non-performing loans). Berger and Ofek (1995) also find a positive relationship between diversification and bank efficiency levels. Regarding to geographic diversification, sufficient research (Hughes et al., 1996, 1999; Bos and Kolari, 2005; Deng et al., 2007) present a positive relationship between it and bank efficiency. Berger and DeYoung (2001)'s explanation it that, geographic diversification allows more efficient banks to take advantage of their network economies and exploit geographic risk diversification, which in turn increases bank efficiency.

Negative correlation is found between risk level and bank efficiency by previous studies. For example, Altunbas et al. (2000) suggest that scale efficiency can be significantly reduced when applied risk factors, after investigating a sample of Japanese commercial bank between 1993 and 1996. The diversification benefit of securitization also allows originators to reduce the risk level by removing part of the risky loans off the balance sheet. It allows securitizers to reallocate resources to output related activities, leading to higher efficiency. Therefore, the first hypothesis is as follows:

Bank efficiency is positively associated with bank's loan securitization.

5.2.2 The negative impact of loan securitization on bank efficiency

Loan securitization can also be negatively associated with bank efficiency, due to the information asymmetry problem. Information asymmetry problems of securitization can be categorized into two groups. On one hand, the inequality of information about managerial actions and uncertain factors that affect security payoffs between originators and investors during the securitization process could lead to moral hazard problem (Kahn and Winton, 2004; Acharya and Viswanathan, 2011; Hartman-Glaser, Piskorski, and Tchistyi, 2012; Chemla and Hennessy, 2014), which encourages securitizers to reduce managerial incentives in the transaction (Keys et al., 2010). The lax monitoring and screening of originators contribute to a gradual deterioration in credit quality of individual assets (Demyanyk and Hemert, 2011). Empirical evidence (Keys et al., 2010; Jiang, Nelson, and Vytlacil, 2010; Elul, 2011) show that securitized subprime mortgages had default rates 10% to 25% higher than similar mortgages that were not securitized.

On the other hand, hiding information about securities are issued in the transaction could result in regulatory arbitrage problem (An, Deng, and Gabriel, 2011; Benmelech, Dlugosz, and Ivashina, 2012). In order to pursue higher reputations or ratings, originators choose to securitize better loans in the portfolio and ignore potential risk left within their balance sheet. Agarwal, Chang and Yavas (2012) find banks in prime mortgage market are more likely to sell low-default-risk loans while retaining higher-default-risk ones in their portfolio, and also that issuers could purchase better rating by doing this. In this case, originators are not able to realize risk reduction benefits of securitization but in turn hold a higher proportion of risky loans. Both information asymmetry problems could lead to a loan quality deterioration effects.

Banks with lower quality of loans can be less efficient because they are not able to allocate inputs efficiently according to the costs but forced to concentrate assets into risky loans. Studies of bank efficiency provide sufficient evidence to show a negative relationship with risk factors (Mester, 1996; Eisenbeis et al., 1999; Altunbas et al., 2000; Gonzalez, 2005; Pasiouras, 2008; Chiu and Chen, 2009; Sun and Chang, 2011). The explanation is that, loan risk is an essential ingredient in bank production, which can be considered as an undesirable output in practice. The higher the amount of this output, the lower the bank efficiency is. It may because high loan risk is likely to indicate poor risk management (Berger and Mester, 1997), which means managers may seek to maximize their own compensation and choose inputs or outputs suiting their own preferences, rather than to maximize firm value (Berger, 1995). Therefore, the second hypothesis is as follows:

Bank loan securitization is more likely to decrease bank efficiency.

5.3 Data and methodology

5.3.1 Data

All annual accounting data are collected from the Reports of Income and Condition for commercial banks (the Call Report) in the period of 2002-2012. The full sample starts from 2002 because U.S. banks are required to provide detailed information on their securitization activities from June 2001. Following Bedendo and Bruno (2012), small banks (with total assets under $1 billion) are excluded from the sample because they are rare securitizers due to the substantial upfront costs. The final sample consists of 863 large commercial banks in the U.S., including 150 securitizers and 713 non-securitizers, accounting for a total of 5,275 bank-year observations.

5.3.2 Variables

5.3.2.1 Bank efficiency

This section first uses the data envelopment analysis (DEA) model to estimate bank's efficiency scores.[7] The outputs of the banking industry are arguably more likely to be determined by the market (see e.g., Miller and Noulas, 1996; Topuz, Darrat, and Shelor, 2005; Kumbhakar and Tsionas, 2006). Therefore, an input-oriented data envelopment analysis model using the intermediation approach are applied. This chapter assumes that banks use three types of inputs:

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[7] DEA model does not require the explicit specifications of the functional form of the underlying production relationship, which is popular in banking studies. Berger and Humphrey (1997) provide a comprehensive survey of related efficiency research in banking.

a) customer deposits and short-term funding; b) total costs, defined as the sum of interest expenses and non-interest expenses; and c) equity capital to adequately account for the impact of risk, to produce the following outputs: a) loans; b) other earning assets; and c) non-interest income as a proxy for off-balance sheet activities.[8] Descriptive statistics for the inputs and outputs used in the DEA efficiency measurement are reported in Table 5.1.

<Insert Table 5.1 >

In general, a data envelopment analysis model estimates efficiency scores from a production set as follows:

$$\boldsymbol{P = \{INPUT, OUTPUT\}} \qquad \textbf{(5.1)}$$

The technology frontier is therefore defined as:

$$\boldsymbol{P^T = \{(INPUT, OUTPUT) | (INPUT, OUTPUT) \in P, (\sigma INPUT, \sigma^{-1} OUTPUT) \notin P,\ \forall\, 0 < \sigma < 1\}}$$

This is then used to estimate a bank's input technical efficiency:

$$\boldsymbol{\delta_{INPUT}(INPUT_i, OUTPUT_i) \equiv \inf\{\sigma > 0 | (\sigma INPUT_i, OUTPUT_i) \in P^T} \qquad \textbf{(5.2)}$$

A bank's technical efficiency represents the proportion by which input quantities can feasibly be reduced without reducing output quantities. Bank efficiency scores are measured relative to a common frontier by pooling the data across individuals estimated separately for each year. Bank efficiency scores range from zero to one, with a higher value indicating a higher level of efficiency.

5.3.2.2 Independent variables

The *securitization ratio* (defined as the ratio of outstanding principal balance of assets securitized over total assets) is used to represent a bank's securitization activity. The signalling theory suggests providing credit enhancements could improve securitizers' managerial efforts (Downing, Jaffee, and Wallace, 2009). Thus, use the *retained interest ratio* is used to control for bank's credit enhancement situation. *Retained interest ratio* is defined as the total amount of retained interest divided by the total amount of securitization assets, including the aggregate retained interests into credit enhancements, liquidity provisions, and seller's interest.

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[8] Selected descriptive statistics for the inputs and outputs used in the DEA efficiency measurement are presented in Appendix B.

Control variables include a group of bank-specific characteristics. *Bank size* is measured by the natural logarithm of total assets. The impact of bank size on bank efficiency could be positive, as larger firms are expected to use better technology and be more diversified and better managed. However, a negative effect may be observed in situations where there will be a loss of control resulting from inefficient hierarchical structures in the management of the company. *Diversification ratio,* defined as non-interest income divided by total operating income, controls for a bank's portfolio diversification. Conventional finance theory suggests that risk-adjusted returns are higher for a well-diversified portfolio, which can in turn increase bank efficiency (Rossi, Schwaiger, and Winkler, 2009). *Liquidity ratio,* measured as liquid assets divided by total assets, controls for banks' liquidity situation. Higher liquidity can give banks more flexibility, which can increase efficiency (Jensen, 1986; Myers and Rajan, 1998). *Non-interest expense ratio* is defined as non-interest expenses divided by total assets. Non-interest expenses are usually not associated with targeting customers to deposit funds, which may decrease bank efficiency. *Non-performing loans ratio* is the total value of loans 90 days past due divided by total assets, reflecting the bank's risk management situation. Berger and DeYoung (1997) provide evidence to show that problem loans significantly reduce bank efficiency. *Local-market power* is the bank-level Herfindahl-Hirschman Index of deposit concentration for local markets in which the bank operates (Berger and Bouwman, 2013).

5.3.3 Empirical strategy

The baseline framework uses the following OLS model to estimate the impact of loan securitization on bank efficiency:

$$\boldsymbol{Efficiency\ Scores_{it} = \beta_0 + \beta_1 Securitization\ Ratio_{it} + \beta_2 X_{it} + \alpha_i + \gamma_t + \mu_{it}} \quad \textbf{(5.3)}$$

Where $Efficiency\ Scores_{it}$ is the dependent variable calculated from the DEA model, X_{it} is the vector of bank-specific control variables, α_i is the intercept of for each bank, γ_t is the intercept for each year, and μ_{it} is the disturbance term.

The relationship between securitization ratio and bank efficiency score identified by the fixed effects estimator could be endogenous. For example, banks with higher efficiency are expected to have higher future profits, and thus greater charter value and reputation. Those higher efficiency banks can in turn be benefited with a lower lemon discounts when securitizing assets (Campbell and Kracaw, 1980; Diamond, 1984; Boyd and Prescott, 1986). Therefore, it could be that banks with higher efficiency are naturally more active securitizers. It is also a rational conjecture that there exist other unobservable factors impacting on both securitization ratios and efficiency scores.

Therefore, two methods are employed to identify the causal effects between securitization and bank efficiency. First, the Heckman self-selection model is used to address the potential self-selection bias, where introduces three sets of exogenous instruments in the Heckman model. The first instrument is the annual *state-level corporate tax rate*, with data obtained from the U.S. Tax Foundation website.[9] The analysis also exploits the state-time variations in corporate tax rates as an instrument for bank securitization because higher corporate tax rate is found to increase bank's incentive to securitize due to the corporate tax exemption of securitized assets (Han, Park, and Pennacchi, 2015).

The second instrument is the *peer liquidity index*, conducted based on Loutskina's (2011) liquidity index which captures banks' incentive to securitize. It is a weighted average of the potential to securitize loans of a given type, based on market-wide averages. Following Loutskina (2011), a bank's loan portfolio is decomposed into six groups: 1) home mortgages, 2) multifamily residential mortgages, 3) commercial mortgages, 4) agricultural loans, 5) commercial and industrial (C&I) loans, and 6) consumer credit.[10] Liquidity index is defined as:

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[9] The data are available at: http://www.taxfoundation.org/taxdata/show/230.html.

$$\boldsymbol{Liquidity\ Index_{it}} = \sum_{j=1}^{6}\left(\frac{\boldsymbol{Economy\ Wide\ Securitization_{jt}}}{\boldsymbol{Economy\ Wide\ Total\ Loans_{jt}}}\right) \times \left(\boldsymbol{Loan\ Share_{j,it}}\right) \quad \textbf{(5.4)}$$

In this equation, $\boldsymbol{Economy\ Wide\ Securitization_{jt}}$ is the amount of economy-wide securitized loans of type $\boldsymbol{j}$ at time $\boldsymbol{t}$, $\boldsymbol{Economy\ Wide\ Total\ Loans_{jt}}$ is the economy-wide total loans outstanding of type $\boldsymbol{j}$ at time $\boldsymbol{t}$, and $\boldsymbol{Loan\ Share_{j,it}}$ is the share of type $\boldsymbol{j}$ loans in bank $\boldsymbol{i}$ at time $\boldsymbol{t}$.

Bank $\boldsymbol{i}$'s peer liquidity index is then contructed by calculating the average of the liquidity indexes all of bank $\boldsymbol{i}$'s peers, excluding bank $\boldsymbol{i}$ itself. A bank's tendency to securitize loans is arguably related to its industry peers' securitizing behaviour because of the herd effect (Chari and Kehoe, 2004). It is unlikely that a bank's industry peers' securitizing behavior can directly affect the bank's efficiency (other than through the channel of securitization).

The *state-level corporate tax rate* does not have a bank-specific component, so it only provides the impact of a state's "average" bank. The *peer liquidity index* provides the impact only based on bank-specific accounting information. The cross-product of the *state-level corporate tax rate* and the *peer liquidity index* is used as a third instrument to capture both characteristics (see more empirical research using interaction terms, e.g., Santos and Winton (2008), Leary (2009), Foos, Norden, and Weber (2010), Maskara (2010), Benmelech and Bergman (2011), He, Qian, and Stahan, (2012), Callen and Fang (2013) among others).

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[10] The data used to construct this instrument variable come from the "Financial Accounts of the United States" (Z.1) data release.

Second, this chapter uses a Difference-in-Difference (DID) approach to explore the association between the changes in securitization ratios and bank's efficiency scores. Following Brunnermeier, Dong, and Palia (2012), the bankruptcy of Lehman Brothers in September 2008 is introduced as a source of exogenous variation. The bankruptcy of Lehman Brothers triggered a wide withdrawal of short-term repurchase agreements (repos), and led to a securitized banking run (Gorton and Metrick, 2012). The sudden shrunk in the securitization market scale could jeopardize bank's efficiency improving through securitizing assets. Thus, the efficiency scores of securitizers is expected to decrease more significantly than non-securitizers after the bankruptcy of Lehman Brothers. First, this identification strategy uses a subsample including only matched securitizers and non-securitizers to test this hypothesis. Propensity scores are assigned for each bank using the following bank specific characteristics: *capital ratio, bank size, diversification ratio, liquidity ratio, non-interest expense ratio, non-performing loans ratio, and local-market power*. Then each securitizer is matched with the most similar non-securitizer using nearest-neighbour matching by imposing a 1% tolerance level on the maximum propensity score distance.[11] The DID analysis is based on the following model:

$$\boldsymbol{Efficiency\ Scores_{i,t} = \beta_0 + \beta_1 Securitizer\ Dummy_{i,t} \times Post\ Lehman\ Bankruptcy_{i,t} + \beta_2 X_{i,t} + \alpha_i + \tau_t + \varphi_{i,t}} \qquad \mathbf{(5.5)}$$

$Securitizer\ Dummy_{i,t}$ is to identify securitized banks (one for securitizers and zero otherwise), $Post\ Lehman\ Bankruptcy_{i,t}$ is a dummy variable which set to unity after the year of 2008, and zero before 2008, $X_{i,t}$ is the vector of bank specific controls, α_i is the intercept of for each bank, τ_t is the intercept for each year, and $\varphi_{\mathrm{i,t}}$ is the error term. The *Post Lehman bankruptcy* dummy and $\mathrm{Securitizer\ Dummy}$ do not appear by itself on the right-hand side of the regression because they would be perfectly collinear with the year and bank fixed effects, respectively.

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[11] The unreported analysis also uses the matched sample to conduct a Propensity Score Matching analysis. Results show that the average efficiency scores of securitizers is 0.79, which is significantly (at 1% significance level) higher than that of non-securitizers (0.57), supporting that securitization is likely to increase bank efficiency.

This chapter also hypothesizes that the bankruptcy of Lehman Brothers could impact more significantly on those banks with higher securitization incentives. Following Loutskina (2011), $\boldsymbol{bank\ loan\ portfolio\ liquidity\ index}$ is used to identify banks’ incentives to securitize. The 90% distribution threshold[12] of the $\boldsymbol{bank\ loan\ portfolio\ liquidity\ index}$ is used to define the most affected securitizers. Following Berger and Bouwman (2013), the year of 2005 is used as the normal period and use $\boldsymbol{bank\ loan\ portfolio\ liquidity\ index}$ values of 2005 to define the size distribution of liquidity index. Then the use of $\boldsymbol{Top\ 10\%\ securitizers}$ dummy is to identify the most active securitizers. $\boldsymbol{Top\ 10\%\ securitizers}$ dummy is set to unity if a securitizer’s $\boldsymbol{bank\ loan\ portfolio\ liquidity\ index}$ value is larger than 90% distribution of all securitizers, and zero otherwise. Then $\boldsymbol{securitizer\ dummy}$ are replaced by $\boldsymbol{Top\ 10\%\ Securitizers\ dummy}$ in Equation (5) and run the regression using a subsample including only securitized banks.

5.4 Empirical results

5.4.1 Descriptive statistics

Table 5.2 shows summary statistics (means, medians, and standard deviations (SD)) on all variables for securitizers and non-securitizers. Student's t-test and Wilcoxon rank-sum test for the differences in means and medians between securitizers and non-securitizers are also presented. Letters of “a” and “b” represent a 1% statistical significance level for means and medians, respectively.

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[12] The robustness tests consider various other bank size thresholds (e.g., 95%, 98%). The results are qualitatively similar.

<Insert Table 5.2 Here>

Results show a higher average efficiency score for securitizers (0.55) compared with that of non-securitizers (0.43). Both differences in means and medians of efficiency scores between securitizers and non-securitizers are statistically significant at 1% level, suggesting that securitized banks are likely to be more efficient. On average, 13.74% of securitizers' total assets have been securitized during 2002 to 2012. The median of securitization ratio is 0.14 and the SD is 37.56, suggesting that some banks are more active and massive securitizers. The signalling theory suggests that securitizers can use credit enhancements to signal the quality of the assets being securitized (Demiroglu and James, 2012). 7.08% of the securitized assets are backed by credit enhancements. Literature also suggest securitization provides banks with capital relief (Martín-Oliver and Saurina, 2007), diversification (DeMarzo, 2005), and liquidity increase (Loutskina, 2011) benefits. Securitizers are more likely to be related to higher capital ratio (11.23% vs. 10.60%)[13], larger in total assets ($6.2 billion vs. $2.4 billion) and lower liquidity (20.86% vs. 21.59%) than non-securitizers. Securitization process requires a substantial amount of upfront costs (e.g., consultancy and organizational costs, payments to rating agencies, underwriting fees, and legal expenses). Securitizers are in turn associated with higher operating costs (Gorton and Souleles, 2005). The average non-interest expense ratio is higher for securitizers (3.53%) than non-securitizers (2.86%). The securitized assets are also required a certain amount of lemon discount by the investor. Larger banks with higher reputation or market powers are more likely to be benefit from a lower lemon discount (Campbell and Kracaw, 1980; Diamond, 1984; Boyd and Prescott, 1986). Results also support that securitizers are likely to be larger (with total assets of $6.4 billion vs. $2.4 billion) with higher market power (6.47 vs. 1.79).

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[13] The two numbers stand for securitizers' and non-securitizers', respectively.

5.4.2 The impact of securitization on bank efficiency

Results of the baseline regression using OLS and endogeneity analyses using Heckman self-selection model, propensity score matching, and panel Heckman self-selection model, are reported in Table 5.3, 5.4, 5.5, 5.6, respectively. The first-step results of Heckman self-selection model, using instruments of $\boldsymbol{state-level\,corporate\,tax\,rate}$, $\boldsymbol{peer\,liquidity\,index}$, and $\boldsymbol{state-level\,corporate\,tax\,rate \times peer\,liquidity\,index}$, are reported in column (2), (4) and (6), respectively.

<Insert Table 5.3 Here>

<Insert Table 5.4 Here>

<Insert Table 5.5 Here>

<Insert Table 5.6 Here>

Total securitization ratio is significantly (at the 1% statistical significance level) related to the increase of bank efficiency scores, suggesting the involvement of securitization is likely to increase bank efficiency. A one-standard-deviation increase in total securitization ratio leads to an increase of 9.23% of a standard deviation in bank's efficiency scores. Securitization provides securitizers with capital relief and liquidity increase, which in turn increases the flexibility of banks and positively impacts on bank's efficiency. This finding is also confirmed by the Heckman self-selection analysis, where an average 17.04% of standard deviation increase in bank's efficiency score due to a one-standard-deviation increase of total securitization ratio. Also, all instruments are statistically significant in the first step of Heckman self-selection model, suggesting the instruments are all valid.

Results on control variables are largely consistent with previous literature. Retained interest ratios, on average, are found to have a positive impact on bank efficiency. As expected, larger size and higher capital and non-performing loans ratios are associated with lower bank efficiency scores, while higher diversification and liquidity ratios are related to higher efficiency scores.

A Difference-in-Difference (DiD) analysis is also used, using the bankruptcy of the Lehman Brothers in 2008 as the exogenous shock. On the one hand, it is expected that the dramatic dive in securitization market scale to significantly decrease securitizers' efficiency improving through securitization. Thus, the coefficient of interest ($\boldsymbol{\beta_1}$) in Equation (5) is expected to be negative. On the other hand, the impact of the bankruptcy of Lehman Brothers on most active securitizers could be more significant. Results are reported in Table 5.7. In general, the change in efficiency scores of securitizers is lower than that of non-securitizers, suggesting the contribution of securitization to bank's efficiency improving decreased significantly after the bankruptcy of Lehman Brothers. Similar results are reported for banks with the highest securitization incentives and other securitizers. Overall, the DiD framework support the main findings.

<Insert Table 5.7 Here>

Additionally, this chapter provides a split sample analysis to support the DiD results by comparing the impact of securitization on bank's efficiency score in pre- (2002-2006) and post-crisis (2007-2012) periods. Results are reported in Table 5.7. In both specifications, securitization ratios are positively and significantly related to bank's efficiency scores in both periods. Interestingly, there is a decrease in the economic impact of securitization on bank's efficiency scores. Before 2007, a one-standard-deviation increase of total securitization ratio is associated with an increase of 17.82% of a standard deviation in bank's efficiency scores, while this impact decreases to 12.49% after the breakout of the 2007-09 financial crisis.

<Insert Table 5.8 Here>

5.4.3 Additional analysis

The main findings suggest a positive association between securitization ratios and the increase of bank's efficiency scores. The hypothesis is that the efficiency improving effects of securitization may be related to flexibility and diversification increase. To shed more lights on this argument, the additional analysis explores the co-variations between securitization ratio and several bank-specific characteristics in the first additional analysis. The empirical models are specific as follows:

$$\boldsymbol{Efficiency\ Scores_{it} = \beta_0 + \beta_1 Securitization\ Ratio_{it} + \beta_2 Bank\ Characteristics_{it} + \beta_3 Securitization\ Ratio_{it} \times Bank\ Characteristics_{it} + \beta_4 X_{it} + \alpha_i + \gamma_t + \mu_{it}} \quad \textbf{(5.6)}$$

In equation (5.6), $\boldsymbol{\beta_3}$ is the coefficient of interest, which can be considered as the additional impact of securitization caused by the corresponding bank characteristic. First, securitization provides banks with capital relief benefit which allows securitized banks to hold a lower level of capital buffer. Banks with higher level of regulatory capital ratios are thus able to benefit more from this off-balance-sheet transaction. Thus, the efficiency scores of banks with higher capital ratios are expected to be more significantly improved by securitization. This regression uses $\boldsymbol{capital\ ratio}$ to represent bank's capital levels and expect $\boldsymbol{\beta_3}$ to be positive.

Second, securitization allows banks to shift potential risk to security investors through true sales of the underlying assets. Banks with higher balance-sheet risk can in turn benefit more from securitization to decrease the potential risk. Hence, the efficiency improving impact of securitization is expected to be more significant for banks with higher risk. This regression uses $\boldsymbol{LogZ}$ to represent bank risk. Since a higher value of $\boldsymbol{LogZ}$ indicates a lower level of bank risk, the expectation is that $\boldsymbol{\beta_3}$ to be negative.

Third, securitization allows banks to transfer illiquid assets on the balance sheet into marketable securities (Loutskina, 2011). Banks with insufficient liquidities can in turn benefit more from the extra liquidity provided by securitization and pursue other more profitable projects. The impact of securitization on efficiency scores for banks with lower liquidity levels is expected to be more significant. In this regression, $\boldsymbol{liquidity\,ratio}$ is used to represent bank's liquidity level, and the expectation is that $\boldsymbol{\beta_3}$ to be negative.

Last, securitization increases bank's diversification by allowing securitizers to take advantage of network economies and exploit geographic diversification. Less diversified banks are more likely to be the beneficiaries of securitization to improve efficiency through diversification. The impact of securitization on efficiency for banks with unfavourable level of diversification is thus expected to be more significant. This specification uses $\boldsymbol{diversification\,ratio}$ to represent bank's diversification situation, which means $\boldsymbol{\beta_3}$ is expected to be negative. All results of the co-variations between securitization ratios and bank characteristics are reported in Table 5.9. Overall, results are in the line with the hypotheses and support the argument that the efficiency improving effect of securitization may be associated with flexibility and diversification improvement.

<Insert Table 5.9 Here>

5.4.4 The impact of mortgage and non-mortgage loan securitization on bank efficiency

Results so far suggest the efficiency improving of securitization is likely to related to risk transferring. To shed more light on risk transferring, it would be informative to explore the possible differences between mortgage and non-mortgage securitization. Mortgage loan are backed by real estates which are not easily depreciated (Campbell and Cocco, 2015). Mortgage loans are widely considered as safer than non-mortgage loans. Thus, securitizing risky assets (e.g., non-mortgage loans) is a more efficient risk transferring (Minton et al., 2004). Non-mortgage securitization is expected to be more significantly related to the increase of bank's efficiency scores. To test the hypothesis, another additional analysis breaks down securitization into mortgage and non-mortgage securitizations. Mortgage loans include 1-4 home mortgages, while non-mortgage loans contain all other types of loans, including home equity lines, credit card receivables, auto loans, commercial & industrial loans, other consumer loans, and all other loans. Total securitization ratio is thus replaced by mortgage and non-mortgage securitization ratios in both OLS and Heckman self-selection models. Results on mortgage and non-mortgage securitization ratios are reported in Table 5.10.

<Insert Table 5.10 Here>

Empirical results show that mortgage securitization ratio is not significantly related to bank's efficiency scores (column (1)), and non-mortgage securitization ratios are significantly associated with the increase of bank's efficiency scores (column (2)). This finding is in the line with the expectation that non-mortgage securitization is likely to be more significant related to bank's efficiency than mortgage securitization. This finding holds after controlling for self-selection bias using Heckman self-selection model.

5.4.5 The impact of loan sale activities on efficiency scores

Finally, the additional analysis focuses on examining the impact of loan sales. In practice, loan sales are related to a lower level of fixed upfront costs (Carlstrom and Samolyk, 1995). Banks that intend to pursue additional flexibility may choose loan sales rather than securitization. Loan sales involve the totality of an originated loan (Gorton and Haubrich, 1987) and are affected without recourse (Greenbaum and Thakor, 1987). Thus, loan sales can also reduce banks risk by separating the ownership of riskier assets from their balance sheet (Berger and Udell, 1993). The impact of loan sale ratios on bank efficiency scores is expected to be positive as securitization ratios. Following Bedendo and Bruno (2012), loan sales are defined by the difference between: 1) the outstanding principal balance of assets owned by others with servicing retained by the bank, and 2) the outstanding principal balance of assets sold and securitized by the bank. Loan sales data are collected from the Call Report, and the regression results are reported in Table 6.10.

<Insert Table 5.10 Here>

Results show that the impact of loan sales on bank efficiency is positive in all specifications. The coefficients of loan sale ratios are all positive and significant (at least at the 5% level). A one-standard-deviation increase of loan sale ratios is associated with an increase of 7.22% and an average of 11.06% in the standard deviation of bank's efficiency scores estimated by OLS and Heckman self-selection models, respectively. All instruments in the first-step of Heckman self-selection models are all statistically significant, suggesting the instruments are all valid. Overall, the empirical results show a similar efficiency improving effect of loan sales.

5.5 Conclusion

This chapter empirically examines the impact of securitization on bank efficiency. The identification strategy applies a two-stage approach using U.S. large commercial bank data during 2002 to 2012. In the first step, a DEA model is employed to calculate bank efficiency scores, which are then regressed against securitization ratios and control variables in the second step. A positive and significant relationship between securitization ratio and bank's efficiency scores is identified.

To address the endogeneity problem in securitization, the identication analysis first employs a Heckman self-selection model by introducing three instruments, i) state-level corporate tax rate; ii) peer liquidity index; iii) state-level corporate tax rate × peer liquidity index; in both analyses. By using a Difference-in-Difference analysis, empirical results also support the main findings.

The additional analysis first examines the co-variations between securitization ratios and several bank-specific characteristics. Results show that securitization impacts more significantly on those banks with higher capital ratios, bank risks, and lower liquidity ratios. The second analysis examines the difference between mortgage and non-mortgage securitization. Mortgage loans are considered as safer compared with non-mortgage loans. Securitizing non-mortgage loans are likely to be a more efficient risk transferring, and thus more significantly impacts on bank’s efficiency. Empirical evidence supports this hypothesis. The final analysis examines the impact of loan sales, and results show a similar impact of loan sale ratios on bank’s efficiency scores.

Stringent capital regulation is implemented mainly to reduce bank risk and risk-taking incentives (Kahane, 1977), but bank efficiency can be decreased because of the financial restrictions. This chapter of research suggests that the rapid development of off-balance sheet activities, including securitization and loan sales, provides commercial banks with an alternative way to regain better efficiency. The results also suggest that simply employing the capital to asset ratio as the measurement of capital regulation is not sufficient, especially if the residual asset quality is not considered. Commercial banks can still take on more risk using securitization. In the presence of capital arbitrage, securitizers can become even riskier and less efficient when facing strict regulation on capital, increasing the likelihood of failure (Koehn and Santomero, 1980).

Table 5.1: Bank inputs and outputs

Table 5.1 reports the summary statistics of inputs and outputs used in the DEA model, in order to calculate bank efficiency scores. Three inputs are considered in the model, including: a) customer deposits and short-term funding; b) total costs, defined as the sum of interest expenses and non-interest expenses; and c) equity capital, to adequately account for the impact of risk (Berger, 2007). Three outputs include: a) loans; b) other earning assets; and c) non-interest income as a proxy for off-balance sheet activities. This table presents descriptive statistics for: (i) all sample banks (863), (ii) securitizers (banks with securitized loans) (141), and (iii) non-securitizers (banks without securitized loans) (722). Mean, Median, and SD stand for mean, median, and standard deviation values of the individual bank time-series observations, respectively. The last two columns report the comparison analysis of variables between securitizers and non-securitizers. Difference in means is calculated as the difference between securitizers' and non-securitizers' means in absolute (abs) values, with the p-values of the t-test on the equality of means reported in the last column.

Variable	All Banks			Securitizers			Non-securitizers			Difference in Means	
	mean	median	SD	mean	median	SD	mean	median	SD	(abs)	p-value
Inputs	($ billion)										
Customer deposits and short-term funding	12.76	1.68	70.52	72.64	11.10	186.65	4.22	1.50	11.84	68.42	0.00
Total costs	1.03	0.11	5.40	6.13	1.15	14.08	0.31	0.10	0.97	5.82	0.00
Equity capital	1.97	0.23	10.08	11.19	2.06	2.06	0.66	0.20	1.95	10.53	0.00
Outputs	($ billion)										
Loans	10.43	1.49	49.36	57.71	11.16	127.38	3.69	1.32	10.48	54.02	0.00
Other earning assets	16.72	2.03	92.95	96.10	17.34	246.06	5.41	1.82	15.06	90.70	0.00
Non-interest income	0.39	0.02	2.15	2.44	0.41	5.58	0.10	0.02	0.43	2.34	0.00

Table 5.2: Summary statistics

Table 5.2 shows the descriptive statistics of the dependent variable (bank efficiency scores), securitization ratios, and control variables used in the regression analysis. Following Bedendo and Bruno (2012) to include all domestic commercial banks with total assets of more than $1 billion over the time period, because banks smaller than $1 billion are rarely active securitizers (e.g., Minton et al., 2004; Martin-Oliver and Saurina, 2007). The statistics are based on the panel data of 863 banks, including 141 banks with securitized loans and 722 without, during the period of 2002 to 2012, accounting for a total of 5,275 bank-year observations. Variable definitions are provided in Appendix 5.A. Descriptive statistics of mean, median, and standard deviation are presented for securitizers and non-securitizers, respectively. The differences between securitizers and non-securitizers are also reported. Tests on means and medians use Student's t-test and Wilcoxon rank-sum, respectively. Letters of "a" and "b", in the last column, indicate a significant difference of means and medians at 1% level, respectively.

	Securitizers				Non-securitizers				Differences in means (i) and medians (ii)		
Variables	mean	median	SD	obs.	mean	median	SD	obs.	(i)	(ii)	t-test
Dependent variable											
Efficiency score	0.55	0.50	0.21	658	0.43	0.41	0.13	4,617	0.12	0.00	a, b
Securitization regressors											
Total securitization ratio%	13.74	0.14	37.56	658	-	-	-	-	-	-	-
Bank-specific control variables											
Total retained interest ratio%	7.08	0.00	17.03	658	-	-	-	-	-	-	-
Capital ratio%	11.23	9.60	5.61	658	10.60	9.55	5.61	4,617	0.63	0.00	a
Bank size	15.64	16.15	0.82	658	14.68	14.47	0.74	4,617	0.96	0.62	a
Diversification ratio%	0.44	0.34	0.31	658	0.19	0.16	0.16	4,617	0.25	0.05	a, b
Liquidity ratio%	20.86	19.23	12.29	658	21.59	19.89	12.56	4,617	-0.73	0.59	a, b
Non-interest expense ratio%	3.53	2.90	2.08	658	2.86	2.66	1.33	4,617	0.67	0.00	a, b
Non-performing loans ratio%	0.36	0.10	0.55	658	0.13	0.02	0.30	4,617	0.23	0.01	a, b
Local-market power	6.47	2.43	8.01	658	1.79	0.22	4.07	4,617	4.69	0.00	a

Table 5.3: Baseline framework, OLS estimation

This table presents the baseline results on the impact of loan securitization on bank efficiency scores, using OLS estimator. Both bank and year fixed effects are controlled in the regression. The sample period is 2002-2012. All control variables have been lagged for one year. T-statistics are based on robust standard errors clustered by banks, where *, **, *** denote statistical significance at the 10%, 5%, and 1% levels respectively. All variable definitions are presented in Appendix 5.A.

Dependent Variable	Bank efficiency scores
Total securitization ratio$_{t-1}$	0.080**
	(0.03)
Total retained interest ratio$_{t-1}$	0.045*
	(0.03)
Capital Ratio$_{t-1}$	-1.260***
	(0.24)
Bank size$_{t-1}$	-0.066
	(0.05)
Diversification ratio$_{t-1}$	2.876
	(1.83)
Bank liquidity ratio$_{t-1}$	0.045
	(0.05)
Non-interest expense ratio$_{t-1}$	0.015
	(0.02)
Non-performing loans ratio$_{t-1}$	0.036
	(1.08)
Local-market power$_{t-1}$	-0.137
	(0.14)
Constant	0.555***
	(0.03)
Bank fixed effects	Yes
Time Fixed Effect	Yes
Observations	4399
Adjusted-R^2	0.1838

Table 5.4: Heckman self-selection model

This table presents regression results on the impact of loan securitization on bank efficiency scores, using Heckman self-selection methods. The sample period is 2002-2012. Three instruments are introduced in Heckman model: 1) *state-level corporate tax rate*; 2) *peer liquidity index*; 3) *state-level corporate tax rate × peer liquidity index*. Main results are reported in Panel A, while the firs-step results of Heckman self-selection model are reported in Panel B. All control variables have been lagged for one year. T-statistics are based on robust standard errors clustered by banks, where *, **, *** denote statistical significance at the 10%, 5%, and 1% levels respectively. All variable definitions are presented in Table 5.A.

Panel A: Main Results

Dependent Variable

Instrument	(1) Tax Rate	(2) Peer Liquidity	(3) Interaction
Total securitization ratio$_{t-1}$	0.144***	0.151***	0.148***
	(0.02)	(0.02)	(0.02)
Total retained interest ratio$_{t-1}$	-0.264**	-0.233***	-0.245***
	(0.12)	(0.09)	(0.09)
Capital Ratio$_{t-1}$	-2.201***	-2.235***	-2.329***
	(0.19)	(0.18)	(0.19)
Bank size$_{t-1}$	-0.170**	-0.176***	-0.188***
	(0.07)	(0.06)	(0.07)
Diversification ratio$_{t-1}$	13.666*	11.821	12.215
	(8.10)	(7.92)	(8.11)
Bank liquidity ratio$_{t-1}$	-0.010	0.004	-0.008
	(0.08)	(0.08)	(0.08)
Non-interest expense ratio$_{t-1}$	0.053	0.072**	0.065**
	(0.03)	(0.03)	(0.03)
Non-performing loans ratio$_{t-1}$	-0.990	0.118	0.383
	(2.26)	(2.12)	(2.17)
Local-market power$_{t-1}$	-0.796***	-0.895***	-0.898***
	(0.24)	(0.19)	(0.19)
Constant	1.292***	1.270***	1.297***
	(0.11)	(0.07)	(0.07)
Inverse Mills Ratio	-0.277***	-0.273***	-0.279***
	(0.05)	(0.03)	(0.03)
Bank fixed effects	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes
Observations	4399	4399	4399
Adjusted-R^2	0.2401	0.2433	0.2182

Table 5.4: Heckman self-selection model

Panel B: First-step results of Heckman self-selection model

Dependent Variable	*Total securitization dummy*		
	(1)	(2)	(3)
Capital Ratio$_{t-1}$	-1.351*	-1.106*	-1.448**
	(0.79)	(0.54)	(0.56)
Bank size$_{t-1}$	0.695***	60.26***	60.26***
	(0.19)	(4.35)	(4.35)
Diversification ratio$_{t-1}$	-58.874	0.915***	0.879***
	(43.59)	(0.15)	(0.15)
Bank liquidity ratio$_{t-1}$	0.024	-0.276	-0.259
	(0.24)	(0.24)	(0.24)
Non-interest expense ratio$_{t-1}$	2.380***	12.50***	12.80***
	(0.68)	(1.97)	(1.98)
Non-performing loans ratio$_{t-1}$	20.096***	10.11	9.075
	(7.61)	(6.91)	(6.96)
Local-market power$_{t-1}$	6.461***	3.173***	3.271***
	(0.48)	(0.48)	(0.47)
Constant	-2.422***	-2.433***	-2.174***
	(0.17)	(0.12)	(0.11)
Bank fixed effects	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes
Observations	4399	4399	4399
Adjusted-R^2/Pseudo-R^2	0.2207	0.2425	0.2433

Table 5.5: Panel Heckman self-selection model

This table presents the regression results on the impact of loan securitization on bank efficiency scores, using the Chamberlain-Mundlak approach (Mundlak, 1978; Chamberlain, 1982). The sample period is 2002-2012. Inverse Mills ratios are calculated using three instruments: 1) *state-level corporate tax rate*; 2) *peer liquidity index*; 3) *state-level corporate tax rate × peer liquidity index*. To deal with the possible time series issue, all the control variables have been lagged for one year. T-statistics are based on robust standard errors clustered by banks, where *, **, *** denote statistical significance at the 10%, 5%, and 1% levels respectively. All variable definitions are presented in Appendix 5.A. The first-step results are reported in Appendix 5.C.

Dependent Variable	*Bank efficiency scores*		
Total securitization ratio$_{t-1}$	0.071**	0.090***	0.086***
	(0.03)	(0.03)	(0.03)
Total retained interest ratio$_{t-1}$	0.032	0.038	0.037
	(0.03)	(0.03)	(0.03)
Capital Ratio$_{t-1}$	-1.306***	-1.292***	-1.292***
	(0.26)	(0.26)	(0.26)
Bank size$_{t-1}$	-0.086*	-0.078*	-0.079*
	(0.05)	(0.04)	(0.04)
Diversification ratio$_{t-1}$	2.781	2.502	2.562
	(1.77)	(1.76)	(1.73)
Bank liquidity ratio$_{t-1}$	0.099***	0.075**	0.075**
	(0.04)	(0.04)	(0.04)
Non-interest expense ratio$_{t-1}$	0.026	0.019	0.018
	(0.02)	(0.01)	(0.01)
Non-performing loans ratio$_{t-1}$	-0.305	-0.678	-0.654
	(1.10)	(1.12)	(1.13)
Local-market power$_{t-1}$	-0.209	-0.331**	-0.321**
	(0.15)	(0.16)	(0.16)
Inverse Mills Ratio (State-level corporate tax rate)	-0.050***		
	(0.01)		
Inverse Mills Ratio (Peer liquidity index)		-0.018***	
		(0.01)	
Inverse Mills Ratio (State-level corporate tax rate × Peer liquidity index)			-0.079***
			(0.02)
Constant	0.771***	0.396**	0.948***
	(0.15)	(0.13)	(0.16)
Mean value of control variables	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes
Observations	4399	4399	4399
Adjusted R-squared	0.4257	0.4202	0.4299

Table 5.6: Propensity score matching estimation

Table 5.6 presents the results using propensity score matching (PSM) approach. Panel A shows the probit regression estimating of the propensity to securitize. The dependent variable is total securitization dummy which equals to one for banks with securitized assets, and zero otherwise. Panel B reports the propensity score matching estimates of the treatment effect of total securitization on banks' efficiency scores. Results show the balancing is good for all covariates (abs(bias)<5%). All explanatory variables are lagged one year. The reported standard errors are clustered at the bank level. *, **, *** stand for statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Determinants of Banks' Propensity Scores

Dependent Variable	*Total securitization dummy*
Capital Ratio	-2.693***
	(0.70)
Bank Size	56.51***
	(3.98)
Diversification Ratio	1.217***
	(0.13)
Liquidity Ratio	-0.298
	(0.22)
Non-Interest Expenses	10.66***
	(1.83)
Non-Performing Loans	15.61*
	(6.34)
Local Market Power	3.874***
	(0.44)
Constant	-10.86***
	(0.63)
Observations	5275
Likelihood	-1276.5704

Panel B: Treatment Effects

	Efficiency Scores		
	Treated	Controls	Difference (SD)
Average treatment effect on the treated	0.6007	0.5819	0.0189***
			(0.06)
Matched observations:	822		

Table 5.7: Difference-in-Difference analysis

The DiD framework used the bankruptcy filing of Lehman Brothers in 2008 as an exogenous shock (see Brunnermeier, Dong, and Palia, 2012 for similar practice). *Post-Lehman bankruptcy* dummy equals to one from the year 2008 onwards, and zero before 2008. Column (1) and (2) report the results using a subsample of matched securitizers with non-securitizers based on bank-specific variables and constrain the matching to the same year. Securitizers serve as the control group in the matched sample. The sample period is from 2002 to 2012. Column (3) and (4) report the results using a subsample including only securitizers. Banks with higher liquidity and potential to securitize loans are defined as the treatment group, while banks with lower liquidity and potential to securitize loans are the control group. The potential to securitize loans is measured by the liquidity index proposed by Loutskina (2011). *Top 10% securitizers* dummy is set to unity if a securitizer's liquidity index value is larger than 90% distribution of all securitizers, and zero otherwise, based on the value of 2005. Bank and year fixed effects are both included. *, **, *** denote statistical significance at the 10%, 5%, and 1% levels respectively. All variable definitions are presented in Appendix.

Dependent variable	*Bank efficiency scores*$_t$			
	(1)	(2)	(3)	(4)
Securitizer dummy$_t$ × *Post-Lehman bankruptcy dummy*$_t$	-0.011***	-0.015***		
	(0.00)	(0.00)		
Top 10% securitizers dummy$_t$ × *Post-Lehman bankruptcy dummy*$_t$			-0.006***	-0.007***
			(0.00)	(0.00)
Total retained interest ratio$_t$		0.055**		0.055**
		(0.02)		(0.02)
Capital Ratio$_t$		-1.699***		-1.703***
		(0.32)		(0.32)
Bank size$_t$		-0.095		-0.095
		(0.06)		(0.06)
Diversification ratio$_t$		7.367**		7.436**
		(3.56)		(3.55)
Bank liquidity ratio$_t$		0.196***		0.195***
		(0.06)		(0.06)
Non-interest expense ratio$_t$		0.030		0.031*
		(0.02)		(0.02)
Non-performing loans ratio$_t$		2.548*		2.546*
		(1.49)		(1.48)
Local-market power$_t$		-0.051		-0.056
		(0.19)		(0.19)
Constant	0.658***	0.714***	0.587***	0.714***
	(0.01)	(0.04)	(0.01)	(0.04)
Bank fixed effects	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes
Observations	2,174	2,174	1,087	1,087
Adjusted-R^2	0.2465	0.4294	0.1466	0.4310

Table 5.8: Co-variations between securitization ratios and bank-specific characteristics

Table 5.8 presents regression results on the relationship between cross products of *securitization ratios* and *capital ratio, LogZ, liquidity ratio*, and *diversification ratio*, and *bank efficiency scores*. The regression uses the interaction term to explore the possible mechanisms that securitization can impact on bank efficiency scores. Both bank and year fixed effects are controlled in all regressions. T-statistics are based on robust standard errors clustered by banks. *, **, *** denote statistical significance at the 10%, 5%, and 1% levels respectively. All variable definitions are presented in Appendix 5.A.

Dependent Variable	Bank efficiency scores			
	(1)	(2)	(3)	(4)
Total securitization ratio × Capital Ratio$_t$	0.147***			
	(0.05)			
Total securitization ratio × LogZ$_t$		-0.562***		
		(0.15)		
Total securitization ratio × Bank liquidity ratio$_t$			-1.280***	
			(0.26)	
Total securitization ratio × Diversification ratio$_t$				-0.335**
				(0.17)
Total securitization ratio$_t$	0.083***	0.099***	0.102***	0.082**
	(0.03)	(0.03)	(0.03)	(0.03)
Capital Ratio$_t$	-0.012***	-1.254***	-1.346***	-1.263***
	(0.00)	(0.25)	(0.24)	(0.25)
LogZ$_t$		0.009**		
		(0.00)		
Bank liquidity ratio$_t$	0.064*	0.037**	0.063***	0.045**
	(0.04)	(0.05)	(0.02)	(0.05)
Diversification ratio$_t$	0.309***	0.317***	0.314***	0.028***
	(0.04)	(0.04)	(0.04)	(0.01)
Total retained interest ratio$_t$	0.042	0.044*	0.044*	0.045*
	(0.03)	(0.03)	(0.03)	(0.03)
Bank size$_t$	-0.093**	-0.077	-0.074	-0.067
	(0.04)	(0.05)	(0.05)	(0.05)
Non-interest expense ratio$_t$	-0.424	-0.751*	-0.752	-0.784**
	(0.38)	(0.51)	(0.51)	(0.51)
Non-performing loans ratio$_t$	0.176	0.550*	0.625*	0.122
	(1.01)	(0.99)	(0.96)	(1.00)
Local-market power$_t$	-0.238	-0.274	-0.285	-0.251
	(0.18)	(0.18)	(0.18)	(0.19)
Constant	0.668***	0.819***	0.815***	0.758***
	(0.22)	(0.25)	(0.25)	(0.25)
Bank fixed effects	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes
Observations	4399	4399	4399	4399
Adjusted-R^2/Pseudo-R^2	0.1268	0.2671	0.2125	0.3770

Table 5.9: Mortgage and non-mortgage securitization estimation

Table 5.9 presents regression results on the impact of loan securitization on bank efficiency scores using both OLS and Heckman self-selection methods. The sample period is 2002-2012. Three instruments are introduced in Heckman model: 1) *state-level corporate tax rate*; 2) *peer liquidity index*; 3) *state-level corporate tax rate × peer liquidity index*. Results on mortgage securitization are reported in Panel A and non-mortgage securitization in Panel B. Only the second-step results are reported in Heckman model. The first-step results are reported in Appendix 5.D. To deal with the possible time series issue, all control variables have been lagged for one year. T-statistics are based on robust standard errors clustered by banks, where *, **, *** denote statistical significance at the 10%, 5%, and 1% levels respectively. All variable definitions are presented in Appendix.

Panel A: Mortgage securitization estimation

Dependent Variable	Bank efficiency scores			
	(1)	(2)	(3)	(4)
	OLS	Heckman self-selection		
Mortgage securitization ratio$_{t-1}$	-0.254	-0.007	-0.035	-0.025
	(0.06)	(0.09)	(0.07)	(0.07)
Mortgage retained interest ratio$_{t-1}$	-0.046*	-0.837***	-0.578***	-0.586***
	(0.03)	(0.23)	(0.13)	(0.14)
Capital Ratio$_{t-1}$	-1.224***	-2.085***	-1.842***	-2.034***
	(0.24)	(0.27)	(0.17)	(0.19)
Bank size$_{t-1}$	-0.065	-0.357***	-0.291***	-0.314***
	(0.05)	(0.10)	(0.07)	(0.07)
Diversification ratio$_{t-1}$	2.460	18.687	12.951	13.216
	(1.99)	(12.28)	(8.60)	(8.68)
Bank liquidity ratio$_{t-1}$	0.050	0.013	0.055	0.036
	(0.05)	(0.11)	(0.08)	(0.08)
Non-interest expense ratio$_{t-1}$	0.003	0.000	0.039	0.033
	(0.01)	(0.05)	(0.03)	(0.04)
Non-performing loans ratio$_{t-1}$	0.351	-1.426	4.464**	4.663**
	(1.05)	(3.80)	(2.23)	(2.25)
Local-market power$_{t-1}$	-0.145	-1.517***	-1.049***	-1.026***
	(0.15)	(0.40)	(0.20)	(0.20)
Constant	0.553***	1.646***	1.333***	1.369***
	(0.03)	(0.18)	(0.08)	(0.08)
Inverse Mills Ratio 1		0.257***		
		(0.05)		
Inverse Mills Ratio 2			2.291***	
			(0.18)	
Inverse Mills Ratio 3				0.536***
				(0.04)
Bank fixed effects	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes
Observations	4,399	4,399	4,399	4,399
Adjusted-R^2/Pseudo-R^2	0.2075	0.3633	0.3736	0.3425

Note: Inverse Mills Ratio 1, 2, and 3 are estimated using the instrument of state-level corporate tax rate, peer liquidity index, and *State-level corporate tax rate × Peer liquidity index*, respectively.

Table 5.9: Mortgage and non-mortgage securitization estimation

Panel B: Non-mortgage securitization

Dependent Variable	*Bank efficiency scores*			
	(1)	(2)	(3)	(4)
	OLS	Heckman model		
Non-mortgage securitization ratio$_{t-1}$	0.110***	0.156***	0.166***	0.161***
	(0.03)	(0.02)	(0.02)	(0.02)
Non-mortgage retained interest ratio$_{t-1}$	0.009**	-0.004	-0.008	-0.010
	(0.00)	(0.02)	(0.02)	(0.02)
Capital Ratio$_{t-1}$	-1.268***	-2.258***	-2.340***	-2.435***
	(0.25)	(0.18)	(0.17)	(0.18)
Bank size$_{t-1}$	-0.069	-0.103	-0.124**	-0.136**
	(0.05)	(0.06)	(0.06)	(0.06)
Diversification ratio$_{t-1}$	2.791	12.366*	10.873	11.149
	(1.87)	(7.51)	(7.60)	(7.66)
Bank liquidity ratio$_{t-1}$	0.043	0.025	0.030	0.019
	(0.05)	(0.07)	(0.07)	(0.07)
Non-interest expense ratio$_{t-1}$	0.012	0.075**	0.087***	0.081***
	(0.01)	(0.03)	(0.03)	(0.03)
Non-performing loans ratio$_{t-1}$	0.121	-2.219	-0.984	-0.657
	(1.08)	(2.14)	(2.05)	(2.07)
Local-market power$_{t-1}$	-0.131	-0.683***	-0.854***	-0.834***
	(0.14)	(0.19)	(0.17)	(0.17)
Constant	0.558***	1.225***	1.245***	1.264***
	(0.03)	(0.08)	(0.06)	(0.06)
Inverse Mills Ratio 1		0.137***		
		(0.05)		
Inverse Mills Ratio 2			2.014***	
			(0.19)	
Inverse Mills Ratio 3				0.473***
				(0.04)
Bank fixed effects	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes
Observations	4,399	4,399	4,399	4,399
Adjusted-R^2/Pseudo-R^2	0.2155	0.2252	0.2821	0.2143

Note: Inverse Mills Ratio 1, 2, and 3 are estimated using the instrument of state-level corporate tax rate, peer liquidity index, and *State-level corporate tax rate × Peer liquidity index, respectively.*

Table 5.10: Loan sales estimation

This table presents regression results on the impact of loan securitization on bank efficiency scores. using both OLS and Heckman self-selection methods. The sample period is 2002-2012. Three instruments are introduced in Heckman model: 1) *state-level corporate tax rate*; 2) *peer liquidity index*; 3) *state-level corporate tax rate × peer liquidity index*. The first and second step results are reported in the left and right columns within the instrument groups, respectively. To deal with the possible time series issue, all control variables have been lagged for one year. T-statistics are based on robust standard errors clustered by banks, where *, **, *** denote statistical significance at the 10%, 5%, and 1% levels respectively. All variable definitions are presented in Appendix.

Dependent Variable	Bank efficiency scores						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	OLS	Heckman self-selection					
		1st step	2nd step	1st step	2nd step	1st step	2nd step
Total securitization ratio$_{t-1}$	0.022*		0.030**		0.037***		0.034***
	(0.01)		(0.01)		(0.01)		(0.01)
Capital Ratio$_{t-1}$	-0.656***	-0.537	-1.338***	0.747	-1.417***	-0.266	-1.496***
	(0.14)	(0.63)	(0.21)	(0.49)	(0.18)	(0.56)	(0.18)
Bank size$_{t-1}$	-0.051	0.687***	-0.252***	0.486***	-0.264***	0.515***	-0.268***
	(0.05)	(0.18)	(0.08)	(0.18)	(0.07)	(0.18)	(0.06)
Diversification ratio$_{t-1}$	2.984	-51.299	15.570	-52.299	12.463	-48.523	12.186
	(1.84)	(42.56)	(9.65)	(42.60)	(8.73)	(42.63)	(8.16)
Bank liquidity ratio$_{t-1}$	0.086	0.119	0.017	0.327	0.034	0.304	0.030
	(0.05)	(0.23)	(0.09)	(0.23)	(0.08)	(0.23)	(0.08)
Non-interest expense ratio$_{t-1}$	0.011	3.144***	0.037	-3.919***	0.053	-3.186***	0.051
	(0.02)	(0.75)	(0.04)	(0.41)	(0.04)	(0.37)	(0.03)
Non-performing loans ratio$_{t-1}$	-0.369	38.289***	-1.011	44.114***	2.525	42.788***	3.227
	(0.95)	(6.87)	(3.13)	(6.39)	(2.28)	(6.45)	(2.13)
Local-market power$_{t-1}$	-0.129	6.674***	-1.113***	4.093***	-1.156***	4.784***	-0.979***
	(0.15)	(0.46)	(0.33)	(0.51)	(0.21)	(0.50)	(0.19)
Constant	0.471***	-2.561***	1.333***	-2.522***	1.278***	-2.263***	1.243***
	(0.03)	(0.16)	(0.14)	(0.11)	(0.08)	(0.11)	(0.07)
State-level corporate tax rate		0.259***					
		(0.05)					
Peer liquidity index				2.318***			
				(0.18)			
Corporate tax rate × Peer liquidity index						0.540***	
						(0.04)	
Inverse Mills Ratio			-0.321***		-0.303***		-0.279***
			(0.06)		(0.03)		(0.03)
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4399	4399	4399	4399	4399	4399	4399
Adjusted-R² /Pseudo-R²	0.3051	0.3129	0.3773	0.3704	0.3705	0.3176	0.3696

Chapter 6
Results Review and Conclusions

6.1 Review results on the impact of securitization on bank risk: A short- and long-term explanation

Ambiguous results exist in securitization literature. While classic theories suggest securitzation is likely to lead to a risk reduction effect, some recent studies report that banks can take on more risk through securitization. The empirical results from chapter 3 and 4 provide a possible explanation. Results of chapter 3 report that bank securitization leads to bank risk decrease effect, while empirical evidence from chapter 4 finds a bank failure increase effect. This disparate can be explained by a short-term risk reduction and long-term bank failure increase effect.

6.1.1 Short- and long-term effect

Regarding to short-term effect, the focus of analysis is the potential impact of securitization on bank risk *of structuring and operating this transaction action until the objectives are met*[14]. It can be interpreted as follows: short-term effect is usually accompanied with a predefined target of the executor, and outcome can be evaluated right after the action.

The traditional "hold-to-maturity" banking model determines that commercial banks could face liquidity shortage. Loan securitization modifies the functioning of banks from a traditional "hold-to-maturity" to an "originate-to-distribute" model, which in turn increases bank's liquidity, and decreases the cost of capital (Pennacchi, 1988). Meanwhile, commercial banks can also shed off the undesirable risk they do not wish to bear and transfer the credit risk to security investors. All the benefits above are the pre-set goals to be accomplished after securitization, which are also their prior concerns during the transaction.

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[14] This is not a direct definition in finance, but it is a similar statement in the field of social science (e.g., refers to the report of U.S. Department of Energy in August 1997, reference DOE/EH-413/9708.

However, the risk reduction effect is more likely to be a short-term benefit that may not be able to retain for a long time after the securitization transaction is terminated. Issuers could choose to use the benefits acquired from securitization to invest in other riskier fields. With the possibility to transfer or share risk, they could be much more aggressive in risk taking, which would possibly increase bank risk in the long run. The greater risk-taking capacity leads to an increased demand for new assets to fill the expanding balance sheets and an increase in leverage. As shown in Shin (2009), banks would search for borrowers that they can do. However, when they have exhausted all good borrowers, they need to scour for other borrowers who even could be worse ones. Thus, the seeds of the subsequent downturn in the credit cycle are sown, and they will lead to real risk with time flowing. Maddaloni and Peydro (2011) argue that securitization may be a crucial factor that softening the short-term policy, which leads to higher possibility of risk-taking behaviour for commercial banks.

Meanwhile, some banks are becoming more and more mere originators of loans and distributors of their risk (Martin-Oliver and Saurina, 2007). They anxiously pursue the short-term benefits of securitization and sometimes grant loans in the aim of securitizing them out: the loans are packaged into a bundle of other mortgages, given a risk assessment by rating agency and sold out. Therefore, securitization could introduce in more potential problems into the banking system, which in turn increases the long-term risk of banks.

Similarly, the focus of the analysis of long-term effect is the *risk remaining on the site after the action has been taken, or to say, the residual risk*. It can be translated as long-term effect considers the ignored potential risk or uncertainty in a particular action. Therefore, higher level of ignorance of the potential risk and uncertainty is related to higher possibility of long-term risk. In the case of securitization, the likelihood of bank failure increase effect could indicate a long-term impact on bank risk.

Securitization is associated with information inequality between originators and security buyers. Hiding either hard or soft information from the originators on the quality of underlying loans introduces in higher uncertainty in the transaction. This information asymmetry is not likely to be solved by the market within a short period. For example, hiding soft information makes it possible for issuers to securitize the worse assets as the good ones to outside investors. It means that, within a short time period, this action, in fact, decreases bank risk. Although in the long run, this effect will introduce in more risk to the system and eventually positively impact on individual bank risk, it will not be aware of by the public shortly. Issuers could also choose to hide hard information to securitize better assets in order to retain their lending ability with good ratings (the regulatory arbitrage theory). In this case, the residual portfolio risk could be worse because of the “illusion of risk transferring”, but this situation could be only known by the public for the following periods when new ratings coming. Several studies provide empirical evidence to support this argument. For example, Demyanyk and Hemert (2011) argue that problems in the subprime mortgage market in 2007-09 financial crisis are apparent before the actual crisis erupted in 2007, at least by the end of 2005. In fact, loan quality had been worsening for almost five year in a row at that point according to their research, but investors are only able to aware of it after 2007. However, the problem is only aware of by the public and authorities after 2007 when the financial crisis broke out.

The information asymmetry encourages securitized banks to act recklessly, which in turn decreases incentives of originators to carefully screen borrowers and monitor loans. Parlour and Plantin (2008) argue that even without actual securitization, or to say risk sharing, issuers are still greatly discouraged from effective monitoring. In this case, the potential risk which banks assume to securitize out stays inside. With the potential risk accumulating, the stability of the banking system decreases which in turn increases the likelihood of bank failure. A best example is the collapse in 2007 to 2008 of overnight wholesale market. It is widely agreed in academia that the securitization of mortgage loans played a key role in the subprime lending crisis (Kashyap et al., 2008; Brunnermeier, 2009).

Securitization could also soften the standard of regulation. Loutskina (2011) argues that securitization can even weaken the ability of the monetary authority to affect banks' lending activity. As security market, such as mortgage market, is not a “perfect” one (Gerardi, Rosen and Willen, 2010), regulations from authorities are very important for both issuers and investors. Therefore, all the types of impact of securitization above are related to the definition of long-term effect.

6.1.2 The link between short- and long-term impact of securitization

It is notable that there is a link between short- and long-term impact of loan securitization on bank risk. Anxiously pursuing the short-term benefits of securitization makes the issuers to ignore the possible uncertainty and potential risk, and even lack of incentive to carefully screen borrowers and monitor the loans. Issuers have the belief that all the potential risk can be shared through securitization transaction. In practice, securitization gathers different institutions and hundreds of thousands of investors, which in turn provides an illusion that: the higher the level of risk is diversified, the lower the possibility of bank risk. However, as the residual risk accumulated, bank failure occurs, and even the banking system collapses.

Securitization may also increase systemic risk even if banks’ individual risk does not increase by shedding idiosyncratic exposures. Nijskens and Wagner (2011) argue that the idiosyncratic share in a bank’s risk can be lowered if banks chose to hedge the potential undiversified exposures by buying protection, while simultaneously buying other credit risk by selling protection. In this case, banks may end up being more correlated with each other, which may amplify the risk of systemic crisis in the financial system (Elsinger et al., 2006; Acharya and Yorulmazer, 2007; Wagner, 2008) since it increases the likelihood that banks incur losses jointly (a situation experienced in the current crisis).

Results in Chapter 3 and 4 suggest a short-term risk reduction and long-term bank failure increase effect. The explanations are as follows. Securitization creates a more efficient risk sharing through diversification. The pooling and traching of securitization create low-risk and highly liquid securities to attract investors (DeMarzo, 2005). Securitizers thus may easily shift their credit-risk exposures to the counter parties through true sales (Humphreys and Kreistman

1995; Kramer 2003). In practice, some risk can also be transferred out of the banking system through securitization, for example to hedge funds and equity investors, creating an even larger number of investors to share the potential risk. Thus, securitization could reduce bank risk by substituting large potential exposures to direct borrowers with smaller and more diversified exposures and smoothing out the risks among many investors (Duffie, 2007).

In the long run, however, securitizers may decrease their efforts on screening borrowers, lower borrowing standards, and grant more poor-quality loans considering the potential risk can be easily transferred to the investors (Hakenes and Schnabel, 2010). The reckless behaviour links securitizers with aggressive risk taking and greater retentions of risky assets (Acharya and Johnson, 2007). The increased risk on the balance sheet may also increase their cost of financing. In response, securitizers may choose to securitize better assets rather than risky assets (Acharya, Schnabl, and Suarez, 2013), and left with insufficient capital buffer to survive a severe event (Berger and Bouwman, 2013). The development of complex structured credit products makes it more difficult for most investors and rating agencies to analyse the potential risks and fair values of securitized assets (Griffin and Tang, 2009). Thus, the potential risk increase is not likely to be recognized within a short period. When the diversification mechanism of securitization is not able to cover the losses, a majority bank failure could breakout (Wagner, 2010).

6.1.3 Contribution

These results provide direct empirical evidence on the impact of securitization on bank risk. Previous studies on securitization and bank risk pay more attentions on the theoretical basis, providing both risk reduction (Benveniste and Berger, 1987; Pennacchi, 1988) and risk increase theories (Kobayashi and Osano, 2012; van Oordt, 2014). Empirical examinations of securitization provide evidence with the impact on bank performance (Guner, 2006; Casu et al., 2012), or specific on the impact of CMBS (Titman and Tsyplakov, 2010; An, Deng, and Gabriel, 2011), CLOs (Benmelech, Dlugosz, and Ivashina, 2012), subprime mortgage loans (Keys, Seru, and Vig, 2012), and asset-backed commercial papers

(Acharya, Schnabl, and Suarez, 2013) on bank performance and managerial efforts.

To author's best knowledge, there is no direct empirical evidence to test the impact of the involvement of securitization on bank risk. Thus, this study reconciles the conflicts of theories and find a short-term risk reduction and long-term bank failure increase effect of securitization. Part of the bank failure increase arguments is related to the rapid development of complex structured credit products. Higher complexity of securitization makes investors and rating agencies more difficult to analyse the potential risks and fair values (Griffin and Tang, 2009). Securitizers can in turn take advantage of the private information to take on more risk and decrease their monitoring efforts. Recent literature show higher complexity in securitization transactions can significantly decrease loan performance (Furfine, 2015) and increase default rates (Ghent, Torous, and Valkanov, 2014). This study adds more evidence to this group of studies by providing a positive association between a higher complexity of securitization and the likelihood of failure.

This research also extends the understanding of the impact of securitization on bank behaviour. Previous literature finds that securitization leads to a decreased cost of capital (Berger, Herring, and Szego, 1995; Carlstrom and Samolyk, 1995; Duffee and Zhou, 2001; Nicolo and Pelizzon, 2008; Nadauld and Weisbach, 2012), a higher level of diversification (Allen and Carletti, 2006; Rossi, Schwaiger, and Winkler, 2009), and a higher level of liquidity (Loutskina, 2011; Casu et al., 2013). Thus, securitization is beneficial to securitizers because it relieves underinvestment problems (Lockwood, Rutherford, and Herrera, 1996) and increases profitability (Schliephake and Kirstein, 2013). However, securitization may also encourage banks to take advantage of the asymmetric information and decrease managerial efforts (Parlour and Plantin, 2008; Maddaloni and Peydro, 2011; Ahn and Breton, 2014; Wang and Xia, 2014). Thus, securitization can also undermine the loan quality in the market (Jones, 2000; Berndt and Gupta, 2009; Mian and Sufi, 2009; Purnanandam, 2011; Rosch and Scheule, 2012; Carbo-Valverde, Marques-Ibanez, Rodriguez-Fernandez, 2012). This research provides a link between the disparate behaviours.

Finally, the empirical results may shed some light on the ongoing discussion of the role of securitization in changing the banking models and contributing to the 2007-09 global financial crisis. The implication of the results on the different impact of securitization on bank risk in the short and long term may suggest that the examination of bank risk should not only be focused on balance sheet ratios but also on the managerial system.

6.2 Recent development

Studies and practice on securitization have experienced a good period after the 2007-09 financial crisis. After the research on the impact of securitization on the banking system, the attention nowadays has been moved to the mechanism. The main mechanism has been identified by the literature is the contagion effect which caused by the interconnection among financial institutions. This connection leads to the commonality of asset holdings of different banks (Wagner, 2010) and increases the likelihood of banks to respond to external shocks in similar patterns (Cai, Saunders, and Steffen, 2015). When the magnitude of the external shock exceeding a certain threshold, the internal linkage among institutions triggers the contagion effects.

Another strand of research focuses on the so-called macro-prudential framework to address or prevent similar crisis to happen again. For example, Brunnermeier and Sannikov’s (2017) model studies the equilibrium dynamics of an economy with financial frictions and argue that macro-prudential policies will increase the stability of the financial system.

Appendices

Appendix 1-A: Variable definition

Variable	Definition
Dependent variable	
Z-score	Z-score is banks' distance to insolvency, which equals to the return on assets plus the capital asset ratio divided by the standard deviation of asset returns.
Independent variables	
Total Securitization Ratio	The outstanding principal balance of toal amount of assets securitized over total assets.
Mortgage Securitization Ratio	The outstanding principal balance of total amount of mortgage assets securitized over total assets.
Non-Mortgage Securitization Ratio	The outstanding principal balance of total amount of non-mortgage assets securitized over total assets.
Total Retained Interests Ratio	The total dollar amount of credit exposure from all retained interest only strips, all other credit enhancements, unused commitments to provide liquidity to asset securitized, and ownership (or sellers) interests carried as securities or loans on related assets, divided by the total of all securitized assets.
Mortgage Retained Interests Ratio	The total dollar amount of credit exposure from all retained interest only strips, all other credit enhancements, unused commitments to provide liquidity to asset securitized, and ownership (or sellers) interests carried as securities or loans on related assets, divided by the total of all securitized mortgage assets.
Non-Mortgage Retained Interests Ratio	The total dollar amount of credit exposure from all retained interest only strips, all other credit enhancements, unused commitments to provide liquidity to asset securitized, and ownership (or sellers) interests carried as securities or loans on related assets, divided by the total of all securitized non-mortgage assets.
Bank Size	The natural logarithm of total assets.
Diversification Ratio	Noninterest income divided by total operation income.
Liquidity Ratio	Liquid assets divided by total assets.
Non-Interests Expenses Ratio	Noninterest expense divided by total assets.
Non-Performing Loans Ratio	Loans past due 90 days divided by total assets.
Local-Market Power	The sum of the squares of each portfolio in every bank.
Bank Holding Company Dummy	Bank holding company dummy equals to one if the bank belongs to a bank holding company, and zero otherwise.
Metropolitan Statistical Area Dummy	Metropolitan statistical area dummy equals to one if the bank locates in metropolitan area, and zero otherwise.
Instruments	
Peer Liquidity Index	Peer liquidity index is the average of liquidity indexes of a bank's peers. Liquidity index is proposed by Loutskina (2011) to effectively capture banks' potential ability to securitize loans.
State-level corporate tax rate	State level corporate tax rate
Peer Liquidity Index × State-level Corporate Tax Rate	The cross product of peer liquidity index and state-level corporate tax rate.

Appendix 1.B: Correlation matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1)	1.0000										
(2)	0.0205***	1.0000									
(3)	0.0116***	0.1838***	1.0000								
(4)	-0.0661***	0.0736***	0.0954***	1.0000							
(5)	0.0768***	0.2032***	0.1332***	0.2721***	1						
(6)	0.0617***	-0.0068	-0.0043	-0.0538***	0.0741***	1					
(7)	0.0101**	0.1629***	0.0583***	-0.1337***	0.5157***	-0.0929***	1				
(8)	-0.031**	0.0649***	0.0410***	-0.0486***	0.0242***	-0.0573***	0.0702***	1			
(9)	-0.0011***	0.0472***	0.0641***	0.2172***	0.1844***	0.0737***	-0.0169***	0.0328***	1		
(10)	-0.0638***	-0.0408***	-0.0041	0.1920***	0.0584***	0.0131***	-0.1042***	-0.0180***	0.0257***	1	
(11)	-0.0246***	0.0235***	0.0302***	0.2723***	0.0982***	-0.1124***	0.0807***	-0.0383***	-0.0268***	-0.0337***	1

Note: Variables are numbered as follows: (1) *Z-score*, (2) *Total securitization ratio*; (3) *Total retained interests*; (4) *Bank size*; (5) *Diversification ratio*; (6) *Liquidity ratio*; (7) *Non-interests expense ratio*; (8) *Non-performing loans ratio*; (9) *Local-market power index*; (10) *BHC dummy*; (11) *MSA dummy*.

Appendix 1.C: All first-step results

Appendix 3.C shows all first-step results of Heckman and 2SLS regressions. Results on securitization activities using Heckman and 2SLS regressions are reported in Panel A and B, respectively. First-step results of Heckman regression on loan sales, mortgage, and non-mortgage securitizations are reported in Panel C, D, and E, respectively. Instrumental variables include: 1) *state-level corporate tax rate*; 2) *peer liquidity index*; and, 3) *state-level corporate tax rate × peer liquidity index*. Bank characteristics include *bank size, diversification ratio, liquidity ratio, non-interest expense ratio, non-performing loans ratio, local-market power index, bank holding company dummy* and *metropolitan statistical area dummy*. All variable definitions are provided in Appendix 3.A.

Panel A: First-step results of Heckman self-selection model on securitization

Dependent Variable	Securitization Ratio								
	full sample			before 2007			after 2007		
Bank size	0.352***	0.331***	0.346***	0.428***	0.410***	0.418***	0.275***	0.254***	0.696***
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.21)
Diversification ratio%	0.082	0.196*	0.152*	0.172*	-0.039	-0.025	0.279**	0.404***	0.011*
	(0.10)	(0.10)	(0.10)	(0.17)	(0.17)	(0.17)	(0.13)	(0.13)	(0.01)
Bank liquidity ratio%	-3.839	-3.399	-3.621	-3.431	-2.802	-2.863	-4.275	-4.023	-0.073
	(9.70)	(9.33)	(9.68)	(13.18)	(12.77)	(13.30)	(14.41)	(13.53)	(0.05)
Non-interest expense ratio%	1.005***	0.786***	1.003***	1.136***	0.918***	1.137***	0.907***	0.668***	0.874**
	(0.13)	(0.10)	(0.13)	(0.17)	(0.13)	(0.17)	(0.19)	(0.17)	(0.50)
Non-performing loans ratio%	3.325***	3.533***	3.299***	22.301***	26.834***	23.695***	3.528***	3.702***	2.579**
	(0.71)	(0.71)	(0.71)	(5.06)	(5.15)	(5.13)	(0.74)	(0.73)	(1.32)
Local-market power	0.004	0.186	0.119	0.176	0.501*	0.326	-0.229	-0.124	0.019
	(0.16)	(0.16)	(0.16)	(0.28)	(0.26)	(0.27)	(0.21)	(0.21)	(0.02)
Bank holding company dummy	-0.038	-0.025	-0.038	-0.135*	-0.147**	-0.136*	0.043	0.066	-0.012***
	(0.04)	(0.04)	(0.04)	(0.07)	(0.07)	(0.07)	(0.06)	(0.05)	(0.01)
Metropolitan statistical area dummy	-0.014	-0.060*	-0.021	-0.079	-0.120**	-0.091	0.023	-0.013	-0.003*
	(0.03)	(0.03)	(0.03)	(0.06)	(0.06)	(0.06)	(0.04)	(0.04)	(0.00)
State-level corporate tax rate	0.206***			0.009***			0.004***		
	(0.10)			(0.00)			(0.00)		
Peer liquidity index		0.023***			0.023**			0.022***	
		(0.01)			(0.01)			(0.01)	
State-level corporate tax rate × Peer liquidity index			0.001***			0.001***			0.001***
			(0.00)			(0.00)			(0.00)
Constant	-6.832***	-6.521***	-6.748***	-7.883***	-5.816***	-7.705***	-7.513***	-5.576***	-5.799***
	(0.13)	(0.12)	(0.13)	(0.23)	(0.17)	(0.22)	(0.21)	(0.16)	(0.17)
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	69,258	69,258	69,258	29,638	29,638	29,638	39,620	39,620	39,620
Pseudo-R^2	0.3587	0.3227	0.4487	0.4514	0.3959	0.2434	0.3436	0.3902	0.2632

Appendix 1.C: All first-step results

Panel B: First-step results of 2SLS model on securitization

Dependent Variable	Securitization Ratio								
	full sample			before 2007			after 2007		
Bank size	0.462***	0.484***	0.462***	0.693***	0.770***	0.696***	0.331***	0.336***	0.332***
	(0.12)	(0.13)	(0.12)	(0.21)	(0.24)	(0.21)	(0.10)	(0.10)	(0.10)
Diversification ratio%	0.013**	0.015**	0.008*	0.019**	0.010***	0.011*	0.005***	0.005***	0.010
	(0.01)	(0.01)	(0.01)	(0.01)	(0.08)	(0.01)	(0.00)	(0.01)	(0.01)
Bank liquidity ratio%	-0.042	-0.049*	-0.043	-0.067	-0.029*	-0.073	-0.008	-0.007	-0.086
	(0.03)	(0.03)	(0.03)	(0.05)	(0.01)	(0.05)	(0.01)	(0.01)	(0.08)
Non-interest expense ratio%	0.449	0.241**	0.447	0.869*	0.387**	0.874**	-0.086	-0.084	0.238
	(0.32)	(0.14)	(0.31)	(0.50)	(0.22)	(0.50)	(0.08)	(0.08)	(0.19)
Non-performing loans ratio%	0.112**	0.117*	0.113**	2.520**	2.646**	2.579**	0.238	0.126	0.105**
	(0.06)	(0.06)	(0.06)	(1.31)	(1.36)	(1.32)	(0.19)	(0.08)	(0.05)
Local-market power	0.010	0.029	0.013	0.013	0.059	0.019	0.104*	0.107**	0.011
	(0.02)	(0.02)	(0.02)	(0.02)	(0.04)	(0.02)	(0.05)	(0.05)	(0.01)
Bank holding company dummy	-0.010***	-0.010***	-0.010***	-0.012***	-0.014***	-0.012***	0.006	-0.006	-0.010**
	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)
Metropolitan statistical area dummy	-0.002	-0.002**	0.003**	0.002***	0.003**	-0.003*	0.007**	0.002**	-0.002
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)
State-level corporate tax rate	0.236***			0.008***			0.009**		
	(0.07)			(0.00)			(0.00)		
Peer liquidity index		0.171**			0.023***			0.035**	
		(0.16)			(0.03)			(0.01)	
State-level corporate tax rate × Peer liquidity index			0.025***			-0.101***			-0.063***
			(0.01)			(0.03)			(0.02)
Constant	-0.097***	-0.076***	-0.091***	-0.122***	-0.077***	-0.653***	-0.067***	-0.053***	-0.107**
	(0.03)	(0.02)	(0.03)	(0.04)	(0.02)	(0.24)	(0.02)	(0.01)	(0.05)
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	69,258	69,258	69,258	29,638	29,638	29,638	39,620	39,620	39,620
Adjusted-R^2	0.2900	0.2689	0.2895	0.1491	0.2720	0.2473	0.2013	0.2623	0.2718

Appendix 1.C: All first-step results

Panel C: First-step results of Heckman self-selection model on loan sales

Dependent Variable	Loan Sales Dummy								
	full sample			before 2007			after 2007		
Bank size	0.315***	0.281***	0.304***	0.319***	0.288***	0.303***	0.278***	0.243***	0.271***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Diversification ratio%	-0.183***	-0.030	-0.072	-0.185**	-0.062	-0.045	-0.110	0.056	-0.021
	(0.06)	(0.06)	(0.06)	(0.09)	(0.09)	(0.09)	(0.07)	(0.07)	(0.07)
Bank liquidity ratio%	2.913	2.815	2.913	1.511	2.541	2.610	3.827	2.797	3.119
	(6.25)	(5.95)	(6.18)	(8.48)	(8.41)	(8.65)	(9.44)	(8.62)	(9.14)
Non-interest expense ratio%	0.665***	0.387***	0.668***	0.656***	0.469***	0.667***	0.583***	0.190	0.585***
	(0.13)	(0.11)	(0.13)	(0.17)	(0.13)	(0.17)	(0.20)	(0.20)	(0.20)
Non-performing loans ratio%	3.314***	4.036***	3.364***	79.146***	101.047***	86.513***	2.372***	2.911***	2.375***
	(0.98)	(1.00)	(0.99)	(15.29)	(16.14)	(15.64)	(0.91)	(0.94)	(0.91)
Local-market power	-0.479***	-0.397***	-0.368***	-0.219	-0.087	-0.079	-0.762***	-0.708***	-0.674***
	(0.09)	(0.09)	(0.09)	(0.15)	(0.15)	(0.15)	(0.12)	(0.12)	(0.12)
Bank holding company dummy	0.386***	0.414***	0.391***	0.253***	0.270***	0.259***	0.493***	0.525***	0.497***
	(0.02)	(0.02)	(0.02)	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)
Metropolitan statistical area dummy	-0.042***	-0.090***	-0.053***	-0.036	-0.077***	-0.048*	-0.029	-0.073***	-0.038**
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
State-level corporate tax rate	0.007***			0.010***			0.005***		
	(0.00)			(0.00)			(0.00)		
Peer liquidity index		0.027***			0.026***			0.025***	
		(0.00)			(0.00)			(0.00)	
State-level corporate tax rate × Peer liquidity index			0.001***			0.001***			0.001***
			(0.00)			(0.00)			(0.00)
Constant	-5.670***	-5.209***	-5.515***	-5.908***	-5.364***	-5.638***	-5.139***	-4.714***	-5.036***
	(0.08)	(0.07)	(0.07)	(0.12)	(0.12)	(0.12)	(0.10)	(0.09)	(0.10)
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	69,258	69,258	69,258	29,638	29,638	29,638	39,620	39,620	39,620
Pseudo-R^2	0.3506	0.3173	0.3621	0.3306	0.3076	0.3521	0.3680	0.3449	0.3063

Appendix 1.C: All first-step results

Panel D: First-step results of Heckman self-selection model on mortgage securitization

Dependent Variable	Mortgage Securitization Dummy								
	full sample			before 2007			after 2007		
Bank size	0.242***	0.218***	0.235***	0.250***	0.234***	0.240***	0.233***	0.201***	0.228***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Diversification ratio%	0.026	0.172**	0.121	0.037	0.136	0.142	0.030	0.216*	0.120
	(0.08)	(0.09)	(0.08)	(0.13)	(0.13)	(0.13)	(0.11)	(0.12)	(0.11)
Bank liquidity ratio%	-4.037	-3.569	-3.879	-5.093	-4.167	-4.478	-3.001	-2.980	-3.287
	(7.49)	(7.17)	(7.44)	(9.39)	(9.28)	(9.44)	(12.63)	(11.50)	(12.25)
Non-interest expense ratio%	0.137	-0.126	0.144	-1.139	-1.194	-1.062	0.430*	0.168	0.436*
	(0.27)	(0.30)	(0.27)	(0.85)	(0.84)	(0.84)	(0.26)	(0.28)	(0.26)
Non-performing loans ratio%	1.601***	1.865***	1.593***	1.928	3.044*	2.128	1.634***	1.931***	1.603***
	(0.48)	(0.49)	(0.47)	(1.60)	(1.66)	(1.60)	(0.51)	(0.52)	(0.50)
Local-market power	-0.256*	-0.189	-0.156	-0.124	-0.038	-0.005	-0.373**	-0.313*	-0.277
	(0.14)	(0.14)	(0.14)	(0.21)	(0.21)	(0.21)	(0.19)	(0.19)	(0.19)
Bank holding company dummy	0.129***	0.152***	0.132***	0.101**	0.115**	0.105**	0.153***	0.184***	0.155***
	(0.03)	(0.03)	(0.03)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Metropolitan statistical area dummy	0.115***	0.072***	0.108***	0.084**	0.045	0.071*	0.144***	0.097***	0.139***
	(0.02)	(0.02)	(0.02)	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)
State-level corporate tax rate	0.005***			0.008***			0.005***		
	(0.00)			(0.00)			(0.00)		
Peer liquidity index		0.025***			0.020***			0.028***	
		(0.00)			(0.01)			(0.01)	
State-level corporate tax rate × Peer liquidity index			0.001***			0.001***			0.001***
			(0.00)			(0.00)			(0.00)
Constant	-5.333***	-5.012***	-5.240***	-5.444***	-5.119***	-5.260***	-5.228***	-4.854***	-5.177***
	(0.10)	(0.10)	(0.10)	(0.15)	(0.15)	(0.15)	(0.15)	(0.14)	(0.14)
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	69,258	69,258	69,258	29,638	29,638	29,638	39,620	39,620	39,620
Pseudo-R^2	0.2350	0.2744	0.2612	0.2233	0.2761	0.2521	0.3226	0.3739	0.3463

Appendix 1.C: All first-step results

Panel E: First-step results of Heckman self-selection model on non-mortgage securitization

Dependent Variable	Non-mortgage Securitization Dummy								
	full sample			before 2007			after 2007		
Bank size	0.358***	0.346***	0.358***	0.351***	0.343***	0.350***	0.346***	0.334***	0.348***
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)
Diversification ratio%	-0.280***	-0.180*	-0.257***	-0.429***	-0.369**	-0.407***	-0.182	-0.054	-0.167
	(0.10)	(0.10)	(0.10)	(0.15)	(0.15)	(0.15)	(0.13)	(0.13)	(0.13)
Bank liquidity ratio%	-1.948	-1.743	-1.874	-3.190	-2.875	-3.120	0.929	0.215	0.786
	(10.05)	(9.81)	(10.09)	(11.36)	(11.33)	(11.43)	(20.31)	(18.97)	(20.27)
Non-interest expense ratio%	1.056***	0.789***	1.050***	1.173***	0.836***	1.156***	0.912***	0.688***	0.909***
	(0.12)	(0.10)	(0.12)	(0.17)	(0.13)	(0.17)	(0.19)	(0.17)	(0.19)
Non-performing loans ratio%	12.222***	12.547***	12.128***	46.207***	47.124***	45.217***	9.356***	9.579***	9.236***
	(1.60)	(1.61)	(1.60)	(6.79)	(6.73)	(6.72)	(1.67)	(1.69)	(1.67)
Local-market power	0.194	0.412***	0.242	0.166	0.426*	0.204	0.200	0.401**	0.245
	(0.15)	(0.15)	(0.15)	(0.24)	(0.23)	(0.24)	(0.20)	(0.20)	(0.20)
Bank holding company dummy	-0.049	-0.050	-0.053	-0.119**	-0.129**	-0.121**	0.035	0.042	0.028
	(0.04)	(0.04)	(0.04)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Metropolitan statistical area dummy	0.006	0.004	0.013	-0.012	-0.003	-0.003	0.016	0.012	0.025
	(0.03)	(0.03)	(0.03)	(0.05)	(0.05)	(0.05)	(0.04)	(0.04)	(0.04)
State-level corporate tax rate	0.001***			0.001**			0.001***		
	(0.00)			(0.00)			(0.00)		
Peer liquidity index		0.026***			0.018**			0.033***	
		(0.01)			(0.01)			(0.01)	
State-level corporate tax rate × Peer liquidity index			0.001***			0.001**			0.001**
			(0.00)			(0.00)			(0.00)
Constant	-6.695***	-6.695***	-6.727***	-6.491***	-6.507***	-6.540***	-6.627***	-6.691***	-6.691***
	(0.13)	(0.12)	(0.13)	(0.19)	(0.18)	(0.18)	(0.18)	(0.17)	(0.18)
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	69,258	69,258	69,258	29,638	29,638	29,638	39,620	39,620	39,620
Pseudo-R^2	0.2855	0.2273	0.2757	0.2355	0.1949	0.2526	0.2613	0.2324	0.3063

Appendix 2.A: Variable definition

Variable	Definition
Dependent variable	
Bank Failure	Bank failure dummy, which equals to one if the bank failed or is acquired by another bank under the government assistance in the sample and zero otherwise.
Independent variables	
Total Securitization Ratio	The outstanding principal balance of total amount of assets securitized over total assets.
Mortgage Securitization Ratio	The outstanding principal balance of total amount of mortgage assets securitized over total assets.
Non-Mortgage Securitization Ratio	The outstanding principal balance of total amount of non-mortgage assets securitized over total assets.
Total Retained Interests Ratio	The total dollar amount of credit exposure from all retained interest only strips, all other credit enhancements, unused commitments to provide liquidity to asset securitized, and ownership (or sellers) interests carried as securities or loans on related assets, divided by the total of all securitized assets.
Mortgage Retained Interests Ratio	The total dollar amount of credit exposure from all retained interest only strips, all other credit enhancements, unused commitments to provide liquidity to asset securitized, and ownership (or sellers) interests carried as securities or loans on related assets, divided by the total of all securitized mortgage assets.
Non-Mortgage Retained Interests Ratio	The total dollar amount of credit exposure from all retained interest only strips, all other credit enhancements, unused commitments to provide liquidity to asset securitized, and ownership (or sellers) interests carried as securities or loans on related assets, divided by the total of all securitized non-mortgage assets.
Bank Size	The natural logarithm of total assets.
Diversification Ratio	Noninterest income divided by total operation income.
Liquidity Ratio	Liquid assets divided by total assets.
Non-Interests Expenses Ratio	Noninterest expense divided by total assets.
Non-Performing Loans Ratio	Loans past due 90 days divided by total assets.
Local-Market Power	The sum of the squares of each portfolio in every bank.
Bank Holding Company Dummy	Bank holding company dummy equals to one if the bank belongs to a bank holding company, and zero otherwise.
Metropolitan Statistical Area Dummy	Metropolitan statistical area dummy equals to one if the bank locates in metropolitan area, and zero otherwise.
Instruments	
Peer Liquidity Index	Peer liquidity index is the average of liquidity indexes of a bank's peers. Liquidity index is proposed by Loutskina (2011) to effectively capture banks' potential ability to securitize loans.
State-level corporate tax rate	State level corporate tax rate
Peer Liquidity Index × State-level Corporate Tax Rate	The cross product of peer liquidity index and state-level corporate tax rate.

Appendix 2.B: Correlation matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1)	1.0000										
(2)	0.0068*	1.0000									
(3)	0.0002	0.1838***	1.0000								
(4)	0.0249***	0.0736***	0.0954***	1.0000							
(5)	-0.0208***	0.2032***	0.1332***	0.2721***	1						
(6)	-0.0427***	-0.0068	-0.0043	-0.0538***	0.0741***	1					
(7)	0.0687***	0.1629***	0.0583***	-0.1337***	0.5157***	-0.0929***	1				
(8)	0.0386***	0.0649***	0.0410***	-0.0486***	0.0242***	-0.0573***	0.0702***	1			
(9)	-0.0024	0.0472***	0.0641***	0.2172***	0.1844***	0.0737***	-0.0169***	0.0328***	1		
(10)	-0.0077**	-0.0408***	-0.0041	0.1920***	0.0584***	0.0131***	-0.1042***	-0.0180***	0.0257***	1	
(11)	0.0326***	0.0235***	0.0302***	0.2723***	0.0982***	-0.1124***	0.0807***	-0.0383***	-0.0268***	-0.0337***	1

Note: Variables are numbered as follows: (1) *Failure dummy*, (2) *Total securitization ratio*; (3) *Total retained interests*; (4) *Bank size*; (5) *Diversification ratio*; (6) *Liquidity ratio*; (7) *Non-interests expense ratio*; (8) *Non-performing loans ratio*; (9) *Local-market power index*; (10) *BHC dummy*; (11) *MSA dummy*.

Appendix 3.A: Variable definition

Variable	Definition
Dependent variable	
Bank Efficiency Score	Bank efficiency scores range from zero to one, derived from a data envelopment analysis (DEA) model using three inputs and outputs (summary statistics for inputs and outputs are reported in Table 5.1). A higher score indicates a higher level of efficiency, and vice versa.
Independent variables	
Total Securitization Ratio	The outstanding principal balance of total amount of assets securitized over total assets.
Mortgage Securitization Ratio	The outstanding principal balance of total amount of mortgage assets securitized over total assets.
Non-mortgage Securitization Ratio	The outstanding principal balance of total amount of non-mortgage assets securitized over total assets.
Total Retained Interests Ratio	The total dollar amount of credit exposure from all retained interest only strips, all other credit enhancements, unused commitments to provide liquidity to asset securitized, and ownership (or sellers) interests carried as securities or loans on related assets, divided by the total of all securitized assets.
Mortgage Retained Interests Ratio	The total dollar amount of credit exposure from all retained interest only strips, all other credit enhancements, unused commitments to provide liquidity to asset securitized, and ownership (or sellers) interests carried as securities or loans on related assets, divided by the total of all securitized mortgage assets.
Non-Mortgage Retained Interests Ratio	The total dollar amount of credit exposure from all retained interest only strips, all other credit enhancements, unused commitments to provide liquidity to asset securitized, and ownership (or sellers) interests carried as securities or loans on related assets, divided by the total of all securitized non-mortgage assets.
Capital Ratio	Capital divided by total assets.
Bank Size	The natural logarithm of total assets.
Diversification Ratio	Noninterest income divided by total operation income.
Liquidity Ratio	Liquid assets divided by total assets.
Non-Interests Expenses Ratio	Noninterest expense divided by total assets.
Non-Performing Loans Ratio	Loans past due 90 days divided by total assets.
Local-Market Power	The sum of the squares of each portfolio in every bank.

Appendix 3.B: Correlation matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1)	1													
(2)	0.2618***	1												
(3)	0.1818***	0.2976***	1											
(4)	0.2164***	0.9529***	-0.0059	1										
(5)	0.2490***	0.3521***	0.0435***	0.3550***	1									
(6)	0.0809***	0.0304**	0.1084***	-0.0026	0.4596***	1								
(7)	0.1568***	0.1284***	0.0072	0.1321***	0.2228***	0.0016	1							
(8)	-0.2796***	0.1747***	-0.0245	0.1908***	0.0948***	-0.0268	0.0471***	1						
(9)	0.2845***	0.1685***	0.1899***	0.1162***	0.2119***	0.1128***	0.1057***	0.0677***	1					
(10)	0.4961***	0.3493***	0.2345***	0.2914***	0.3231***	0.1039***	0.1756***	0.1911***	0.4800***	1				
(11)	0.0423***	-0.0503***	0.0102	-0.0559***	-0.0140	0.0325**	-0.0547***	-0.1229***	0.0216	0.0481***	1			
(12)	0.1102***	0.4163***	0.0436***	0.4222***	0.2664***	-0.0136	0.0976***	0.2384***	0.0171	0.4695***	-0.0470***	1		
(13)	0.1777***	0.2839***	0.1206***	0.2591***	0.1979***	0.0412***	0.1687***	0.1346***	0.2252***	0.2592***	-0.1320***	0.2237***	1	
(14)	0.2310***	0.1295***	0.2557***	0.0545***	0.1472***	0.1367***	0.0293**	-0.0131	0.4272***	0.3771***	-0.0036	0.0435***	0.1806***	1

Note: Variables are numbered as follows: (1) Bank efficiency scores, (2) Total securitization ratio; (3) Mortgage securitization ratio; (4) Non-mortgage securitization ratio; (5) Total retained interests; (6) Retained interests on mortgage loans; (7) Retained interests on non-mortgage loans; (8) Capital ratio; (9) Bank size; (10) Diversification ratio; (11) Liquidity ratio; (12) Non-interests expense ratio; (13) Non-performing loans ratio; (14) Local-market power index.

Appendix 3.C: Panel Heckman model, first-step results

This set of tables shows the results of cross-sectional Probit regressions in the first-step of Chamberlain-Mundlak approach (Mundlak, 1978; Chamberlain, 1982) which is the instrumental variable approach. In the first step, the main concern it to calculate the self-selection bias control variable, inverse Mills ratio. The dependent variable is total securitization dummies and the independent variables are bank specific control variables in every sample year during 2002 to 2012, respectively. Three instruments are applied in the research, including state-level corporate tax rates in the U.S. (Panel A), peer liquidity index (Panel B), and the interaction term of them (Panel C). Securitization dummies are defined equaling to one if the bank has securitized loans, and zero otherwise. Corporate tax rates data are collected from Tax Foundation of U.S. which is available at: http://www.taxfoundation.org/taxdata/show/230.html, while liquidity index is calculated based on Equation (4), of which the data are collected from “Financial Accounts of the United States” (Z.1) data release. Bank specific control variables include: 1. capital ratio (capital divided by total assets); 2. bank size (the natural logarithm of total assets); 3. diversification ratio (noninterest income divided by total operation income); 4. liquidity ratio (liquid assets divided by total assets); 5. non-interest expense ratio (noninterest expense divided by total assets); 6. non-performing loans ratio (loans past due 90 days divided by total assets); and, 7. local-market power (the sum of the squares of each portfolio in every bank). Likelihood ratios of every regression are reported instead of adjusted R-squared. T-statistics are based on standard errors clustered at the bank level, where *, **, *** denote statistical significance at the 10%, 5%, and 1% levels respectively.

Panel A: instrument: corporate tax rate

Dependent variable	Total Securitization Dummy									
Year	2002	2003	2004	2005	2006	2007	2009	2010	2011	2012
Capital Ratio	-9.545**	-9.067*	-6.744*	-2.546	-0.887	-1.345	-3.129	-2.053	-2.107	-1.742
	(3.40)	(3.55)	(3.39)	(2.13)	(1.70)	(1.89)	(2.76)	(2.75)	(3.22)	(2.73)
Bank Size	68.99***	58.96***	71.15***	62.16***	69.32***	66.37***	44.68***	38.41**	47.62***	37.78**
	(13.49)	(13.31)	(15.53)	(14.15)	(14.66)	(14.66)	(13.28)	(13.41)	(13.31)	(12.82)
Diversification Ratio	0.598	1.535**	1.449**	1.277**	1.047*	1.241**	1.318**	0.945*	1.133**	1.638***
	(0.49)	(0.48)	(0.55)	(0.48)	(0.47)	(0.47)	(0.46)	(0.44)	(0.44)	(0.44)
Liquidity Ratio	-0.874	-0.737	-1.082	-0.801	-0.0785	-0.751	-0.776	0.00293	-0.746	-0.198
	(0.65)	(0.68)	(0.86)	(0.82)	(0.87)	(0.93)	(0.77)	(0.73)	(0.75)	(0.73)
Non-Interest Expenses	14.74*	2.372	8.322	10.55	12.30	11.14	13.89*	6.134	6.083	0.702
	(6.70)	(6.46)	(6.91)	(6.70)	(7.37)	(7.58)	(5.95)	(6.65)	(6.86)	(6.50)
Non-Performing Loans	49.95	60.08	71.32	16.44	34.96	36.18	32.07	7.970	8.501	20.87
	(28.89)	(31.59)	(39.29)	(34.66)	(35.68)	(31.09)	(19.31)	(17.06)	(16.47)	(16.96)
Local Market Power	2.392	3.246*	5.449**	4.586**	5.686***	4.899**	3.822*	4.118**	3.186*	2.442
	(1.49)	(1.56)	(1.67)	(1.47)	(1.53)	(1.53)	(1.52)	(1.52)	(1.45)	(1.47)
Corporate tax rate	0.595**	0.705**	0.352***	0.089	0.114	0.202**	0.185	0.108**	0.615**	0.581***
	(0.22)	(0.24)	(0.25)	(0.17)	(0.16)	(0.15)	(0.19)	(0.18)	(0.17)	(0.16)
Constant	-12.98***	-11.92***	-13.29***	-11.36***	-12.95***	-12.62***	-9.293***	-8.005***	-8.686***	-7.366***
	(2.14)	(2.08)	(2.47)	(2.21)	(2.31)	(2.38)	(2.09)	(2.04)	(2.03)	(2.01)
Observations	406	423	441	471	489	508	507	495	507	525
Pseudo R-squared	0.3378	0.4046	0.4777	0.3947	0.4269	0.4286	0.3768	0.2575	0.2780	0.2709

Appendix 3.C: Panel Heckman model, first-step results

Panel B: instrument: peer liquidity index										
Dependent variable	Total Securitization Dummy									
Year	2002	2003	2004	2005	2006	2007	2009	2010	2011	2012
Capital Ratio	-3.393	-1.650	-3.095	-1.900	-0.512	0.203	-1.257	-1.188	-2.314	-1.696
	(2.10)	(1.55)	(2.06)	(1.71)	(1.54)	(1.33)	(1.85)	(2.20)	(2.92)	(2.83)
Bank Size	64.43***	61.08***	70.03***	62.59***	67.79***	64.56***	41.28**	39.55**	48.05***	38.49**
	(14.00)	(13.30)	(15.71)	(14.16)	(14.82)	(14.44)	(13.38)	(13.40)	(13.35)	(12.89)
Diversification Ratio	-0.744	1.048	1.172	0.990	0.169	0.994	1.033*	0.755	0.761	1.284**
	(0.71)	(0.59)	(0.64)	(0.55)	(0.67)	(0.59)	(0.49)	(0.46)	(0.48)	(0.49)
Liquidity Ratio	-0.477	-0.507	-0.802	-0.665	0.105	-0.630	-0.495	0.0414	-0.645	-0.104
	(0.64)	(0.65)	(0.85)	(0.82)	(0.87)	(0.92)	(0.76)	(0.73)	(0.76)	(0.74)
Non-Interest Expenses	29.25***	9.198	11.85	13.21	21.11*	12.41	13.48*	6.712	8.684	3.199
	(8.59)	(6.96)	(7.66)	(7.07)	(8.94)	(7.77)	(5.46)	(6.56)	(6.94)	(6.67)
Non-Performing Loans	44.06	42.48	58.73	11.97	14.71	36.70	21.42	1.695	2.514	13.66
	(26.59)	(28.70)	(37.96)	(35.21)	(40.10)	(31.38)	(20.78)	(17.89)	(17.27)	(18.07)
Local Market Power	-0.416	1.152	4.154*	3.990**	4.799**	3.776*	2.315	3.195*	2.554	1.850
	(1.65)	(1.63)	(1.68)	(1.50)	(1.58)	(1.59)	(1.67)	(1.56)	(1.52)	(1.55)
Peer Liquidity Index	3.476*	1.153***	0.756	0.393***	1.377***	0.490*	1.011***	0.295*	0.349	0.306*
	(1.60)	(0.90)	(0.87)	(0.39)	(0.89)	(0.59)	(0.64)	(0.22)	(0.27)	(0.26)
Constant	-12.33***	-11.14***	-12.63***	-11.35***	-12.86***	-11.98***	-8.610***	-7.956***	-9.012***	-7.731***
	(2.09)	(2.01)	(2.39)	(2.16)	(2.26)	(2.26)	(2.00)	(2.00)	(2.02)	(1.99)
Observations	406	423	441	471	489	508	507	495	507	525
Pseudo R-squared	0.3471	0.3886	0.4781	0.3986	0.4400	0.4288	0.3888	0.2665	0.2876	0.2779

Appendix 3.C: Panel Heckman model, first-step results

Panel C: instrument: corporate tax rate * peer liquidity index

Dependent Variable	Total Securitization Dummy									
Year	2002	2003	2004	2005	2006	2007	2009	2010	2011	2012
Capital Ratio	-7.499**	-3.247	-4.228	-2.186	-1.001	-0.122	-2.034	-1.389	-2.649	-1.892
	(2.74)	(1.95)	(2.39)	(1.76)	(1.62)	(1.39)	(2.03)	(2.27)	(2.95)	(2.91)
Bank Size	63.80***	57.94***	68.75***	62.41***	67.88***	64.73***	41.82**	39.51**	48.03***	38.48**
	(13.92)	(13.61)	(15.81)	(14.16)	(14.78)	(14.44)	(13.32)	(13.42)	(13.35)	(12.90)
Diversification Ratio	-0.861	0.751	1.034	0.955	0.255	0.884	0.921	0.705	0.759	1.296**
	(0.64)	(0.59)	(0.64)	(0.55)	(0.62)	(0.59)	(0.51)	(0.47)	(0.48)	(0.49)
Liquidity Ratio	-0.541	-0.419	-0.784	-0.664	0.105	-0.588	-0.518	0.062	-0.635	-0.1
	(0.66)	(0.67)	(0.85)	(0.82)	(0.87)	(0.92)	(0.76)	(0.73)	(0.76)	(0.74)
Non-Interest Expenses	29.35***	10.93	13.04	13.41	20.33*	13.41	14.84**	7.069	8.612	3.054
	(7.98)	(6.88)	(7.63)	(7.07)	(8.54)	(7.89)	(5.59)	(6.59)	(6.94)	(6.67)
Non-Performing Loans	40.57	42.86	58.06	11.05	13.22	33.46	20.4	0.993	2.561	14.14
	(28.85)	(29.40)	(38.27)	(35.26)	(40.92)	(32.15)	(20.96)	(17.99)	(17.30)	(18.03)
Local Market Power	0.186	1.184	4.269**	4.053**	5.167***	3.882*	2.424	3.243*	2.671	1.953
	(1.61)	(1.60)	(1.64)	(1.48)	(1.57)	(1.57)	(1.64)	(1.55)	(1.50)	(1.54)
Peer Liquidity Index × Tax Rate	1.181**	0.636*	0.301	0.127**	0.329***	0.176*	0.315***	0.091	0.090**	0.0749
	(0.37)	(0.32)	(0.25)	(0.11)	(0.20)	(0.16)	(0.17)	(0.07)	(0.07)	(0.06)
Constant	-11.91***	-10.79***	-12.40***	-11.30***	-12.74***	-12.01***	-8.615***	-7.932***	-8.962***	-7.695***
	(2.11)	(2.04)	(2.41)	(2.16)	(2.27)	(2.26)	(2.00)	(2.00)	(2.02)	(1.99)
Observations	406	423	441	471	489	508	507	495	507	525
Pseudo R-squared	0.3164	0.2899	0.5366	0.3699	0.3225	0.5797	0.2533	0.1331	0.2864	0.2732

Appendix 3.D: Heckman model, first-step results (mortgage and non-mortgage securitization)

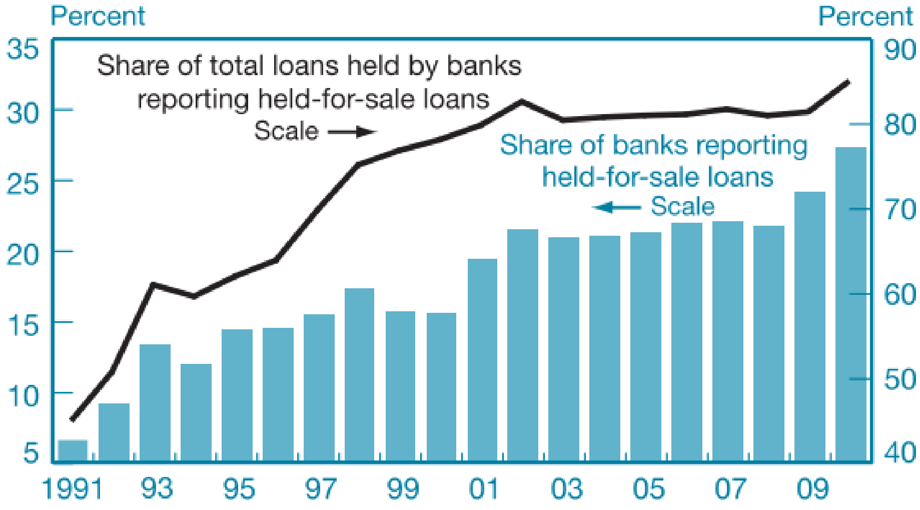
This table presents the first-step results of the Heckman self-selection model for mortgage and non-mortgage securitizations. The sample period is 2002-2012. Three instruments are introduced in Heckman model: 1) *state-level corporate tax rate*; 2) *peer liquidity index*; 3) *state-level corporate tax rate × peer liquidity index*. To deal with the possible time series issue, all control variables have been lagged for one year. T-statistics are based on robust standard errors clustered by banks, where *, **, *** denote statistical significance at the 10%, 5%, and 1% levels respectively. All variable definitions are presented in Appendix 5.A.

Dependent Variable	Mortgage securitization dummy			Non-mortgage securitization dummy		
	(1)	(2)	(3)	(4)	(5)	(6)
Capital Ratio$_{t-1}$	-2.975**	-3.230***	-3.746***	-2.660**	-0.471	-1.105
	(1.09)	(0.90)	(0.91)	(0.83)	(0.54)	(0.58)
Bank size$_{t-1}$	66.06***	67.22***	67.31***	39.99***	41.05***	40.92***
	(5.45)	(5.45)	(5.46)	(5.09)	(5.12)	(5.13)
Diversification ratio$_{t-1}$	0.939***	0.490**	0.494**	1.317***	0.736***	0.672***
	(0.15)	(0.17)	(0.17)	(0.16)	(0.18)	(0.18)
Bank liquidity ratio$_{t-1}$	0.146	0.247	0.231	-1.261***	-1.034***	-0.995**
	(0.27)	(0.27)	(0.27)	(0.30)	(0.30)	(0.30)
Non-interest expense ratio$_{t-1}$	-6.213*	-1.985	-2.101	13.40***	18.21***	18.87***
	(2.46)	(2.53)	(2.54)	(2.03)	(2.10)	(2.12)
Non-performing loans ratio$_{t-1}$	-2.385	-12.18	-12.51	12.68	-1.692	-5.148
	(7.75)	(8.32)	(8.33)	(7.47)	(8.42)	(8.66)
Local-market power$_{t-1}$	4.343***	3.707***	3.837***	3.118***	0.804***	1.017
	(0.48)	(0.50)	(0.49)	(0.52)	(0.59)	(0.58)
Constant	-11.47***	-11.99***	-11.94***	-9.050***	-8.835***	-8.748***
	(0.85)	(0.85)	(0.84)	(0.80)	(0.78)	(0.79)
State-level corporate tax rate	0.782***			0.269***		
	(0.07)			(0.06)		
Peer liquidity index		0.398***			0.955***	
		(0.09)			(0.16)	
State-level corporate tax rate × Peer liquidity index			0.107***			0.280***
			(0.02)			(0.04)
Observations	4,399	4,399	4,399	4,399	4,399	4,399
Pseudo-R^2	0.3330	0.3471	0.3633	0.3448	0.3691	0.2065

Figures

Figure 1-1

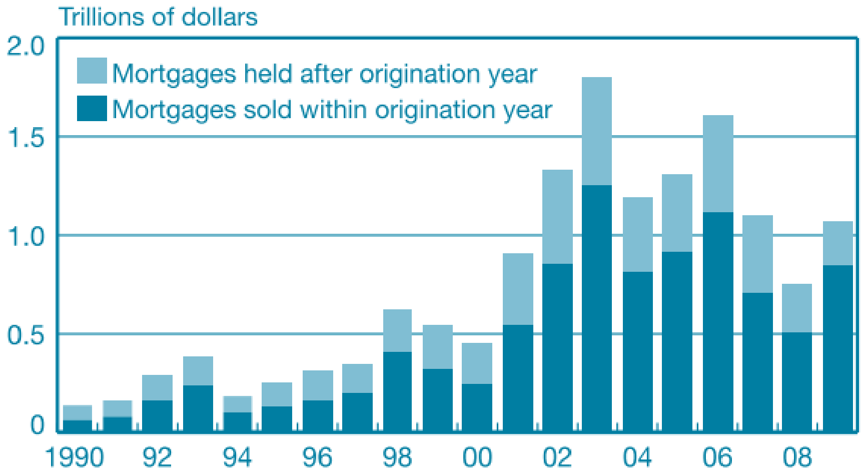
Commercial Banks Reporting Loans Held for Sale



Source: Federal Financial Institutions Examination Council, *Consolidated Reports of Condition and Income.*

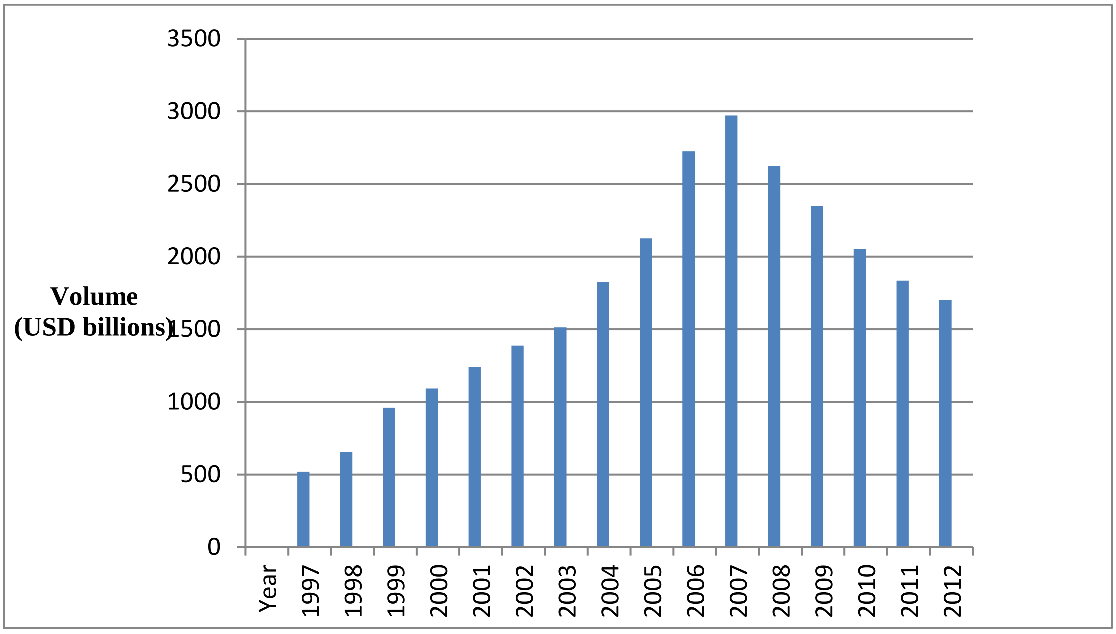
Figure 1-2

Mortgage Originations by Commercial Banks



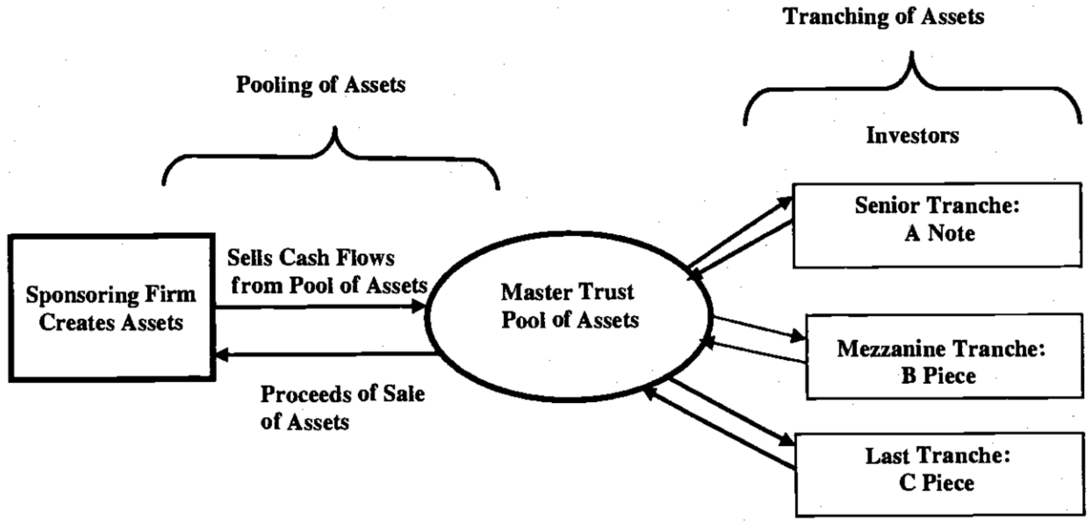
Source: Home Mortgage Disclosure Act.

Figure 2-1: ABS Outstanding in U.S.



Source: SIFMA Database (2013), US ABS Issuance and Outstanding 1997-2012

Figure 2-2: A standard process of securitization


Tranching of Assets
Pooling of Assets
Investors
Senior Tranche:
A Note
Sponsoring Firm
Creates Assets
Sells Cash Flows
from Pool of Assets
Master Trust
Pool of Assets
Mezzanine Tranche:
B Piece
Proceeds of Sale
of Assets
Last Tranche:
C Piece

Source: Gorton and Souleles (2005)

Figure 2-3: A representative securitization deal

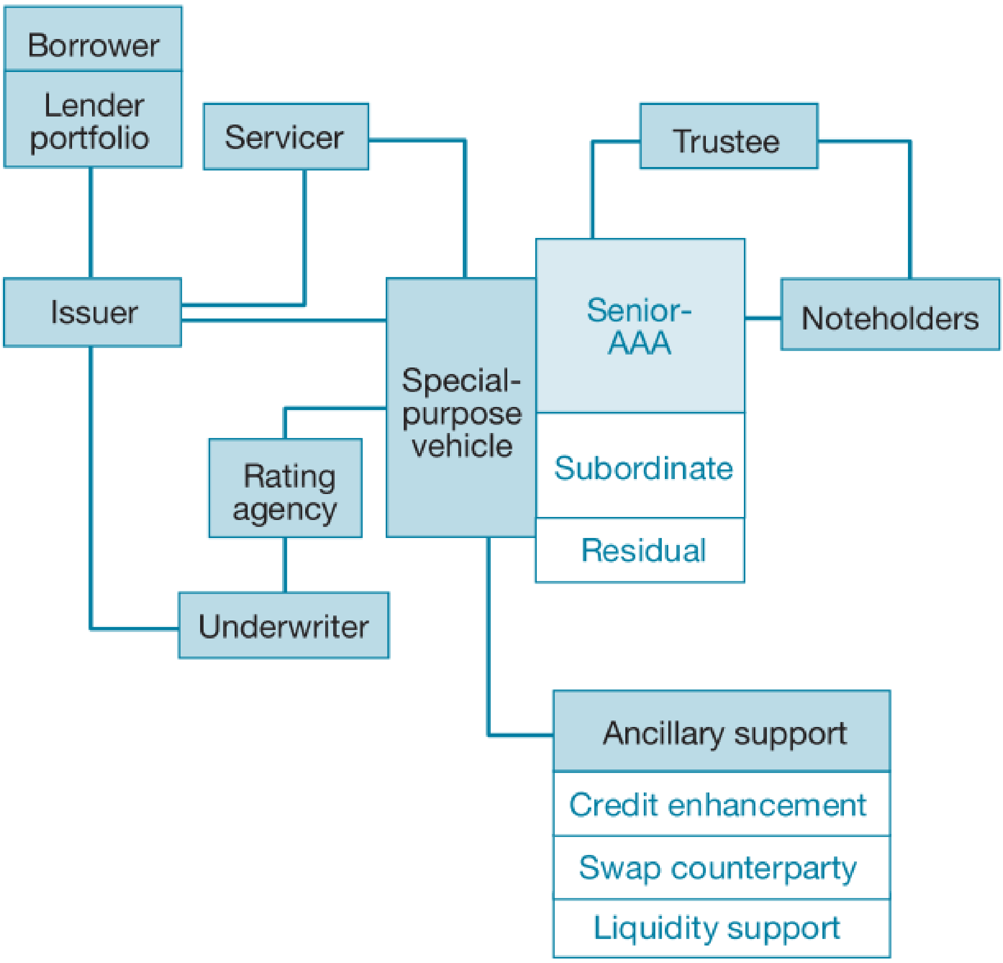

Borrower
Lender portfolio
Servicer
Trustee
Issuer
Senior-AAA
Noteholders
Special-purpose vehicle
Rating agency
Subordinate
Residual
Underwriter
Ancillary support
Credit enhancement
Swap counterparty
Liquidity support

Figure 4-1: Nelson-Aalen Estimation of the Hazard Function - Total Loan Securitization

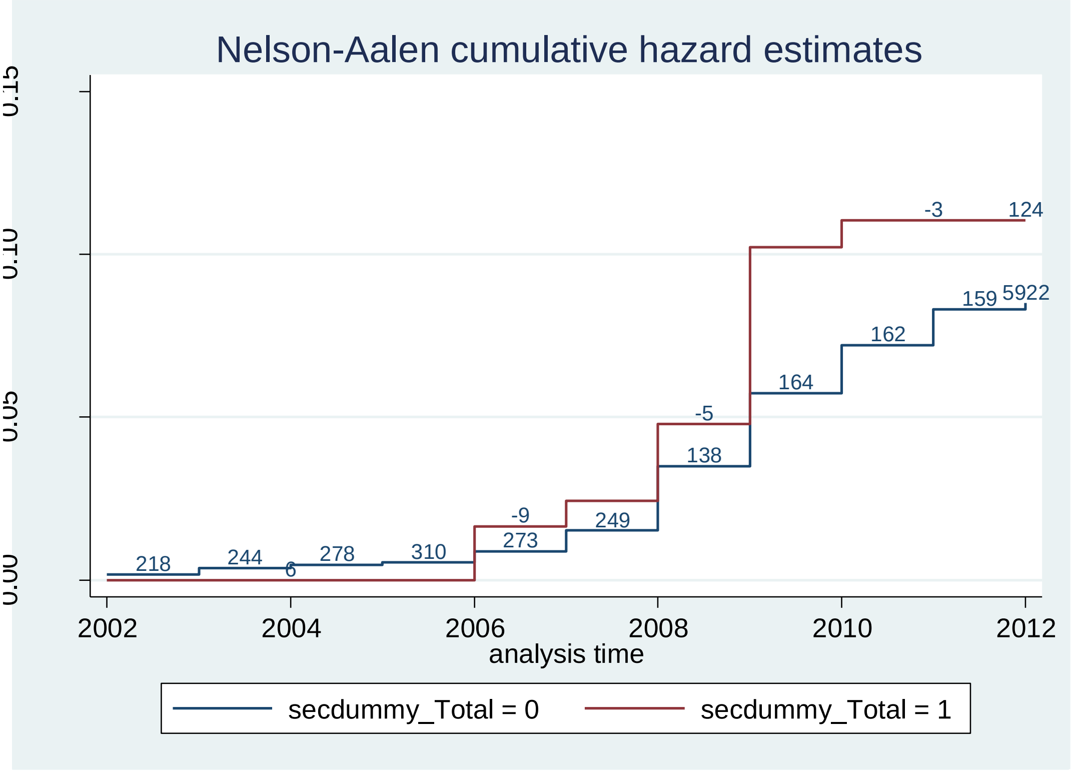


Figure 4-2: Nelson-Aalen Estimation of the Hazard Function - Mortgage Loan Securitization

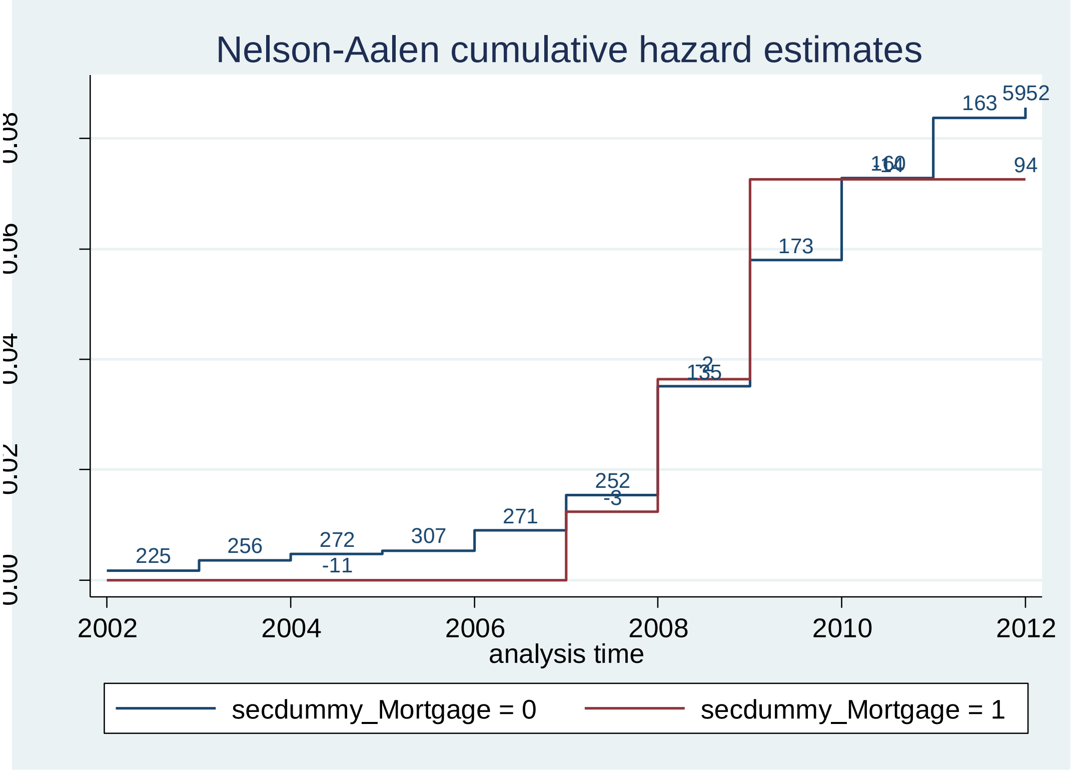
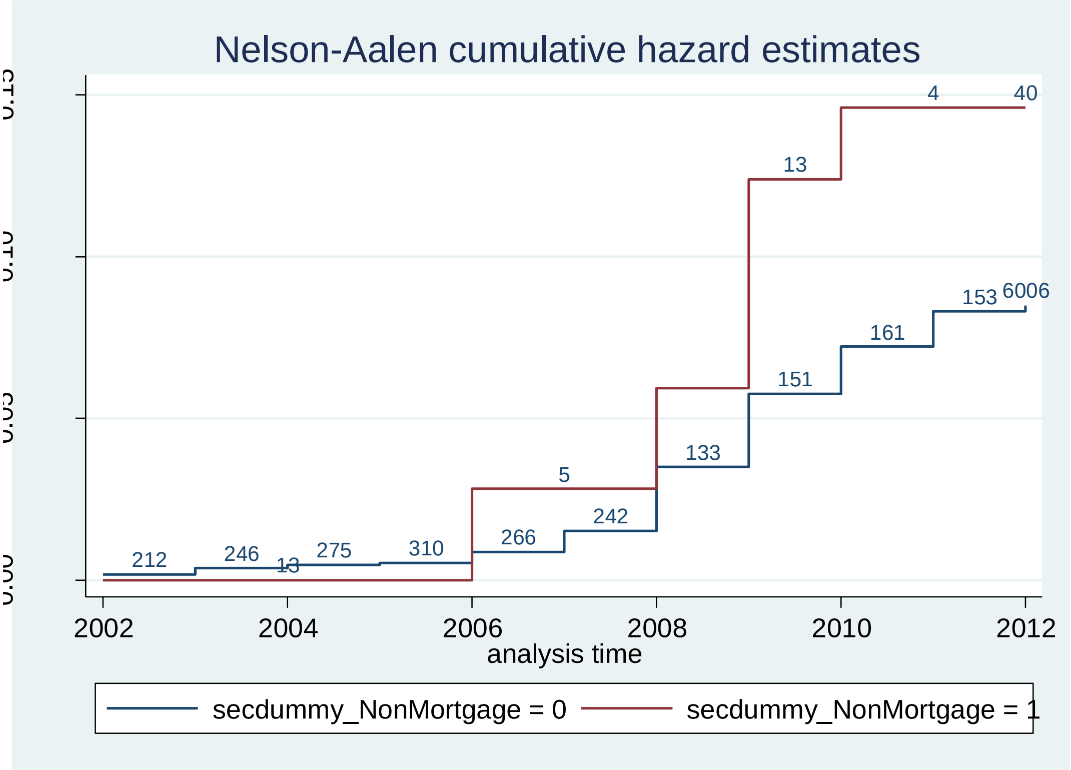


Figure 4-3: Nelson-Aalen Estimation of the Hazard Function - Non-Mortgage Loan Securitization



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