Empirical Essays on Strategic Behaviors: Application to the Banking and Financial Institutions

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A Dissertation submitted to

The Faculty of
The School of Business
of The George Washington University
in partial fulfillment of the requirements
for the degree of Doctor of Philosophy

August 31, 2016

Dissertation directed by

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Acknowledgments

I wish to express sincere gratitudes to my advisor Professor Van Order for the continuous support of my Ph.D study and related research, and I am grateful for his patience, motivation, and immense knowledge.

I would like to thank the rest of my dissertation research committee: Professor Savickas, Professor Klock, Professor Hwang, and Professor Soyer, for their insightful comments and encouragement that help widen my research and academic pursuit.

My sincere thanks goes to Professor Murillo Campello and Janet Gao from Cornell University for their generous advice and comments.

I also want to thank my husband, Ke Luo, for his support and love.

Abstract of Dissertation

Empirical Essays on Strategic Behaviors: Application to Banking and Financial Institutions

My dissertation research focuses on the strategic behaviors of banks and financial intermediaries, with regard to the loans they issue or service. It contains three empirical essays: the first examining the effects of short-selling ban on banks' lending behaviors, the second studying borrowers' strategic behaviors to exercise delinquency option and default option, and the third analyzing the strategic behaviors of banks as sellers and servicers in the transitional performance of mortgage loans.

My first chapter examines the effects of the 2008 short-selling ban on banks' lending behaviors. Comparing the affected banks with other banks of similar characteristics, I find that the treated banks enjoy more adequate capital reserves and a higher perceived financial stability, as reflected by their CDS spreads and traded options. Those banks were also more able to increase equity issuance, maintain a higher deposit growth rate, and keep more adequate capital reserves. Subsequently, affected banks extended credit at lower markups and experienced lower loan default rates. These effects are temporary as they manifest during the short-selling ban but disappear after the ban is lifted.

My second chapter studies borrowers' strategic behaviors to exercise delinquency option and default option. The Basel capital rule framework and much of the recent literature on mortgage default have used 60-day or 90-day delinquency to define mortgage default; yet the differences between default (here meaning actual loss of the property) and delinquency have been neither clearly recognized nor well understood. By distinguishing borrowers' delinquency option (borrowing by not making payments) from default option (giving up property in exchange for the mortgage), I find that borrowers' delinquency options are more affected by personal trigger events

or shocks, while default options are mostly affected by negative equity. Moreover, while origination underwriting standards contributes to increasing delinquencies, its influence on default, on the other hand, is decreasing over the years. As a result studies that have used delinquency in models designed to analyze actual losses appear to have made major errors in understanding causes of financial losses during the Great Recession.

Following up with my previous chapters, Chapter Three analyzes the roles of banks as a seller or servicer in the transition probabilities from delinquency to default and other outcomes. Previous literature have overlooked the effects of mortgage banks as sellers or servicers on loan performance. My results suggest that banks' balance sheet health and business incentive structure play a crucial role in the loan performance. For banks with higher retail funding, higher equity ratio, better credit rating, and less servicing automation, their loans have lower transitional probabilities from delinquency to default, and higher probabilities to get modified.

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Chapter 1

Curb Shorts and Boost Capital: The Effects of Short-selling Ban on Bank Lending Activities

Abstract

The paper examines the effects of the 2008 short-selling ban on treated banks. Comparing the treated banks with other banks of similar characteristics, I find that the treated banks enjoy more adequate capital reserves and a higher perceived financial stability, as reflected by their CDS spreads and traded options. Those banks were also more able to increase equity issuance, maintain a higher deposit growth rate, and keep more adequate capital reserves. Subsequently, affected banks extended credit at lower markups and experienced lower loan default rates. These effects are temporary as they manifest during the short-selling ban but disappear after the ban is lifted.

> [The short-selling ban] helps prevent illegitimate naked short selling and potential "distort and short" manipulation. ... the Commission will continue exploring other remedies for the broader marketplace to further protect investors from distort and short artists.
>
> — *Christopher Cox, Chairman, Security Exchange Commission*

Introduction

At the peak of the financial crisis of 2008, stock prices of financial institutions around the world have seen a dramatic fall and the investors of these stocks blamed their loss on predatory short sellers. For fear that short selling would further cause turbulence in the secondary market and even the collapse of the banking sector, the Security Exchange Commission (SEC) announced a ban of short-selling on stocks of select financial institutions. The ban was designed to "combat market manipulation that threatens investors and capital markets" and to "restore equilibrium to markets" (SEC Chariman Cox, 2008). The short-selling ban was later followed by several European central banks in 2011 during the midst of sovereign debt crisis. These policies triggered a renewed interest from scholars to study their impacts on the financial markets and the economy. Despite numerous studies debate about the price impacts of short-selling bans (Autore et al. (2011), Boehmer et al. (2013), Beber and Pagano (2013), Beber et al. (2014), Boehmer et al. (2012), Harris et al. (2013), Helmes, et al. (2010), Marsh and Payne (2012)), it remains under-studied how a short-selling ban on the financial sector can influence the real economic sectors through a credit-provision channel.

This study examines the effects of the 2008 short-selling ban (SEC 2008-211)[1] on the financial sector. In particular, I aim to understand the impact of the ban on the perceived stability, balance sheet strength, and lending activities of banks. Banks are

[1] https://www.sec.gov/news/press/2008/2008-211.htm

important intermediaries for the financing activities of corporations and households. For example, syndicated loans from banks provide a major source of financing for U.S. corporations (Sufi (2007)). Bank lending in the form of consumer credits and mortgages also consists almost all of household finances in the United States. Understanding the effects of the short-selling ban on bank stability and lending activities can thus shed light on how security regulations may affect the access to credit by industrial sectors and ultimately, and how these regulations may affect real economic growth.

Subject to stringent capital regulations, banks also provide a unique setting to study the effects of short-selling bans. The Basel Accords require banks to maintain a certain level of core capital to absorb potential asset value declines. Due to such regulations, banks are vulnerable to predatory short-selling, as depressed stock prices can lead to sudden withdrawals of funding from depositors, repo counterparties, and credit market (Diamond and Dybvig (1983), Brunnermeier (2009), Bebchuk and Golstein (2011), Martin et al. (2014)). Large swings of stock prices often affect how market investors perceive banks' financial stability. Sudden price declines can thus lead risk averse investors to withdraw from providing funds to these banks (e.g., Golstein et al. (2013)). This inability to obtain funding can intensify banks' capital constraints and force banks to sell off long-term assets to comply with these constraints (Brunnermeier and Oehmke (2013)), ultimately reducing banks' lending capacity and even their chance of survival.

I focus on a sample of 389 banks (SIC = 6020) among all financial institutions that are subject to the 2008 short-selling ban. To understand the effect of the ban on the lending behavior and performance of these affected banks (treated group), I compare them to banks that are not subject to the ban but have similar balance sheet strength and credit conditions (control group). To construct this matched sample of

banks, I collect bank balance sheet information from various databases, including the Federal Reserve Call Report, Bloomberg, and Compstat. I then match every treated bank with three control banks according to their size, equity ratio, and credit ratings. I also require them to be both included in or excluded from the Troubled Asset Relief Program (TARP).

With the matched sample of banks, I first verify the effect of the short-selling ban on the banks' balance sheet strength and their perceived financial health by market participants. I then investigate their performance and lending terms. Overall, I am interested in the differences across the above dimensions between the treated and control banks both during and after the short-selling ban.

Brunnermeier and Oehmke (2013) and Liu (forthcoming) theorize that predatory short-selling can tip banks' capital reserve out of balance, suppress banks' external funding sources, and potentially lead to bank failure. A ban on the short-selling can help limit predatory short-selling activities, restore investors' belief in bank health, and allow banks to obtain external financing. Perceived bank health by investors, according to Brunnermeier and Oehmke (2013) and Liu (forthcoming), plays an important role in determining banks' access to funding from the capital market.

I first examine the effect of the short-selling ban on investors' perceived stability of the treated banks. Given that the short-selling ban is implemented to stabilize market prices and to prevent wide-spread panic (SEC order (2008)), I expect the ban to improve the perceived financial health of affected banks.[2] I verify this conjecture by gauging investors' perception in two ways: credit default swaps (CDS) and out-of-the-money (OTM) put options. Both of these instruments offer a protection against downside risks of a bank's asset. Their traded prices thus reflect perceived probability

[2]Also see *SEC Issues Temporary Ban against Short Selling*, Wall Street Journal, September 19, 2008.

of downside risks (Cao et al. (2010)).

First, I compare the CDS spreads for the treated and control banks. I collect information regarding 1-year and 5-year traded CDS contracts from Markit database, and examine how their spreads change around the short-selling ban. I find that treated banks experience a larger decrease in CDS spreads than the control banks when the ban is in effect, indicating that creditors consider the treated banks to have lower credit risk. However, this difference soon reversed once the short-selling ban is lifted, indicating that investors consider these banks riskier as they are no longer protected from short-sellers.

Second, I examine the implied volatility of banks' traded options. I focus on deep OTM put options, whose trading prices reflect a bank's downside risk as perceived by investors, especially the risk of failure. I examine the implied volatility, a measure that reflects the option's price level and is comparable across different contract features. Consistently, I find that the treated banks experience a reduction in the implied volatility of their deep OTM put options during the short-selling ban. This result suggests that investors are less concerned about the downside risks for the treated banks, paying a lower "premium" to insure against downside risks.

If investors consider the treated banks to have lower downside risks, they should be more likely to provide funding to the bank. To test this mechanism, I examine the actual external financing activities by the sample banks around the short-selling ban, including equity issuance and deposit growth. Comparing with control banks, the treated banks conduct more equity issuances and raise a greater amount of funds during the short-selling ban, but not after the ban was lifted. Similarly, treated banks also experience a higher deposit growth during the short-selling ban. With improved access to external financing, the treated banks should also enjoy an improved capital adequacy. I measure capital adequacy using the Tier-1 capital ratio, which is a widely

used measure in banking regulations (see Basel Capital Accord (1998)). Compared with the control group, the treated banks experience a 2% greater increase in their Tier-1 capital ratios during the effective span of the short-selling ban, suggesting that the short-selling ban effectively improved the balance sheet strength of treated banks.

I then examine the impacts of the short-selling ban on the banks' lending terms and fundamental performance. Given that the short-selling ban restores investors' confidence and relieves banks' capital constraints, I expect the treated banks to be able to extend more credit and achieve a higher earnings capacity. I start by examining the lending terms granted by treated and control banks using information regarding syndicated loans from the LPC Dealscan database. I find that during the short-selling ban, treated banks reduced loan spreads to a greater extent by 89 basis points than control banks. This is a considerable difference given the average loan spreads of 225 basis points in the sample. Consistently, once the ban is lifted, I no longer observe a difference in loan terms between the treated and control banks.

With the treated banks having an improved ability to extend credit, it is a natural concern that they may relax screening standards and be again exposed to a higher credit risk. To understand the quality of syndicated loans extended by the treated banks, I examine the loan amount extended by these banks and their loan default rates around the short-selling ban. Treated banks reduce the amount of syndicated lending to a greater extent than control banks during the ban, but their loans are of higher quality. To wit, the loans extended by treated banks are 35% less likely to experience default, defined as the incidence where a borrower receives S&P ratings "SD", "RD", or "D" before its loan matures. Taken together, these results suggest that the treated banks concentrate their lending to a smaller group of loans, but are able to exert greater screening efforts, leading to a less risky loan portfolio.

Finally, I examine whether the short-selling ban helps improve the performance of

affected banks. I find that the treated banks enjoy a higher investment gain during the short-selling ban, indicating that with a more adequate capital reserve, banks are able to increase screening efforts and invest in more profitable projects. This result provides preliminary evidence that the short-selling ban promotes the performance and efficiency of major banks during the financial crises, which likely also benefits the non-financial sectors.

This study is the first to document the effect of the 2008 short-selling ban on banks' balance sheet strength and lending activities. It is related to a growing literature on the role of short-selling during the financial crises as well as the effect of short-selling bans. The literature is divided regarding the effects of short-selling bans. For example, Boehmer et al. (2013), Boehmer and Wu (2013), and Beber and Pagano (2013) find little price impacts and worsened market liquidity from short-selling bans, while other studies argue that short-selling bans effectively increase prices and reduce negative skewness for U.S. stocks (Autore et al. (2011), Stambaugh, Yu, and Yuan (2012), and Harris et al. (2013)). Various studies focus on short-selling bans globally and study their effects on financial institutions. Still, they provide mixed evidence regarding whether short-selling bans indeed support price level and reduce volatility of affected stocks (Marsh and Payne (2012), Harris et al. (2013), Helmes et al. (2010), Bailey and Zheng (2012), Beber et al. (2014)). Contributing to this debate, the study shows that the short-selling ban in 2008 effectively restores investors' confidence in the affected banks and their capital adequacy. More importantly, this contributes to an improved lending capacity and fundamental performance, benefiting other economic sectors. the results thus suggest a positive, real impact of the short-selling ban.

This study also relates to a large body of literature on the relation between bank capital and banks' lending capacity. Extant theoretical and empirical literature uncover a strong linkage between banks' capital adequacy and bank lending activities

(e.g., Stiglitz and Weiss (1981), Thakor (1996), VanHoose (2007), Khwaja and Mian (2008), Paravisini (2008), and Schnabl (2012)). These studies show that as banks face a positive (negative) liquidity shock, they will expand (shrink) lending accordingly. The liquidity shock could arise from changes to deposits, investment gains and losses, government intervention, or the condition of the interbank lending market. the study adds to this literature by showing that the short-selling ban helps a bank become more financially healthy, maintain more sufficient bank capital, enjoy improved performance and offer better lending terms.

This paper develops as follows: Section 1 introduces the progress of the short-selling ban in 2008. Section 1 discusses the related literature. Section 1 describes the data source and empirical methodology. Section 1 provides results from the empirical tests. Section 1 concludes.

Timeline of Events

On July 21, 2008, U.S. Securities and Exchange Commission (SEC) issued an emergency order to ban naked short selling of 19 financial firms (the July Order). The SEC later issued another order on September 17 to extend the short-selling ban on 797 financial firms, among which 389 institutions are banks.

The July Order restricted naked short selling of 19 financial firms, which include 17 banks (and Freddie Mac and Fannie Mae). Though a small group in number, these banks are among the largest not only in terms of stock market capitalization but also in terms of lending activities in the syndicated loan market: these 17 banks issue around half of the total syndicated loans. The July Order expired on August 12, 2008, yet market participants expected the ban to continue, as Christopher Cox, the SEC chairman, informed lawmakers that the agency was considering to broaden

the ban. [3]

On September 18, 2008, SEC issued a new, more extensive emergency order which banned the naked short selling of 797 financial firms (The September Order). Cox stated that the intension is to "preserve investor confidence" in the stock markets. The Order became effective on September 19, 2008, and was to be terminated on October 2, 2008. Further technical amendments were introduced on September 21, 2008 that allow the listing markets to modify the list of banned financial firms, in case the original ban omitted some financial institutions due to "difficulties with the classification criteria." As a result, over one hundred additional firms were subsequently added by stock exchanges. On the other hand, a few financial firms asked to be removed from the list during this period. Though SEC extended the ban to October 17, 2008 initially, the ban expired on October 8, 2008, following the initiation of TARP.

TARP was approved by congress on October 3, 2008 and its exact plan layout was released on October 13, 2008. There is a concern that studies of the short-selling ban could be confounded if a bank is included both in the short-selling ban and TARP (Beber and Pagano (2013) and Boehmer et al. (2013)). Such a concern is mitigated in the study as I compare treated and control banks that are both included in TARP, or if neither is included in TARP.

Literature Review

This paper is related to two strands of literature. One strand studies the effects of short sales and short-selling bans, and the other studies the effects of bank capital on banks' ability to extend credit.

[3] https://www.sec.gov/news/press/2008/2008-155.htm

Effects of Short Sales and Short-Selling Bans

Previous studies about short-selling constraints mostly focus on two aspects. One focuses on the impact on price efficiency and trading liquidity of affected stocks and their derivative securities. The other focuses on their impact on firms' investment, performance, and the ability to survive the crises.

A number of studies examine the effect of short-selling constraints on security prices, yet the results are mixed. For example, Boehmer et al. (2013) and Beber and Pagano (2013) do not find any effects of short-selling bans on security prices. Others document that short-selling bans lead to elevated prices and reduced negative skewness for U.S. stocks (Jones and Lamont(2002), Bris et al. (2007), Autore et al. (2011), Stambaugh, Yu and Yuan (2012), Harris et al. (2013)).

Several studies further document that short-selling bans impede price discovery and increase trading frictions (e.g. Crotty (2012) and Boehmer and Wu (2013)). Studies such as Battalio and Schultz (2011) and Grundy et al. (2012) investigate the market for equity options and find that short-selling constraints increase bid-ask spreads for option trading. Focusing on financial institutions, several studies examine the effects of short-selling bans on their stock price levels, market quality, and price volatilities (Marsh and Payne (2012), Harris et al. (2013), Helmes et al. (2010), Bailey and Zheng (2012), Beber et al. (2014)). Still, results are mixed. Helmes et al. (2010) and Marsh and Payne (2012) draw inferences from international financial institutions, and show that short-selling bans did little to prevent price from dropping and are detrimental to market quality. Bailey and Zheng (2012) find small stabilizing effects of the short-selling bans, yet the effects vanish quickly. Harris et al. (2013), on the other hand, find inflated price level of the banned financial stocks. These studies, however, are silent on the real impact of short-selling activities and restrictions.

Grullon et al. (2015) study the real impact of short-selling bans, and specifically, how the relaxing of short-selling constraints affects the financing and investment decisions of affected firms. They find that more short-selling leads to lower equity prices, less equity issuance, and reduced investments. Brunnermeirer and Oehmke (2013) analyze through a theoretical perspective why a short-selling ban is necessary for financial institutions when they are vulnerable to predatory short-selling activities. They argue that without constraints, short sellers can force financial institutions to liquidate long-term investments at loss, and banks with high leverage are subject to runs by their investors. Liu (forthcoming) proposes a theoretical scenario where aggressive short-selling attacks can reduce price informativeness and increase the fundamental uncertainty faced by creditors. The creditors, wary of downside risks, will in turn withdraw from the bank. The short-selling activity can thus lead to a self-enforcing bank run by both equity investors and creditors, ultimately leading to bank failures.

Despite the rich theoretical work, there has been limited empirical evidence on the implications of short-selling bans on banks' performance and lending activities. A related study to the research, Beber et al. (2014) compares various types of financial institutions in difference countries to estimate the effects from short-selling bans. They find that on average, short-selling bans do not relate to greater stability in the financial sector. However, their cross-country comparison and their broad sample of financial institutions allows less focus on banks' liquidity provision abilities. the paper focuses on US banks and their credit provisions. I thus contribute to the literature by documenting a positive, restorative effect of the 2008 ban on banks' balance sheet strength, credit provision, and profitability. The results can shed light on a stabilizing role of short-selling bans on financial institutions, and a potential spillover effect benefiting the real sectors of the economy.

Bank Capital and Bank Credit Provision

A large body of theoretical literature analyzes how the bank liquidity and capital regulation can affect banks' lending activities. This literature largely agree that the availability and regulation of bank capital have significant effects on banks' credit provision and loan rates (e.g., Stiglitz and Weiss (1981), Thakor (1996), and VanHoose (2007)).

Empirical studies also document a strong relationship between banks' capital adequacy and bank lending activities (e.g., Khwaja and Mian (2008), Paravisini (2008), and Schnabl (2012)). Liquidity shocks to banks can cause banks to change their supply of credit accordingly. Khwaja and Mian (2008) use a Pakistan nuclear test and a hault in foreign currency exchange as a negative shock to bank capital, and show that this shock leads to a reduction in bank lending. Paravisini (2008) shows that with government injection of funds, Argentinian banks expand lending drastically. Schnabl (2012) further documents that Peruvian banks reduce lending following a negative liquidity shock accompanied by the 1998 Russian default.

I find that the 2008 short-selling ban helps banks restore their balance sheet strength, achieve better performance, and offer cheaper loan rates. The results are consistent with the extant research that positive liquidity shocks and a stronger balance sheet are associated with an improved lending capacity.

Empirical Methodology

Data and Sample

The goal is to examine the impacts of short-selling ban on banks' lending terms and performance. To do so, I collect information regarding bank fundamentals, syndicated

loan terms, and their traded CDS and equity options.

I start with the list of 389 banks that are covered in the short-selling bans. Included in the list are both domestic and foreign banks. I thus match the names of these banks to their identity and collect their balance sheet information from several data sources, including the Federal Reserve Call report, Bloomberg as well as Compustat Bank, North America, and Global databases. By combining all these data sources, I am able to obtain fundamental information for a wide coverage of 140 banks out of 389 that are covered in the short-selling ban.

I obtain detailed information regarding syndicated loan contracts from Loan Pricing Corporation (LPC) Dealscan database. To construct a treated sample consisting of banks that are covered by the short-selling ban, I hand match Dealscan lenders with the lists of banks in July Order and September Order. Out of 17 banks in the July Order, I am able to identify 16 with Dealscan information (except Allianz SE). I am also able to match 140 banks on the September short-selling ban list with Dealscan information.

The initial sample of syndicated loans consists of 13,599 loans issued by 321 unique banks to 2,830 borrower during the period of 2007 to 2009. I link the borrower names in Dealscan to their Compustat identifiers following Chava and Roberts (2008), and exclude loans whose borrowers belong to financial and utility sectors and whose lenders do not have available bank fundamental information. Finally, I require the loans to be extended during the sample period from one year before the start of the ban (July 21, 2007) till one year after the lift of the ban (October 8, 2009). These restrictions leave us 5,344 loans issued by 226 banks.

To study the effect of the short-selling ban on the treated banks (treated), I compare these banks to a group of similar banks whose lending and performance can serve as a benchmark. To do so, I construct a control group of banks that

are not subject to the short-selling ban, but have similar size, equity ratio, and credit conditions. I also require the treated and control banks to be either both included in the TARP program later (in October 2008), or excluded from the TARP program. This helps us distinguish the stabilizing effect of the TARP program from the persistent effects of the short-selling ban.

I employ propensity score matching to construct the control group: for each treated bank, I choose three banks that are not included in the short-selling ban but are the "closest neighbors" of the treated bank in terms of the matching criteria. Given that bank characteristics may go through considerable changes throughout the 2008 crises, I allow the control group to change for every event-length (78 days) window. In this way, I am able to compare a treated bank to a control bank of similar characteristics at all times. The matching procedure identifies 399 pairs of treated and control banks during the one year before the start of the short-selling ban (July 21, 2008), 69 pairs during the effective span of the ban (July 21, 2008–October 8, 2008), and 258 pairs during the one year after the lift of the ban.[4]

Throughout the analysis, I maintain a loan-level sample to facilitate the understanding of bank lending behaviors. The final sample consists of 3,650 syndicated loans that are extended by 56 treated banks and 56 matched control banks.

Time and Event Windows

Given the short span of the 2008 short-selling ban, I am able to closely examine the effects of the initiation and the removal of the ban on the same group of treated banks. I study the initiation effects of the ban by comparing banks' behaviors before the ban is initiated and when the ban is effective. I then study the removal effects

[4]To test the robustness of the results, I also use a constant control group over all event windows, and arrive at similar results.

of the ban by comparing between the effective period and the period after the ban is lifted.

I thus define three event windows: a one-year pre-event window that ends when the first short-selling ban is initiated (July 21, 2007 — July 20, 2008), a during-event window for which the short-selling ban is in effect for a given bank (July 21 — August 12, 2008 for July banks and September 18, 2008 — October 8, 2008 for September banks), and a one-year post-event window that starts when the September short-selling ban is lifted (October 9, 2008 — October 8, 2009). Accordingly, I define three time variables: *Before* is a dummy variable indicating the one-year pre-event window, *During* indicates the effective span of the ban, and *After* indicates the one-year post-event window.[5] Figure 1.1 shows in more detail the definition of the event windows and variables.

CDS and Options

To understand investors' perception about the sample banks' financial stability, I examine measures of downside risks extracted from the traded derivatives of these banks. To understand the beliefs of both creditors and equity investors, I examine the secondary market trading prices of banks' CDS contracts and equity options. CDS contracts provide insurance against banks' defaults or other credit events. The spreads on these contracts thus reflect the insurance premium that buyers and sellers consider "fair" to compensate for these credit events. Spreads thus positively correlate with the perceived credit risk of banks. I collect CDS information from the Markit Pricing database, which reports the spreads and liquidity of CDS contracts on a daily frequency. With this database, I examine the spreads of both 1-year and 5-year CDS

[5]To test the robustness of the results across different definitions of event window, I also use a "rough" definition of event window, assigning all dates in between July 21 — September 18, 2008 as "During" the short-selling ban. This time variable assignment generates similar results.

contracts, which are commonly used maturities in the literature to reflect underlying firms' default risks and credit conditions (Longstaff et al.(2005), Jorion and Zhang (2009), Galil et al. (2014)).

In addition, I examine banks' equity options, whose prices reflect the belief of equity investors. I collect options trading information from OptionMetrics. Among a variety of oustanding option contracts, I focus on deep OTM put options, defined as options whose moneyness is lower than 85%. Deep OTM put options have very low strike prices and they only become valuable as the underlying equity price drops to a level that is below the strike prices. The prices of these options thus reflect investors' belief of the probability that a bank's equity value will drop significantly. The prices of these options provide a proxy for the perceived downside risks (Day and Lewis (1992), Christensen and Prabhala (1998), Bollen and Whaley (2004), Benzoni et al. (2005), Cao et al. (2010)). Following prior literature (Black and Scholes (1973), Dumas et al. (1998), and An et al. (2014)), I collect the Black-Sholes implied volatility of these options, which is positively related to option price and provides a measure that is comparable across underlying security prices and contract features. I focus on only options that have 1-3 months to maturity. These close-to-maturity options can provide a more accurate proxy for investors' concern that the underlying security could face a large loss in the near future.

Equity Issuance and Deposits

Investors' perception about bank risk is only a first step that the short-selling ban can affect bank fundamentals. Yet investors' perception alone does not directly change a bank's operating and lending activities. For the short-selling ban to affect such activities, I should first observe its effect on a bank's access to outside financing, especially equity issuance. If the short-selling ban restores investors' belief about

banks' likelihood of survival, I expect these banks to issue equity with larger amount and higher frequency in the capital market.

I investigate this channel by examining the actual equity issuance activity by the sample banks. To do so, I collect the information regarding equity issuance of the banking sector from SDC platinum database. I measure issuance activities in two ways. First, I measure the frequency of issuance by counting how many times a bank issues equity in a given quarter (*# Equity Issuance*). Second, I measure the amount of equity issued using the log of the total amount of equity financing raised for a bank-quarter (*Equity Issuance Amount*). I expect treated banks to increase their equity issuance activities along the above dimensions during the short-selling ban.

I supplement this test examining the deposit growth of treated and control banks. I measure deposit growth using the percentage annual change in deposit from balance sheet information (*Deposit Growth*). With creditors considering the treated banks as having a lower credit risk, I expect these banks to enjoy a greater deposit growth.

Bank Balance Sheet Strength

If the short-selling ban allows the affected banks to obtain more equity financing, these banks will then enjoy a more adequate capital reserve, indicating a stronger balance sheet. To verify this effect, I extract and combine banks' balance sheet information from several sources, including Federal Reserve Call Report, Compustat, and Bloomberg. I measure banks' balance sheet strength using Tier-1 capital ratio, which includes its common equity and retained earnings, which are of the highest quality capital components ("core capital"). The Basel Accord strictly maintains a minimum Tier-1 capital ratio, stating that a higher ratio indicates that a bank has more adequate resources to absorb future losses. I present the Tier-1 capital ratio in percentage points.

I next study the effect of the short-selling ban on banks' profitability using the ratio of investment gains to total assets. Higher levels of investment gains indicating a higher earnings capacity for the banks. I expect the treated banks to enjoy a higher level of investment gains during the short-selling ban.

Finally, I construct bank characteristics that are used in the matching procedure, including size, equity ratio, and credit ratings.

Lending and Performance

I examine the effect of short-selling ban on banks' lending activity and fundamental performance. This linkage helps us evaluate whether the ban has "real" impacts that extend beyond the financial sector. To do this, I extract information from LPC Dealscan database, which provides detailed information regarding syndicated loan contracts.

Rhodes (2000) and Murfin (2012) show that loan terms are negotiated around three months in advance of a facility's start date reported in Dealscan. The reason is that syndicated loans often take two months to become effective after the borrower awards the lead bank a mandate (syndication/documentation process), and another one month between the time a bank approves of a term sheet and the time it receives a mandate (mandate process). Therefore, a loan that is recorded to start in December could be contracted as early as in September. Naturally, in deciding the contracting terms of this loan, banks are likely to take into account their financial conditions in September rather than in December. Following Murfin (2012), I incorporate this time lag by accounting for the contracting date of a loan as 90 days before its reported start date.

To gauge the impact on banks' lending activities, I consider three dimensions: loan markups, lending capacity, and loan quality. I measure interest rate markups

specified on the loan contracts. Following previous literature (Roberts and Suri (2009) and Campello et al. (2011)), I extract syndicated loan terms from Dealscan database, and measure markups using the "All-in-Drawn" spread in basis points over LIBOR (*Loan Spread*). *Loan Spread* aggregates the coupons and annual fees charged by a lending bank, and it reflects the bank's risk tolerance and its capacity for credit provision.

Next, I directly measure banks' lending capacity by counting the number of syndicated loans extended by each bank to its individual borrowers (*#Loans*). Finally, I examine the quality of loans extended by the sample banks using the default likelihood of loans extended around the short-selling ban. I define a dummy variable *Loan Failure* that equals 1 if the borrower company is rated as default ("SD", "RD", or "D") before the loan matures. Low default rates suggest better quality lending and a higher screening effort. It also helps assess a more subtle implication to the policy, i.e. whether the short-selling ban could induce lax credit extension.

Controls

Despite that the sample of banks are matched based on important bank-level characteristics, I control for various covariates that could correlate with the variables of interests. For bank-level panels, I control for bank characteristics, such as bank size, equity ratio, ratings, and a dummy variable *TARP* indicating whether the bank is later included in the TARP program. For the samples that include loan-level outcomes, I control for loan-level characteristics such as spreads, maturity, the number of covenants, loan size, and an indicator for term loans. I also include syndicate structure such as the number of lenders involved in the syndicate as well as the number of facilities included in the same loan package. In additional, I construct and control for borrower characteristics including size, age, tangibility, market-to-book,

leverage, and ratings. I winsorize all the continuous variables within the 5th and 95th percentiles, and I limit leverage to be within 0 and 1.

Empirical Framework

To examine the effect of the short-selling ban on treated and control banks, I employ a differences-in-differences approach, regressing the variables of interest on the interaction of *Treated* and time variables *During* and *After*. Specifically, I consider the following regression model:

$$\begin{aligned} Y_{i,j,t} = \beta_0 + \beta_1 During + \beta_2 Treated \times During + \beta_3 After \\ + \beta_4 Treated \times After + \beta_5 Controls + \sum \xi_i + \sum \zeta_i + \sum \eta_t + \epsilon_{i,j,t}, \end{aligned} \quad (1.1)$$

where Y indicates the variables of interest. It includes CDS spreads, implied volatility, equity issuance, deposit growth, Tier-1 capital ratio, loan spreads, number of loans issued, loan failure, and bank performance. *Treated* is a dummy variable that equals 1 if the loan is extended by a treated bank and 0 if the loan is extended by a matched control bank; *Controls* include bank characteristics (e.g., size, equity ratio, and ratings), policy features (e.g., whether the bank is included in the July short-selling ban list, and whether the bank is involved in the TARP program), loan characteristics (maturity, covenants, term loan, etc.), and borrower characteristics (size, age, leverage, etc.). ξ stands for bank-fixed effects, ζ stands for borrowers' sector-fixed effects, and η stands for year-quarter-fixed effects. Note that *Treated* is absorbed by bank-fixed effects, but the time variables are not. This is because the short-selling ban does not start exactly at the beginning of a fiscal quarter for every bank.

In Eq. 1.1, I am interested in coefficient β_2, which represents the difference in the changes in the variables of interest from before the ban to during the ban between

treated and control banks. It suggests the effects of the short-selling ban on banks' balance sheet conditions and lending behaviors.

In the next section, I report the results of the analysis in stages. I first present the differences-in-differences results controlling for fixed effects. I then report results controlling for bank characteristics and policy features. For loan-level tests, I further add in controls for loan characteristics and borrower characteristics.

Results

Summary

Table 1.1 shows the summary statistics of the characteristics for the treated and control banks before, during, and after the event periods. It compares the characteristics with which I match the treated and control samples, including bank size, equity ratio, ratings, and whether a bank is included in TARP. There is no significant difference in any matching characteristics between the treated and control banks, with p-values largely above 10% for both before and during the short-selling ban. After the short-selling ban was lifted, the treated banks are similar to their matched counter-parties, except that they have a slightly higher equity ratio.

TABLE 1.1 ABOUT HERE

Figure 1.2 further illustrates the matching process. Panel (a) displays the distribution of the computed propensity score for the affected and unaffected banks by the short-selling ban before the matching and Panel (b) shows the distribution of propensity scores for the matched treated and control banks. In each figure, the red line demonstrates the distribution of treated banks and the green dashed line demon-

strates that of control banks. The patterns in these figures suggest that the affected and unaffected banks by the short-selling ban have very different characteristics before the matching. Yet the matched treated and control banks have very similar characteristics, which suggest close propensities of receiving the treatment.

Perceived Financial Health

I first examine whether the short-selling ban changes investors' percetion about banks' stability and risk. To do this, I focus on the CDS spreads and the implied volatility of deep OTM equity options of the sample banks.

CDS contracts are insurance agreements against credit events such as default, missing payments, and downgrades. The spreads on these contracts reflect banks' credit risk perceived by their creditors. I examine the CDS contracts for all banks with 4-digit SIC code between 6020 and 6719, which is the same range as the SEC order dictated. I then construct a matched treated-control sample with 51 treated banks and 29 control banks with available CDS trading information around the short-selling ban.

Figure 1.4 illustrates how the 5-year CDS spreads of the matched sample banks evolve on a daily basis around the short-selling ban. The red line represents the CDS spreads for treated banks, while the green dashed line represents the CDS spreads for control banks. The blue columns represent the difference between treated and the control groups. Prior to the ban, the 5-year CDS contracts of treated banks are traded at a higher spread than those of control banks, reflecting investors' concerns about the default risk of the treated banks. As the short-selling ban is initiated, the CDS spreads of treated banks decline to a level that is lower than those of control banks. After the ban is lifted, the treated banks see their CDS spreads increase again, passing the level of the control banks. These patterns suggest that the short-selling

ban helps reduce investors' concern regarding the credit risks of treated banks.

I then formally test the effect of the short-selling ban on the CDS spreads of affected banks. Following prior literature (Zhang et al. (2009), Corò et al. (2013), and Galil et al. (2014)), I adopt daily frequency to better capture the trading dynamics of the CDS market. I control for macro conditions that can affect CDS spreads, including interest rates, VIX index, inflation, credit spreads, term spreads, and equity market return. I also control for each bank's equity volatility, which is an indicator of fundamental risk.

Table 1.2 shows the results for banks' CDS spreads. Columns (1) through (3) show the effect of the short-selling ban on 5-year CDS spreads for treated and control banks. Columns (4) through (6) show the effect on 1-year CDS contracts. For each dependent variable, I present the results in 3 steps. I first report results from regressing CDS spreads on the interaction of *Treated* and time variables, controlling only for fixed effects. Next, I report results with controls of macroeconomic variables. Finally, I report results with controls of bank characteristics, such as size, equity ratio, leverage, rating, TARP dummy, and equity volatility.

In all regressions, the coefficient of the interaction term *Treated* $\times$ *During* indicates the difference-in-differences results, i.e., the difference in the changes of CDS spreads from the period before the ban was initiated to the period during the ban between treated and control banks. The interaction term attracts negative, significant coefficients for both 5-year and 1-year CDS contracts, indicating that the short-selling ban enhances the perceived credit worthiness of treated banks relative to that of control banks. The coefficient from column (3) suggests that the treated banks experience a 151-basis point reduction in CDS spreads than the control banks. These results are consistent with the findings in Figure 1.4 that the treated banks are perceived as less risky during the ban. However, *Treated* $\times$ *After* also attracts significant, negative

coefficients, indicating a persistent effect of the ban on investors' belief.

TABLE 1.2 ABOUT HERE

I then examine the perceived downside risk of the sample banks from an equity investors' perspective. To do so, I focus on the Black-Scholes implied volatilities of banks' traded options. Since implied volatility covaries with option prices, it provides information on investors' belief of the likelihood of the option to be in the money. To understand banks' downside risk, I investigate deep out-of-the-money (OTM) put options, defined as moneyness (strike/stock price) being less than 85%. The implied volatility of these options reflects investors' perception of the banks' downside risk. If the short-selling ban indeed reduces investors' concern about downside risk, I should expect the implied volatility of deep OTM put options to increase during the ban.

Table 1.3 shows the results for banks' traded options. In these tests I deviate from the baseline controls and include features of the options contracts and of the underlying securities that can affect the trading of options contracts (Harvey and Whaley (1992), Figlewski and Webb (1993), Bollen and Whaley (2004)). Column (1) reports the regression results of option implied volatility on the interaction of *Treated* and time variables, controlling only fixed effects. Column (2) further controls for option characteristics such as remaining time to maturity and moneyness. Column (3) controls for features of underlying securities, including price, return, volatility, and market capitalization. Finally, column (4) controls for bank characteristics.

TABLE 1.3 ABOUT HERE

In all regression specifications, *Treated* $\times$ *During* attracts negative and significant coefficients, suggesting that equity investors are less concerned about the downside

risk of treated banks when the short-selling ban is in place. However, *Treated* × *After* attracts positive coefficients for trading volumes, indicating a reversal of such a belief after the ban was lifted.

Equity Issuance

It is important to understand how the regulation on secondary market trading behaviors affect banks' performance and the lending decisions. One important channel, as suggested by preceding theoretical work, is that when the regulatory entity halts aggressive short-selling activities, it effectively reduces the probability of a run from investors (Brunnermeier and Oehmke (2013) and Liu (forthcoming)). With the short-selling ban in place, these banks are likely to avoid a run from investors. This enables them to raise finances from the capital market and maintain a stable balance sheet.

I verify this economic channel by examining banks' equity issuance. I measure equity issuance in two ways. First, I count the number of equity issuance by a bank during a certain quarter and define it as *# Equity Issuance*. I also measure the amount of equity capital raised by a bank using the log amount of principals it issues in a given quarter (*Equity Issuance Amount*). Employing the same difference-in-differences design as shown by eq. 1.1, I compare the issuance activity by treated banks and control banks during the short-selling ban.

Table 1.4 shows the results for equity issuance and deposits. In all specifications, *Treated* × *During* attracts positive, significant coefficients. Columns (1) and (2) show the results for the number of equity issues. The estimates in column (2) suggest that treated banks conduct one more issuance during the short-selling ban than control banks. Columns (3) through (4) show the results for the amount of equity issued. The estimates in column (4) indicate that treated banks are able to obtain more funding

from outside equity investors, around 4.43% more than the control banks. *Treated* × *After*, on the other hand, does not attract a significant coefficient, suggesting that the effect from the short-selling ban on issuance activities is attenuated when the ban was lifted.

TABLE 1.4 ABOUT HERE

Taken together, these results suggest that the treated banks enjoy a better access to external financing when the short-selling ban is in place.

Capital Adequacy and Deposits

Aside from increased equity financing, banks may also benefit from lower perceived risks from investors by maintaining stronger deposit growth. As creditors consider the treated banks as having lower default risks, it is natural to conjecture that treated banks are better able to maintain their deposit growth rates than comparable banks. Columns (1) and (2) of Table 1.5 show the regression results for banks' deposit growth. In both columns, *Treated* × *During* attracts significant, positive coefficients across all specifications. The estimates suggest that treated banks maintain a significant stronger deposit growth, by 2% during the short-selling ban than control banks.

With better access to external financing both on the equity and liability side, treated banks should be better able to reserve capital on their balance sheet. Columns (3) and (4) of Table 1.5 thus examine whether treated banks enjoy a higher Tier-1 capital ratio. Tier-1 capital ratio is defined by the Basel Accord in 1988 as the ratio of banks' core equity and reserves to its total risk-weighted assets.[6] It is considered to be the highest quality capital and an important measure of a bank's capital adequacy. In the tests for capital ratio, *Treated* × *During* attracts significant, positive coefficients,

[6]See Basel Capital Accord (1988).

indicating that treated banks enjoy more sufficient capital reserves than control banks during the term of the ban. The estimates suggest that on average, treated banks sustained capital ratios by 16 basis points higher than the control banks, around 2% of the sample average level, 9 percentage points.[7] This effect, although seemingly small, is consistent with the magnitudes of equity issuance over total banking assets. This increase in capital adequacy for treated banks, however, does not persist once the ban is lifted, as the coefficients of *Treated* × *After* are insignificantly different from zero. This suggests a short-lived effects from the short-selling ban, consistent with its short effective span.

TABLE 1.5 ABOUT HERE

Figure 1.3 further illustrates the variations of Tier-1 capital ratio of treated and control banks around the short-selling ban. The red line represents the average capital ratio of treated banks, while the green dashed line represents the average capital ratio of control banks. Before the ban was implemented, treated banks have a lower level of capital ratio than control banks, yet their capital ratios experience a similar trend prior to the initiation of the ban. During the ban, the capital ratio of treated banks maintains steadily at 8.5%, while that of control banks experiences a sharp decline. This leads to the treated banks having a higher level of capital ratio following the short-selling ban.

Bank Lending and Performance

I next examine the effects of the short-selling ban on banks' lending activities and fundamental performance. With a more adequate capital reserve to absorb potential

[7] In columns (3) and (4), the capital ratios are presented in percentage points, so 0.16 stands for 16 basis points.

losses, I expect the treated banks to be able to provide cheaper credits to real economic sectors.

Table 1.6 compares the loan spreads extended by treated and control banks around the short-selling ban. The coefficient of *Treated* × *During* is significantly negative across all specifications. The estimates suggest that treated banks extend loans with around 89 basis point more reduction in spreads than control banks during the short-selling ban. This difference is economically large compared to the sample average spreads of around 225 basis points. However, the coefficient of *Treated* × *After* is insignificantly different from zero, indicating that the loan spreads imposed by treated banks are similar to those of control banks after the ban is lifted. These results suggest that the short-selling ban helps the treated banks maintain a better lending capacity and these banks are able to extend cheaper credit during the ban. Once the ban is lifted, these banks raise spreads back to the pre-event level.

TABLE 1.6 ABOUT HERE

One may be concerned that lower loan markups could reflect that banks, instead of extending credit to lower-risk borrowers, exercise a lax lending standard and quote low rates to high-risk borrowers. If this is the case, the short-selling ban would induce more risk-taking behavior by the affected banks. To understand the implications of the loan markup differences, I examine other aspects of lending behaviors and bank performance associated with such lending behaviors. Specifically, I examine the number of loans extended by banks, the likelihood of the bank incurring loan failure, and banks' investment gains.

Table 1.8 shows the results. Columns (1) through (3) show the results for the number of loans. The coefficients of *Treated* × *During* are significantly negative, and

the coefficients of *Treated* × *After* remain insignificantly different from zero. These estimates suggest that treated banks lend one fewer loan than comparable banks during the short-selling ban. Columns (4) through (6) show the results for loan failure rate. The dependent variable is *Loan Failure*, a dummy variable that equals one if the borrower is rated as "SD", "RD", or "D" before the loan matures, and zero otherwise. The interaction term *Treated* × *During* attracts significantly negative coefficient, suggesting that the loans extended by treated banks during the ban are of lower credit risk. The estimates show that treated banks observe 43% less subsequent loan defaults than control banks. The results from columns (1) through (6) seem to suggest that the treated banks scale back their loan portfolios to borrowers of higher quality.

Columns (7) through (9) present results for banks' investment gains over total assets. The coefficient of *Treated* × *During* is significantly positive, indicating an increased investment efficiency for the treated banks during the short-selling ban. These effects are also short-lived, disappearing after the ban is lifted.

Taken together, results from Table 1.8 suggest that treated banks did not relax their lending decisions, despite being protected by the short-selling ban. Treated banks scale back lending to a select group of borrowers, and enjoy a lower loan failure rate and a higher investment efficiency. These results provide additional evidence that the short-selling ban restores stability to the banking sector.

Table 1.8 About Here

Robustness

I further examine the robustness of the main results towards alternative empirical specifications. Focusing on the central tests, e.g., ones regarding bank capital

adequacy and bank lending, I vary several of the design choices in structuring these tests.

First, I vary the length of the before- and after-event windows from one year to 4 and 6 times of the event duration (78 days) around the short-selling ban, to test whether the results are sensitive to the choice of event window length. Second, I define the *During* event dummy according to a "rough" definition of event time. Given that there are two consecutive orders of the short-selling ban (the July order and the September order), some July banks may be still under the influence of the ban even in September and investors may anticipate potential impacts for September banks even in July. Accounting for such a possibility, I define *During* to be 1 between July 21st to Oct 8th, 2008 for all bank, instead of only during the exact treatment dates. This test helps clarify whether the results arise from the short-selling ban or from investors' anticipation of it. Finally, I remove July banks from the sample and only focus on the effect of the September order. The result from this test helps us identify whether the baseline results are driven simply by the large banks included in the July order or reflect the effects on all banks subject to both orders.

Table 1.9 reports the results for Tier-1 capital ratio and loan spreads according to the above specifications. Panel A of this table reports the results for capital ratio, and Panel B presents the results for loan spreads. Columns (1) and (2) of both panels show the results by extending the event window. Column (3) shows the results from using a rough definition of time variables, inclusive of both the July and September orders. Column (4) shows the results from only including September banks in the sample. The results remain robust across all these specifications: treated banks experience a significant increase in capital adequacy during the short-selling ban, and extend cheaper credit to their borrowers. Such effects disappear after the ban is lifted.

TABLE 1.9 ABOUT HERE

Bank Capital and Effects of the Short-Selling Ban

To support the argument that the short-selling ban affects the lending activities of treated banks by strengthening their balance sheet, I explore cross-sectional variations in banks' balance sheet strength before the initiation of the ban. Specifically, I partition the sample of banks according to whether a bank's Tier-1 capital ratio is above or below the sample median prior to the ban, and examine whether the effects of the ban vary across the subsamples. If the short-selling ban affects banks by strengthening their balance sheet, I should expect the effect of the ban to mostly arise from banks with low capital reserves. For banks with sufficient reserves, the effects should be weak.

Table 1.10 shows the results for the subsample tests. The dependent variable is loan spreads extended by treated and control banks. Columns (1) through (3) show the results for loan spreads extended by banks with lower than median capital reserves prior to the ban, and columns (4) through (6) show the results for loan spreads by banks with higher capital reserves. Consistent with the expectation, *Treated*×*During* attracts negative and significant coefficients only for banks with low capital prior to the short-selling ban, and the coefficients show stronger magnitudes than those in Table 1.6. However, for banks with high capital reserves, the coefficients for *Treated*×*During* are low in magnitude and statistically indistinguishable from zero.

TABLE 1.10 ABOUT HERE

The results in this section lend support to the argument that the short-selling ban strengthens banks' balance sheet, whereby affecting banks lending behaviors. Banks with insufficient capital reserves benefit more from the short-selling ban, and are able to extend cheaper credits to the non-financial sectors.

Conclusion

This paper examines how the 2008 short-selling ban regarding financial institutions affects banks during the peak of the financial crises. Using a propensity matched treated and control sample of banks, I find that the short-selling ban has a stabilizing effect on the treated banks. Market participants perceive these banks as less risky, and these banks are able to sustain external financing through equity issuance and new deposits. As a results, the banks included in the short-selling ban maintain a higher level of Tier-1 capital ratios, which facilitates a better lending capacity. In addition, I find that the treated banks did not relax their lending standards, as these banks restrict their loan portfolio to a smaller group of borrowers, and the loans they extended during the short-selling ban exhibit lower likelihood to default. Finally, I find that these banks enjoy a higher investment gain during the short-selling ban, suggestive of a higher earnings capacity.

The central results are robust to various alternative specifications, and are manifested among banks with lower capital ratios prior to the short-selling ban. The results provide empirical support for the notion that the short-selling ban reduces banks' exposure to predatory short sellings, facilitates their access to external financing, and supports their ability to lend to other economic sectors. This suggests that the short-selling ban played an important role in stabilizing the banking sector during the crises, ultimately benefiting the economy through banks' credit extension.

Variable Definitions

Bank-level Variables

- *Tier-1 Capital*: The ratio of the bank's Tier-1 risk adjusted capital/total asset
- *Non-performing Assets*: The ratio of non-performing assets/total asset
- *Investment Gains*: The ratio of investment security gains (losses)/total asset
- *Bank Size*: Log(total asset)
- *Bank Equity Ratio*: The ratio of bank's equity/total asset
- *Bank Rating*: A dummy variable that equals 1 if the bank is rated investment grade, and 0 otherwise
- *Equity Vol*: The volatility of daily equity returns over the past 10 days
- *Trading Volume*: Daily reported equity trading volume

Borrower Characteristics

- *Borrower Size*: Log(total asset)
- *Borrower Age*: The number of years a firm exists in Compustat
- *Borrower Tangibility*: Property, plant and equipment/total asset
- *Borrower MB*: Market-to-book ratio, defined as (stock prices $\times$ stock outstanding + total assets - common equity)/total asset
- *Borrower Leverage*: Book leverage, defined as (long-term debt+ short-term debt)/total asset
- *Borrower Rating*: A dummy variable that equals 1 if the firm has available S&P ratings, and 0 otherwise

Loan-level Variables

- *Loan Spread*: Loan spreads in basis points over LIBOR
- *Loan Maturity*: Loan maturity in months
- *Loan Covenants*: The number of restrictive covenants specified in bank loan contracts
- *Loan Size*: Log(total loan amount)
- *Term Loan*: A dummy variable that equals 1 if the loan is a term loan, and 0 otherwise
- *# Lenders*: The number of lenders that participate in the syndicated loan
- *# Facilities*: The number of facilities included in a loan package

Features of Short-selling Policies

- *July Program*: A dummy variable that equals 1 if the bank is included in the July program in the short-selling ban, and 0 otherwise
- *TARP*: A dummy variable that equals 1 if the bank is included in the TARP program in a given quarter, and 0 otherwise
- *Treatment Duration*: The number of days that a bank is subject to the short-selling ban

Macroeconomic Variables

- *Federal Fund Rate*: The interest rate at which depository institutions trade federal funds (balances held at Federal Reserve Banks) with each other overnight
- *Tbill Rate*: The rates on 1-month treasury bills
- *VIX*: The implied volatility of S&P 500 index options
- *Inflation*: The level of Consumer Price Index
- *Market Return*: Property, plant and equipment/total asset
- *Term Spread*: The rate spreads between 10-year treasury and 1-year treasury notes
- *Credit Spread*: The rate spreads between corporate AAA-rated bonds and treasury bonds

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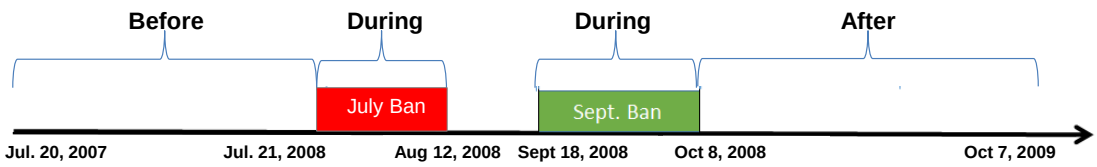
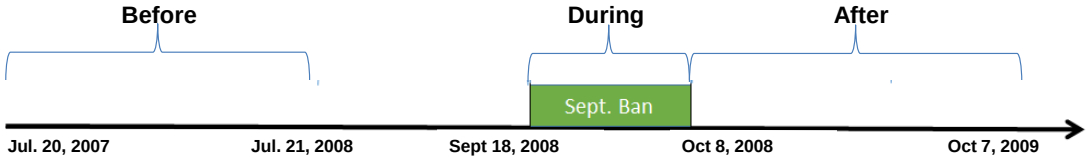


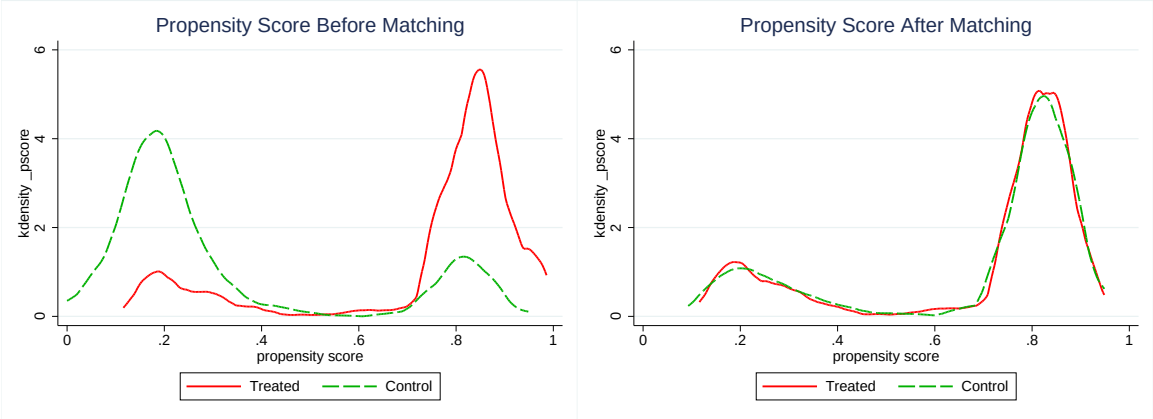
(a) Banks under both the July and the September Order

(b) Banks only under the July Order



(c) Banks only under the September Order

Figure 1.1. Timeline of event periods. This figure shows the definition of the pre-event, during-event, and post-event windows. For all banks, the pre-event window is defined as one year prior to the start of the July Order and the post-event window is defined as one year following the end of the September Order. For banks only affected by the July order, the during-event window is July 21, 2008 to August 12, 2008. For banks only affected by the September order, the during-event window is September 18, 2008 to October 8, 2008. For banks affected by both orders, the during event window is both periods.



(a) **(b)**

Figure 1.2. Distribution of propensity score before and after matching. This figure shows the propensity scores of being treated for the sample banks before and after the matching. Panel (a) shows the distribution of the propensity scores for the affected and unaffected banks before the matching. Panel (b) shows the distribution of the propensity scores for the treated and control banks after the matching. In each panel, the green dashed lines represent the propensity score distribution of treated banks, and the red lines represent that of the control banks.

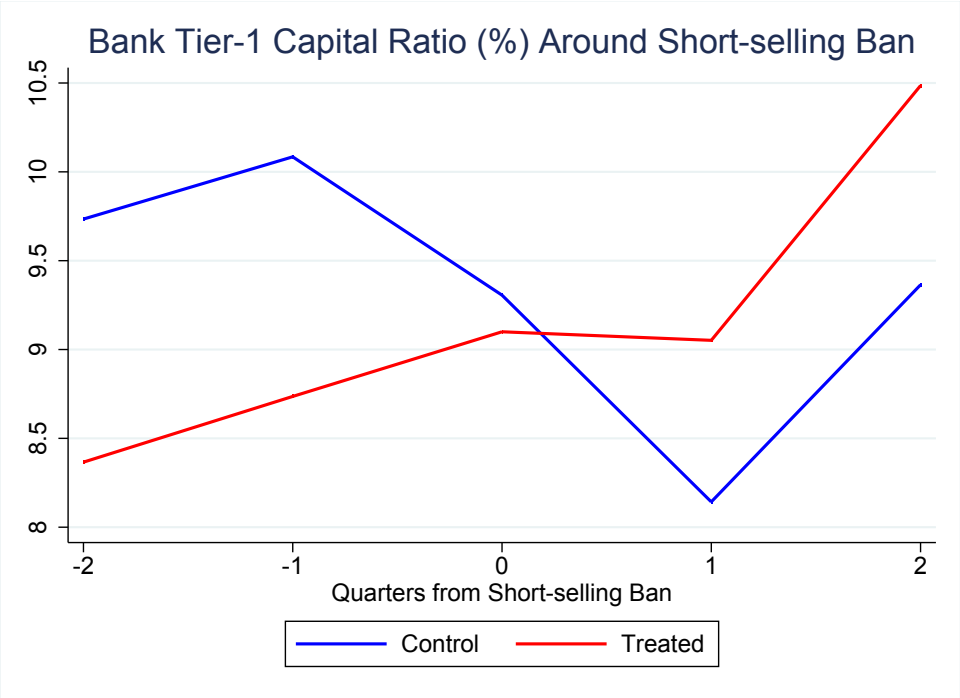


Figure 1.3. Tier-1 capital ratios of treated and control banks around the short-selling ban. This figure compares the Tier-1 capital ratios of treated and control banks before, during, and after the short-selling ban. The horizontal axis shows the number of quarters following the short-selling ban, and quarter 0 indicates the period of July 21—October 8, 2008, during which the ban was in effect. The red line represents the average capital ratio of treated banks, while the blue line represents the average capital ratio of control banks.

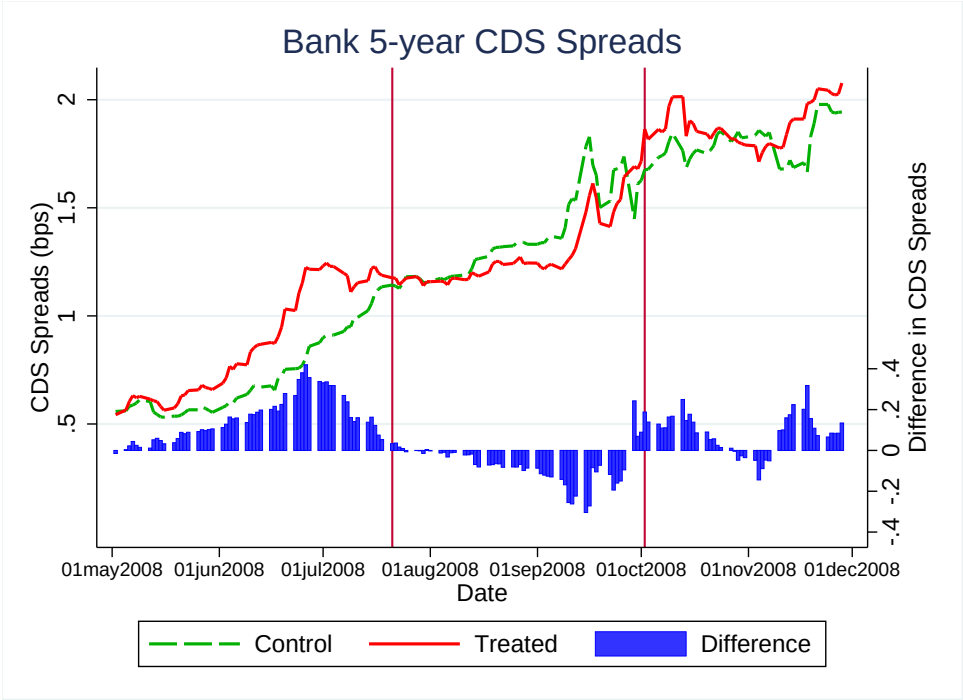


Figure 1.4. CDS spreads of treated and control banks around the short-selling ban. This figure shows the 5-year CDS spreads of treated and control banks around the short-selling ban. The horizontal axis shows dates around the short-selling ban, from February 2007 to March 2009. The red line represents the CDS spreads for treated banks, while the green dashed line represents the CDS spreads for control banks. The blue columns represent the difference between treated and the control groups.

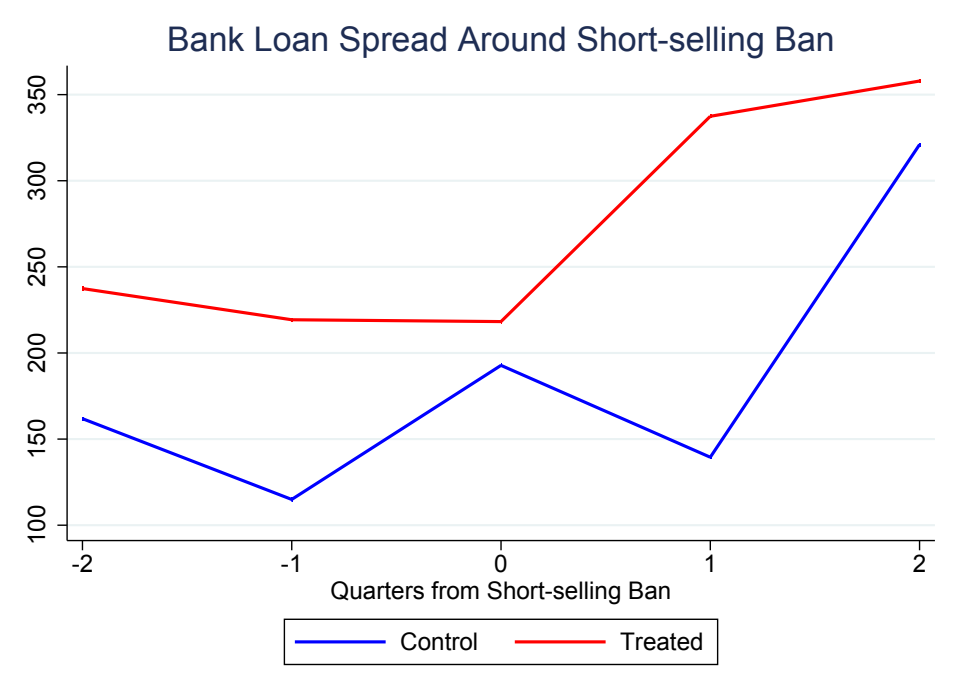


Figure 1.5. Loan spreads extended by treated and control banks around the short-selling ban. This figure compares the loan spreads extended by treated and control banks before, during, and after the short-selling ban. The horizontal axis shows the number of quarters following the short-selling ban, and 0 indicates the period of July 21 – October 8, 2008, during which the ban was in effect. The red line represents the loan spreads extended by treated banks, while the blue line represents the loans spreads extended by control banks.

Table 1.1
Summary Statistics
This table reports the summary statistics of bank characteristics and performance for both treated and control banks. Treated banks are defined as the banks included in the short-selling ban list; and control banks are the banks not included, but having similar characteristics with treated banks. The matching is conducted in every quarter. Panel A compares the characteristics of treated and control banks during different event periods (*Before*, *During*, and *After*), and Panel B compares their loan spreads, capital adequacy, and performance. The sample spans from one year prior to the start of the short-selling ban, to one year after the lift of the Ban. All continuous variables are winsorized within 5 and 95 percentile.

Panel A: Comparison of bank characteristics

	Treated	Control	Difference	*p*-value	On Support
Before					
Size	9.99	9.95	0.04	0.74	399
Equity Ratio	2.80	2.64	0.16	0.63	399
Rating	0.77	0.77	-0.00	0.99	399
TARP	0.00	0.00	0.00	1.00	399
During					
Size	10.40	10.02	0.38	0.21	69
Equity Ratio	2.11	1.97	0.14	0.76	69
Rating	0.87	0.87	0.00	1.00	69
TARP	0.00	0.00	0.00	1.00	69
After					
Size	10.35	10.20	0.15	0.51	258
Equity Ratio	2.50	2.01	0.49	0.06	258
Rating	0.73	0.70	0.03	0.63	258
TARP	0.06	0.06	0.00	0.98	258

Panel B: Comparison of loan characteristics

	Treated	Control	Difference	*p*-value	On Support
Before					
Loan Spreads	211.52	132.29	79.23	0.00	2058
Tier-1 Capital	8.67	9.19	-0.53	0.00	2058
Non-Performing Assets	0.45	0.64	-0.19	0.00	2058
Investment Gains	0.08	0.02	0.06	0.00	2058
During					
Loan Spreads	200.88	198.19	2.69	0.85	310
Tier-1 Capital	9.09	9.31	-0.22	0.33	310
Non-Performing Assets	0.60	0.74	-0.13	0.06	310
Investment Gains	0.16	-0.00	0.16	0.02	310
After					
Loan Spreads	329.67	291.48	38.20	0.00	923
Tier-1 Capital	11.25	9.95	1.29	0.00	923
Non-Performing Assets	0.89	1.02	-0.12	0.10	923
Investment Gains	-0.01	-0.03	0.02	0.01	923

Table 1.2
CDS Spreads

This table shows the effect of the short-selling ban on banks' perceived default risk. The dependent variable is bank CDS spreads, traded at daily frequency. The sample spans from one year prior to the start of the short-selling ban, to one year after the lift of the ban. *Treated* is a dummy variable that equals 1 if the loan is issued by a bank affected by the short-selling ban, and 0 otherwise. *During* is a dummy variable that equals 1 if the loan is issued during the short-selling ban, and 0 otherwise. *After* is a dummy variable that equals 1 if the loan is issued after the lift of the ban, and 0 otherwise. Columns 1 through 4 show the results for the spreads on 5-year CDS contracts, and columns 5 through 8 show the results for 1-year CDS contracts. All regressions use bank-, year-quarter-, and rating-fixed effects.

Dep. Var.:	*5-year CDS spreads*			*1-year CDS spreads*		
	(1)	(2)	(3)	(4)	(5)	(6)
During	0.85***	0.61***	0.74***	1.11***	0.44***	0.60***
	(3.89)	(2.74)	(3.19)	(8.58)	(2.99)	(3.95)
After	0.05	-5.98***	-4.41***	4.58***	-3.13***	-1.92***
	(0.13)	(-10.05)	(-7.22)	(27.43)	(-7.87)	(-4.70)
Treated × *During*	-0.60***	-0.56***	-2.09***	0.61***	-0.39***	-1.47***
	(-4.19)	(-3.93)	(-13.19)	(3.91)	(-4.03)	(-14.04)
Treated × *After*	2.70***	2.80***	3.77***	1.61***	1.28***	1.80***
	(11.09)	(11.28)	(15.13)	(7.34)	(7.81)	(11.46)
Federal Fund Rate		0.14	0.03		0.03	-0.07
		(1.24)	(0.25)		(0.38)	(-0.90)
1 Month Tbill Rate		0.97***	0.12		0.34	-0.21
		(3.24)	(0.43)		(1.52)	(-0.96)
3 Month Tbill Rate		-0.00	0.16		0.05	0.18
		(-0.02)	(0.80)		(0.35)	(1.36)
VIX		0.05***	-0.03***		0.04***	-0.02**
		(4.89)	(-2.88)		(4.62)	(-2.01)
Market Return		4.05	-1.87		2.83	-0.85
		(1.59)	(-0.78)		(1.59)	(-0.51)
Credit Spread		5.11***	4.36***		2.88***	2.39***
		(13.96)	(12.79)		(11.88)	(10.54)
Term Spread		1.18***	-0.10		0.48***	-0.34*

		(5.08)	(-0.45)		(2.61)	(-1.88)
Bank Size			14.71***			6.88***
			(9.27)			(5.84)
Bank Equity Ratio			-0.19***			-0.21***
			(-6.17)			(-9.87)
Bank Rating			-8.80***			-5.81***
			(-18.95)			(-23.05)
TARP			-8.43***			-5.79***
			(-28.46)			(-28.11)
Equity Vol			51.73***			33.63***
			(19.36)			(19.40)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Rating FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	19,906	19,115	18,848	21,596	20,733	20,466
R-squared	0.62	0.63	0.68	0.20	0.62	0.67

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 1.3
Options' Implied Volatility and Trading Volume
This table shows the effect of the short-selling ban on banks' deep out-of-the-money (OTM) options. The dependent variables are the implied volatility and the trading volume of these traded options. The sample spans from one year prior to the start of the short-selling ban, to one year after the lift of the ban. *Treated* is a dummy variable that equals 1 if the loan is issued by a bank affected by the short-selling ban, and 0 otherwise. *During* is a dummy variable that equals 1 if the loan is issued during the short-selling ban, and 0 otherwise. *After* is a dummy variable that equals 1 if the loan is issued after the lift of the ban, and 0 otherwise. Columns 1 through 4 show the results for implied volatility extracted from options' daily trading prices, and columns 5 through 8 show the results for the daily trading volume the options. All regressions use bank- and year-quarter-fixed effects.

Dep. Var.:	*Implied Volatility*				*Trading Volume*			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
During	0.45***	0.32***	0.35***	0.33***	-32.09***	-61.42***	73.85***	82.02***
	(10.42)	(7.56)	(8.12)	(7.45)	(-2.66)	(-4.97)	(4.64)	(4.85)
After	0.04	-0.24***	-0.21***	-0.22***	-6.47	-59.34***	14.08	20.59
	(1.33)	(-8.46)	(-7.33)	(-7.52)	(-0.28)	(-2.64)	(0.60)	(0.87)
Treated × *During*	-0.29***	-0.32***	-0.32***	-0.31***	72.77***	73.33***	-14.93	-17.97
	(-6.66)	(-7.47)	(-7.46)	(-7.09)	(5.61)	(5.60)	(-1.18)	(-1.38)
Treated × *After*	0.10***	0.07***	0.07***	0.07***	63.67***	62.20***	3.57	6.02
	(4.04)	(2.93)	(3.24)	(2.99)	(6.91)	(6.54)	(0.35)	(0.54)
Time to Maturity		-0.01***	-0.01***	-0.01***		-1.13***	-0.74***	-0.75***
		(-68.60)	(-66.49)	(-66.47)		(-10.43)	(-7.70)	(-7.71)
Moneyness		0.09***	0.08***	0.08***		-17.86***	-68.29***	-69.95***
		(20.24)	(15.76)	(16.66)		(-4.14)	(-13.60)	(-13.66)
Equity Price			0.00***	0.00***			1.30***	1.26***
			(13.85)	(16.27)			(8.04)	(7.75)
Equity Return			-0.41***	-0.41***			-383.19***	-386.63***
			(-14.08)	(-14.12)			(-4.49)	(-4.42)
Equity Volume			0.07***	0.07***			111.54***	112.56***
			(15.90)	(15.24)			(11.92)	(12.00)
Equity Mkt Cap			-0.08***	-0.11***			-195.97***	-194.10***
			(-7.62)	(-9.77)			(-11.94)	(-12.81)

Bank Size				-0.76***				220.10***
				(-10.55)				(5.73)
Bank Leverage				0.34***				-85.88
				(11.74)				(-1.44)
Bank Rating				-0.49***				11.55
				(-17.97)				(0.54)
TARP				0.01				-10.22
				(1.20)				(-1.18)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	46,099	46,099	46,099	45,782	46,099	46,099	46,099	45,782
R-squared	0.11	0.20	0.21	0.22	0.03	0.03	0.06	0.06

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 1.4
Equity Issuance

This table shows the effect of the short-selling ban on banks' equity issuance. The dependent variables are the number of equity issuance, the amount of equity issuance, and deposit growth. The sample spans from one year prior to the start of the short-selling ban, to one year after the lift of the ban. *Treated* is a dummy variable that equals 1 if the loan is issued by a bank affected by the short-selling ban, and 0 otherwise. *During* is a dummy variable that equals 1 if the loan is issued during the short-selling ban, and 0 otherwise. *After* is a dummy variable that equals 1 if the loan is issued after the lift of the ban, and 0 otherwise. Columns (1) and (2) show the results for *# Equity Issuance*, the number of equity issuance. Columns (3) and (4) show the results for the log amount of equity principles issued in domestic market (*Issuance Amount*). All regressions use bank- and year-quarter-fixed effects.

Dep. Var.:	*# Equity Issuance*		*Equity Issuance Amount*	
	(1)	(2)	(3)	(4)
During	-0.01	-0.01	-3.11***	-3.11***
	(-0.74)	(-0.68)	(-14.34)	(-14.27)
After	0.03	0.03	0.08	0.13
	(1.25)	(1.21)	(0.45)	(0.65)
Treated × *During*	1.00***	1.01***	4.49***	4.43***
	(2.65)	(2.68)	(4.92)	(4.84)
Treated × *After*	0.32	0.31	1.27	1.22
	(1.17)	(1.12)	(1.51)	(1.39)
Bank Size		-0.01		0.54
		(-0.10)		(0.88)
Bank Equity Ratio		0.91*		2.89
		(1.78)		(0.78)
TARP		0.01		-0.30
		(0.26)		(-0.88)
Bank FE	Yes	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes	Yes
Observations	2,729	2,716	2,697	2,684
R-squared	0.50	0.50	0.56	0.56

Robust *t*-statistics in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 1.5
Capital Adequacy
This table shows the effect of the short-selling ban on banks' capital adequacy. The dependent variable is banks' Tier-1 capital ratio. The sample spans from one year prior to the start of the short-selling ban, to one year after the lift of the Ban. *Treated* is a dummy variable that equals 1 if the loan is issued by a bank affected by the short-selling ban, and 0 otherwise. *During* is a dummy variable that equals 1 if the loan is issued during the short-selling ban, and 0 otherwise. *After* is a dummy variable that equals 1 if the loan is issued after the lift of the Ban, and 0 otherwise. Column 1 shows the regression results of loan spread on the full interaction of *Treated* with *During* and *After*, controlling for loan and borrower characteristics. Column 2 controls further for features of the short-selling ban. Column 3 adds bank characteristics as controls. All regressions use bank-, borrowers' sector-, and year-quarter-fixed effects.

Dep. Var.: *Tier-1 Capital*	(1)	(2)	(3)
During	-8.22***	-8.21***	-8.37***
	(-28.59)	(-28.30)	(-28.78)
After	1.74***	1.73***	1.17**
	(3.09)	(3.05)	(2.00)
Treated × *During*	8.70***	8.69***	8.72***
	(35.30)	(35.05)	(36.96)
Treated × *After*	0.36	0.36	0.66**
	(1.54)	(1.53)	(2.52)
Loan Spread	0.00	0.00	0.00
	(0.23)	(0.22)	(0.71)
Loan Maturity	0.00	0.00	0.00
	(0.05)	(0.06)	(0.67)
Loan Covenants	-0.01	-0.01	0.01
	(-0.24)	(-0.25)	(0.23)
Loan Size	0.04	0.04	0.02
	(1.08)	(1.09)	(0.71)
Term Loan	0.05	0.05	0.04
	(0.78)	(0.79)	(0.76)
# Lenders	-0.00	-0.00	-0.00
	(-0.03)	(-0.04)	(-0.25)
# Facilities	0.00	0.00	0.00
	(0.43)	(0.44)	(0.56)
Borrower Size	-0.04	-0.04	-0.02
	(-0.82)	(-0.83)	(-0.41)
Borrower Age	0.00	0.00	0.00
	(0.80)	(0.78)	(0.36)
Borrower Tangibility	-0.27	-0.28	-0.20
	(-0.85)	(-0.87)	(-0.59)
Borrower MB	-0.02	-0.02	-0.02
	(-0.39)	(-0.39)	(-0.35)
Borrower Leverage	0.25	0.25	0.23
	(1.08)	(1.08)	(1.02)
Borrower Rating	0.05	0.05	0.04
	(0.64)	(0.64)	(0.62)
July Program		72.71***	49.01***
		(15.72)	(6.90)

Treatment Duration		1.20***	0.81***
		(15.93)	(7.10)
TARP		0.07	0.12
		(0.24)	(0.43)
Bank Size			-0.02
			(-0.41)
Bank Equity Ratio			0.12***
			(3.72)
Bank Rating			1.11**
			(2.30)
Bank FE	Yes	Yes	Yes
Borrowers' Sector FE	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes
Observations	922	922	911
R-squared	0.93	0.93	0.94

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 1.6
Loan Spreads
This table shows the effect of the short-selling ban on bank loan spreads. The dependent variable is loan spreads in basis points over LIBOR. The sample spans from one year prior to the start of the short-selling ban, to one year after the lift of the ban. *Treated* is a dummy variable that equals 1 if the loan is issued by a bank affected by the short-selling ban, and 0 otherwise. *During* is a dummy variable that equals 1 if the loan is issued during the short-selling ban, and 0 otherwise. *After* is a dummy variable that equals 1 if the loan is issued after the lift of the ban, and 0 otherwise. Column 1 shows the regression results of loan spread on the full interaction of *Treated* with *During* and *After*, controlling for loan and borrower characteristics. Column 2 controls further for features of the short-selling ban. Column 3 adds bank characteristics as controls. All regressions use bank-, borrower-sector-, and year-quarter-fixed effects.

Dep. Var.: *Loan Spreads*	(1)	(2)	(3)
During	66.47	68.62	79.51*
	(1.47)	(1.51)	(1.74)
After	141.30**	138.41**	158.42***
	(2.48)	(2.42)	(2.77)
Treated × *During*	-68.40**	-69.63**	-79.07***
	(-2.28)	(-2.32)	(-2.58)
Treated × *After*	-24.28	-21.45	-39.40
	(-0.96)	(-0.85)	(-1.41)
Loan Maturity	-0.15	-0.15	-0.20
	(-0.70)	(-0.68)	(-0.92)
Loan Covenants	10.83***	10.56***	11.48***
	(2.86)	(2.77)	(2.96)
Loan Size	-11.33***	-11.17***	-10.62***
	(-3.36)	(-3.29)	(-3.03)
Term Loan	41.72***	41.60***	41.29***
	(6.46)	(6.45)	(6.36)
# Lenders	-0.74	-0.75	-0.63
	(-1.15)	(-1.16)	(-0.95)
# Facilities	0.48	0.50	0.45
	(0.74)	(0.77)	(0.64)
Borrower Size	1.96	2.00	0.59
	(0.40)	(0.41)	(0.12)
Borrower Age	-1.02**	-1.05**	-1.19**
	(-2.29)	(-2.35)	(-2.55)
Borrower Tangibility	-21.36	-24.97	-21.82
	(-0.59)	(-0.69)	(-0.59)
Borrower MB	-26.25***	-26.31***	-25.24***
	(-5.51)	(-5.52)	(-4.83)
Borrower Leverage	141.91***	142.94***	138.02***
	(5.83)	(5.82)	(5.60)
Borrower Rating	-37.07***	-37.48***	-33.97***
	(-4.40)	(-4.45)	(-3.96)
July Program		-141.44**	-151.37**
		(-2.53)	(-2.57)
Treatment Duration		-1.24**	-1.26**
		(-2.18)	(-2.18)

TARP		40.29	44.44
		(1.36)	(1.40)
Bank Size			4.92
			(0.95)
Bank Equity Ratio			-2.26
			(-0.65)
Bank Rating			-110.84**
			(-1.99)
Bank FE	Yes	Yes	Yes
Borrowers' Sector FE	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes
Observations	1,529	1,529	1,466
R-squared	0.72	0.72	0.73

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 1.7
Loan Failure

This table shows the effect of the short-selling ban on bank loan failure rate. The dependent variables are the number of loans extended to each borrower (*# of Loans*) and loan failure (*Loan Failure*). *Loan Failure* is a dummy variable that equals one if the borrower files for bankruptcy before loan maturity, and zero otherwise. The sample spans from one year prior to the start of the short-selling ban, to one year after the lift of the ban.

Dep. Var.:	*# of Loans*			*Loan Failure*		
	(1)	(2)	(3)	(4)	(5)	(6)
During	0.54**	0.55**	0.55**	0.44***	0.44***	0.44***
	(2.14)	(2.17)	(2.15)	(4.95)	(4.93)	(4.87)
After	-0.65	-0.65	-0.65	0.09**	0.09**	0.10**
	(-1.49)	(-1.50)	(-1.44)	(2.53)	(2.55)	(2.52)
Treated× During	-0.70***	-0.70***	-0.69***	-0.42***	-0.42***	-0.41***
	(-3.16)	(-3.18)	(-3.06)	(-4.61)	(-4.61)	(-4.51)
Treated× After	0.06	0.07	0.04	-0.03	-0.03	-0.04
	(0.53)	(0.60)	(0.30)	(-1.46)	(-1.48)	(-1.41)
Loan Spread	0.00**	0.00**	0.00**	0.00***	0.00***	0.00**
	(2.43)	(2.40)	(2.48)	(2.70)	(2.70)	(2.56)
Loan Maturity	0.00***	0.00***	0.00***	-0.00***	-0.00***	-0.00***
	(3.89)	(3.93)	(3.88)	(-3.22)	(-3.22)	(-3.15)
Loan Covenants	-0.01	-0.01	-0.01	0.01*	0.01*	0.00
	(-0.80)	(-0.82)	(-0.82)	(1.82)	(1.81)	(1.53)
Loan Size				0.00	0.00	0.00
				(0.32)	(0.30)	(0.23)
Term Loan	0.20***	0.19***	0.19***	-0.01	-0.01	-0.01
	(4.10)	(4.04)	(3.77)	(-1.40)	(-1.40)	(-1.39)
# Lenders	0.01***	0.01***	0.01***	-0.00	-0.00	-0.00
	(2.65)	(2.67)	(2.66)	(-1.15)	(-1.14)	(-0.97)
# Facilities	0.04***	0.04***	0.04***	-0.00***	-0.00***	-0.00***
	(12.50)	(12.53)	(12.22)	(-3.08)	(-3.09)	(-3.03)
Borrower Size	-0.08***	-0.08***	-0.08***	0.02**	0.02**	0.02**
	(-4.45)	(-4.45)	(-4.28)	(2.44)	(2.44)	(2.43)
Borrower Age	0.00	0.00	0.00	0.00	0.00	0.00

	(0.82)	(0.79)	(1.00)	(1.23)	(1.23)	(1.42)
Borrower Tangibility	0.03	0.01	0.02	0.03	0.03	0.03
	(0.21)	(0.11)	(0.13)	(0.59)	(0.59)	(0.62)
Borrower MB	0.01	0.01	0.01	-0.00	-0.00	-0.00
	(0.48)	(0.47)	(0.48)	(-0.39)	(-0.39)	(-0.37)
Borrower Leverage	0.03	0.03	0.06	0.07**	0.07**	0.07**
	(0.26)	(0.26)	(0.59)	(2.44)	(2.44)	(2.40)
Borrower Rating	0.03	0.03	0.02	-0.03***	-0.03***	-0.03***
	(0.89)	(0.86)	(0.65)	(-2.81)	(-2.79)	(-2.88)
July Program		-0.45	-0.58		-0.02	-0.03
		(-1.08)	(-1.35)		(-0.66)	(-0.49)
Treatment Duration		-0.00	-0.00		-0.00	-0.00
		(-0.31)	(-0.19)		(-1.03)	(-1.06)
TARP		0.15	0.10		-0.01	-0.00
		(1.19)	(0.73)		(-0.47)	(-0.24)
Bank Size			0.01			-0.00
			(0.49)			(-0.14)
Bank Equity Ratio			-0.03*			-0.00
			(-1.67)			(-0.07)
Bank Rating			-0.62			-0.01
			(-1.38)			(-0.21)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Borrowers' Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	916	916	875	1,529	1,529	1,466
R-squared	0.68	0.68	0.67	0.60	0.60	0.60

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 1.8
Bank Performance
This table shows the effect of the short-selling ban on banks' performance. Bank performance is measured by non-perfroming loans (NPA) and Investment Gains (IG). NPA is measured as the ratio of non-performing assets over total assets, and IG is measured by the investment gains over total assets. The sample spans from one year prior to the start of the short-selling ban, to one year after the lift of the ban. *Treated* is a dummy variable that equals 1 if the loan is issued by a bank affected by the short-selling ban, and 0 otherwise. *During* is a dummy variable that equals 1 if the loan is issued during the short-selling ban, and 0 otherwise. *After* is a dummy variable that equals 1 if the loan is issued after the lift of the ban, and 0 otherwise. All regressions use bank-, borrowers' sector, and year-quarter-fixed effects.

Dep. Var.:	*Non-perfoming Assets/Total Assets*			*Investment Gains/Total Assets*		
	(1)	(2)	(3)	(4)	(5)	(6)
During	-0.07	-0.06	0.04	-0.01	-0.01	-0.01
	(-0.23)	(-0.20)	(0.18)	(-0.25)	(-0.22)	(-0.30)
After	0.49	0.41	0.80*	0.10	0.07	0.06
	(0.98)	(0.84)	(1.84)	(0.63)	(0.44)	(0.35)
Treated × *During*	-0.29***	-0.30***	-0.25***	0.33***	0.32***	0.32***
	(-3.05)	(-3.22)	(-2.94)	(3.06)	(3.01)	(2.99)
Treated × *After*	-0.12	-0.04	0.10	-0.07	-0.04	-0.08*
	(-0.67)	(-0.23)	(0.45)	(-1.64)	(-1.07)	(-1.88)
Loan Spread	-0.00	-0.00	0.00	-0.00	-0.00	-0.00
	(-0.13)	(-0.31)	(0.02)	(-1.23)	(-1.35)	(-1.46)
Loan Maturity	-0.00	0.00	-0.00	0.00	0.00	0.00
	(-0.02)	(0.11)	(-0.65)	(0.78)	(0.86)	(0.47)
Loan Covenants	-0.00	-0.00	-0.01	-0.01	-0.01	-0.01*
	(-0.12)	(-0.19)	(-1.07)	(-1.42)	(-1.46)	(-1.68)
Loan Size	-0.01	-0.01	-0.01	0.01	0.01	0.01
	(-1.20)	(-1.16)	(-1.04)	(0.82)	(0.86)	(1.16)
Term Loan	0.01	0.01	0.02	-0.01	-0.01	-0.01
	(0.56)	(0.52)	(1.38)	(-0.96)	(-1.03)	(-0.89)
# Lenders	0.00	0.00	0.00	0.00	0.00	0.00
	(1.28)	(1.29)	(1.40)	(0.29)	(0.27)	(0.37)
# Facilities	-0.01	-0.01	-0.01*	-0.00	-0.00	-0.00
	(-1.33)	(-1.28)	(-1.69)	(-1.43)	(-1.35)	(-1.05)
Borrower Size	-0.00	-0.00	0.00	0.00	0.00	0.00

	(-0.10)	(-0.19)	(0.10)	(0.38)	(0.39)	(0.34)
Borrower Age	0.00	0.00	0.00	0.00	0.00	0.00
	(0.60)	(0.07)	(0.57)	(1.65)	(1.25)	(1.15)
Borrower Tangibility	0.15	0.12	0.02	-0.00	-0.01	-0.01
	(0.77)	(0.63)	(0.14)	(-0.03)	(-0.19)	(-0.18)
Borrower MB	0.05	0.05	0.03	-0.02	-0.02	-0.03*
	(1.64)	(1.54)	(1.23)	(-1.29)	(-1.38)	(-1.71)
Borrower Leverage	0.05	0.02	0.12	-0.02	-0.03	-0.02
	(0.51)	(0.20)	(1.30)	(-0.37)	(-0.57)	(-0.37)
Borrower Rating	-0.03	-0.02	-0.03	-0.01	-0.01	-0.01
	(-0.91)	(-0.68)	(-1.05)	(-0.59)	(-0.48)	(-0.42)
July Program		-0.40**	-5.61***		-0.01	0.37
		(-2.49)	(-4.35)		(-0.13)	(0.65)
Treatment Duration		-0.00**	-0.00		-0.00**	-0.00**
		(-2.12)	(-1.40)		(-2.54)	(-2.38)
TARP		0.23**	0.19		0.09**	0.10**
*Program(Bank*Time)*						
		(2.12)	(1.40)		(2.54)	(2.38)
Bank Size			3.17***			-0.14
			(4.19)			(-0.36)
Bank Equity Ratio			0.14***			-0.00
			(2.92)			(-0.21)
Bank Rating			0.03			-0.13
			(0.12)			(-1.60)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Borrowers' Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	570	570	559	587	587	576
R-squared	0.94	0.95	0.96	0.83	0.84	0.85

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 1.9
Robustness Tests

This table shows alternative specifications for the tests for capital adequacy and loan spreads. Panel A of this table shows the results for banks' capital adequacy. The dependent variable is banks' Tier-1 capital ratio. Panel B shows the results for bank loan spreads. The dependent variable is loan spreads in basis points over LIBOR. Column (1) shows the specification where pre-event and post-event windows are 312 days in length (4 times the length of the short-selling ban). Column (2) shows the specification where pre- and post-event windows are 468 days in length (6 times the length of the short-selling ban). Column (3) shows a "Rough Timing" specification where "During" is defined as when either the July Order or the September Order is in effect. Column (4) shows the specification where July banks are excluded from the sample. *Treated* is a dummy variable that equals 1 if the loan is issued by a bank affected by the short-selling ban, and 0 otherwise. *During* is a dummy variable that equals 1 if the loan is issued during the short-selling ban, and 0 otherwise. *After* is a dummy variable that equals 1 if the loan is issued after the lift of the ban, and 0 otherwise. All regressions use bank- and year-quarter-fixed effects.

Panel A: Tier-1 Capital Ratio

	(1) 4 windows	(2) 6 windows	(3) Rough Timing	(4) Only Sept Ban
During	-0.01	-0.01	-0.11***	-0.01
	(-0.49)	(-0.49)	(-2.92)	(-0.46)
After	-0.13***	-0.21***	-0.20***	-0.20***
	(-2.76)	(-4.44)	(-4.59)	(-4.01)
Treated × *During*	0.08**	0.09**	0.14***	0.09**
	(2.01)	(2.03)	(2.59)	(1.99)
Treated × *After*	0.07	0.07	0.00	0.02
	(1.48)	(1.61)	(0.06)	(0.35)
Treatment Duration	0.39***	0.41***	0.45***	0.41***
	(5.29)	(5.74)	(6.12)	(5.26)
Bank Size	-2.02***	-1.68***	-1.52***	-1.68***
	(-9.72)	(-9.77)	(-8.22)	(-9.53)
Bank Equity Ratio	66.48***	69.72***	71.40***	70.03***
	(25.00)	(31.10)	(31.53)	(30.20)
Bank Rating	-0.51***	-0.52**	-0.54**	-0.52**
	(-2.89)	(-2.45)	(-2.38)	(-2.48)
TARP	0.80***	0.73***	0.72***	0.79***
	(12.75)	(12.95)	(12.74)	(12.25)
Bank FE	Yes	Yes	Yes	Yes
Year Quarter FE	Yes	Yes	Yes	Yes
Bank Type FE	Yes	Yes	Yes	Yes
Observations	6,233	6,988	6,243	6,419
R-squared	0.95	0.94	0.95	0.95

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Panel B: Loan Spreads

	(1) 4 windows	(2) 6 windows	(3) Rough Timing	(4) Only Sept Ban
During	58.02	76.07*	77.63*	140.85***
	(1.00)	(1.80)	(1.67)	(3.83)
After	138.93**	169.36***	158.02***	174.86***
	(2.06)	(3.20)	(2.79)	(3.88)
Treated× During	-66.09*	-89.13***	-77.19**	-107.33**
	(-1.79)	(-3.07)	(-2.44)	(-2.41)
Treated× After	-58.89*	-44.48*	-42.21	-22.07
	(-1.86)	(-1.84)	(-1.58)	(-1.05)
Loan Maturity	-0.07	-0.11	-0.21	-0.81***
	(-0.27)	(-0.56)	(-0.96)	(-2.99)
Loan Covenants	18.62***	7.53**	11.46***	16.69***
	(3.81)	(2.25)	(2.94)	(4.21)
Loan Size	-11.67***	-9.67***	-10.77***	-9.09**
	(-2.77)	(-3.19)	(-3.06)	(-2.26)
Term Loan	39.90***	36.62***	41.84***	48.03***
	(5.11)	(6.16)	(6.45)	(6.26)
# Lenders	-2.25***	-0.85	-0.67	-0.95
	(-2.67)	(-1.51)	(-1.00)	(-1.20)
# Facilities	0.03	0.64	0.50	-0.27
	(0.04)	(1.02)	(0.74)	(-0.46)
Borrower Size	5.91	-4.14	0.41	3.61
	(1.01)	(-0.93)	(0.08)	(0.72)
Borrower Age	-2.62***	-0.93**	-1.20**	-2.16***
	(-4.71)	(-2.43)	(-2.58)	(-3.78)
Borrower Tangibility	13.22	-40.64	-19.82	-21.48
	(0.28)	(-1.25)	(-0.54)	(-0.52)
Borrower MB	-29.21***	-20.00***	-25.71***	-31.90***
	(-4.81)	(-5.06)	(-4.91)	(-5.44)
Borrower Leverage	141.16***	145.48***	137.16***	207.13***
	(4.41)	(6.92)	(5.58)	(7.03)
Borrower Rating	-12.51	-29.92***	-33.78***	-23.08**
	(-1.20)	(-4.29)	(-3.90)	(-2.31)

July Program	-143.63**	-130.87***	-145.36**	16.11
	(-2.08)	(-2.78)	(-2.51)	(1.15)
*Treatment Duratio*n	-1.13*	-1.21***	-1.19**	0.01
	(-1.71)	(-2.77)	(-2.09)	(0.08)
TARP	57.52	41.89	41.14	50.28*
	(1.42)	(1.50)	(1.30)	(1.82)
Bank Size	-1.12	6.61	5.87	-3.16
	(-0.21)	(1.36)	(1.15)	(-1.07)
Bank Equity Ratio	-0.64	0.38	-2.11	3.04*
	(-0.09)	(0.12)	(-0.60)	(1.80)
Bank Rating	-131.52**	-120.58**	-127.47**	21.16*
	(-2.38)	(-2.38)	(-2.41)	(1.74)
Bank FE	Yes	Yes	Yes	No
Borrowers' Sector FE	Yes	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes	Yes
Observations	1,133	1,770	1,460	1,185
R-squared	0.76	0.73	0.73	0.70

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 1.10
Subsamples According to Bank Equity Ratio
This table shows the effect of the short-selling ban on bank loan spreads for subsamples of banks according to their capital ratio before the short-selling ban. The dependent variable is loan spreads in basis points over LIBOR. The sample spans from one year prior to the start of the short-selling ban, to one year after the lift of the ban. Columns (1) through (3) show the results for banks with below median equity ratio before the short-selling ban was implemented. Columns (4) through (6) show the results for banks with above median equity ratio. All regressions use bank-, borrower's sector-, and year-quarter-fixed effects.

Dep. Var.: *Loan Spreads*	Below Median Capital Ratio			Above Median Capital Ratio		
	(1)	(2)	(3)	(4)	(5)	(6)
During	83.71*	84.00*	83.47*	58.21	58.52	102.82
	(1.67)	(1.68)	(1.67)	(0.53)	(0.53)	(0.89)
After	122.74**	108.13*	99.01	68.51	70.49	150.82
	(2.06)	(1.79)	(1.60)	(0.77)	(0.76)	(1.39)
Treated × *During*	-95.47**	-90.35**	-92.44**	1.81	1.76	1.12
	(-2.27)	(-2.11)	(-2.14)	(0.01)	(0.01)	(0.01)
Treated × *After*	-35.15	-19.10	-16.00	53.34	53.56	30.64
	(-0.93)	(-0.48)	(-0.39)	(1.43)	(1.43)	(0.67)
Loan Maturity	-0.49	-0.49	-0.50	0.24	0.24	0.18
	(-1.57)	(-1.58)	(-1.61)	(0.82)	(0.82)	(0.61)
Loan Covenants	16.54**	16.78**	16.87**	-2.68	-2.61	-2.81
	(2.47)	(2.49)	(2.50)	(-0.48)	(-0.45)	(-0.49)
Loan Amount	-13.63***	-13.51***	-13.56***	-9.54*	-9.60*	-7.99
	(-2.87)	(-2.82)	(-2.82)	(-1.90)	(-1.90)	(-1.54)
Term Loan	38.65***	39.34***	39.55***	44.72***	44.69***	44.66***
	(4.05)	(4.14)	(4.16)	(4.79)	(4.78)	(4.77)
# Lenders	-0.27	-0.37	-0.30	-1.44	-1.44	-1.56*
	(-0.26)	(-0.36)	(-0.28)	(-1.59)	(-1.58)	(-1.68)
# Facilities	0.35	0.34	0.33	0.97	0.97	0.99
	(0.36)	(0.35)	(0.34)	(0.92)	(0.91)	(0.89)
Firm Size	-5.66	-5.84	-5.80	-8.20	-8.15	-8.11
	(-0.74)	(-0.77)	(-0.77)	(-1.11)	(-1.10)	(-1.11)

Firm Age	-2.46***	-2.45***	-2.45***	-0.55	-0.55	-0.60
	(-2.98)	(-2.97)	(-2.96)	(-0.80)	(-0.80)	(-0.85)
Firm Tangibility	-52.76	-59.97	-59.77	-49.47	-49.20	-54.89
	(-0.88)	(-0.98)	(-0.97)	(-0.85)	(-0.85)	(-0.94)
Firm MB	-46.49***	-44.86***	-44.83***	-16.30**	-16.28**	-17.41***
	(-3.21)	(-3.10)	(-3.09)	(-2.57)	(-2.56)	(-2.59)
Firm Leverage	89.83**	93.01**	91.95**	152.28***	152.04***	157.74***
	(2.19)	(2.21)	(2.17)	(4.73)	(4.68)	(4.78)
Firm Rating	-13.67	-13.95	-14.19	-24.50**	-24.44**	-26.34**
	(-1.01)	(-1.03)	(-1.04)	(-2.39)	(-2.38)	(-2.56)
July Program		-459.66***	66.49		67.86	-37.67
		(-6.54)	(0.61)		(1.20)	(-0.43)
Treatment Duration		565.36***	1.30		0.05	0.32
		(7.24)	(0.89)		(0.09)	(0.55)
TARP		95.47	91.66		-3.98	-25.38
		(1.56)	(1.48)		(-0.09)	(-0.55)
Bank Size			0.54			3.59
			(0.04)			(0.44)
Bank Equity Ratio			12.30			-4.72
			(0.64)			(-0.95)
Bank Rating			554.30***			-117.66
			(6.45)			(-1.57)
Observations	780	780	780	686	686	686
R-squared	0.77	0.77	0.77	0.80	0.80	0.80
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Borrower's Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Chapter 2

Mortgage Delinquency and Default: A Tale of Two Options

Abstract

The Basel capital rule framework and much of the recent literature on mortgage default have used 60-day or 90-day delinquency to define mortgage default; yet the differences between default (here meaning actual loss of the property) and delinquency have been neither clearly recognized nor well understood. By distinguishing borrowers' delinquency option (borrowing by not making payments) from default option (giving up property in exchange for the mortgage), I find that borrowers' delinquency options are more affected by personal trigger events or shocks, while default options are mostly affected by negative equity. Moreover, while origination underwriting standards contributes to increasing delinquencies, its influence on default, on the other hand, is decreasing over the years. As a result studies that have used delinquency in models designed to analyze actual losses appear to have made major errors in understanding causes of financial losses during the Great Recession.

Introduction

This study is the first to empirically document the differences between delinquency options and default options. It is related to a large body of literature on mortgage performance. The literature recently is treating delinquency options the same as default options. Basel II and the literature have conventionally used mortgage delinquency status of various severities as the definition of actual default – events where actual losses take hit (Archer et al. (2002), Basel Accords (2004), Cowan and Cowan (2004), Mian and Sufi (2009), Haughwout et al. (2010), Jagtiani and Henderson (2010), Demyanyk and Van Hemert (2011), Jagtiani and Lang (2011), Guetter et al. (2011), Eriksen et al. (2013), Chan et al. (2014)). The results thus suggest it is important to distinguish delinquency option from default options, in order to understand mortgage loan performance and related puzzles.

The financial crisis of 2007–2008 was a crisis of both mortgage delinquency (missing payments) and default (occurring actual losses). Triggered by a sharp decline in the house prices, massive delinquencies and defaults of mortgages and mortgage-related securities prompted great losses in banks, leading to a global-level financial crisis. Yet differences between default and delinquency were neither clearly recognized nor understood. Though numerous studies, such as Foster and Van Order (1984), Deng, Quigley, and Van Order (2000), Cowan and Cowan (2004), and Demyanyk and Van Hemert (2011), have adopted the option theory to study the borrowers default behaviors, hardly any clearly distinguishes delinquency option from default option. I show that delinquency option is very different from the default option, and the two are driven by different factors.

In much recent research default has been measured by 60-day or 90-day delinquency (Archer et al. (2002), Basel Accords (2004), Cowan and Cowan (2004), Mian

and Sufi (2009), Haughwout et al. (2010), Jagtiani and Henderson (2010), Demyanyk and Van Hemert (2011), Jagtiani and Lang (2011), Guetter et al. (2011), Eriksen et al. (2013), Chan et al. (2014)). However, delinquency and defaults are related but distinctively different behaviors; many delinquent borrowers do not end up with default. Flanagan and Paxson (2012) theorize that delinquency option is an interim step before terminal states of mortgages. Borrowers may choose to exercise the delinquency option to defer mortgage payment, either triggered by events or to strategically maximize their equity wealth, without necessarily losing the property (i.e. default). By comparison, the default option is traditionally interpreted as implying that the borrowers choose to give up the house, if the option is in-the-money–having negative equity in their house (Deng, Quigley, and Van Order (2000)). The choice of delinquency rather than default is understandable: Delinquency data show up sooner, and defaults are complicated and take; but the two are different, and default captures the things that cause distress to financial institutions.

This paper aims to examine the differences between borrowers delinquency behaviors and default behaviors in light of option theory. I first test if the delinquency option is the same as default option. If delinquency option is not the same as default option, studies and risk management models that use delinquency as proxy for default to calculate actual losses could be misleading. The results show that delinquency is not a constant predictor of default, and the delinquency option is quite different from the default option. Borrowers might choose to exercise the delinquency option, hoping to get cured or modified later, without necessarily exercising the default option (also see evidence in Mayer et al (2014)).

I find that borrower delinquencies are more affected by personal trigger events or local economic shocks, while defaults are more affected by negative equity.

I also find-for data on prime fixed rate mortgages- that focus on delinquency

over-estimated the role of unobservable changes in underwriting. When looking at default I find that unobserved underwriting improved through the millennium, but that unexpected increases in the willingness to default were quite important. It looks the focus on low quality borrowers has been misplaced and that the rise in defaults was more about negative equity and changing attitudes about default than it was about careless underwriting.

I use the loan-level single family dataset from Freddie Mac, matched with bank-level information from Compustat Bank and North America database. The richness of the data allows us to analyze how the predictive power of delinquency varies across time, and how bank balance sheet health and business incentive structures affect post-delinquency transitional probabilities.

First, to distinguish between the delinquency and default option, I verify whether the delinquency option is the same as default options using a multinomial logit model with a competing risk (default or delinquency and prepayment) model, as in Deng, Quigley, and Van Order (2000). Comparing post-delinquency outcomes across the years, based on all the loans as well as subsamples, I find that the relationship between default and delinquency is not constant over time, but rather increases during the market boom, and decreases during the market bust, reaching the trough at the peak of the 2007 crisis.

Second, to further examine the differences between the delinquency and default option, I construct parallel binomial and multinomial regressions with competing risks for both delinquency and default options, and compare the differences between their coefficients. The results show that the exercise of the delinquency option is more sensitive to borrowers personal trigger events and local shocks, while negative equity in the property affects the value of default option to a larger extent.

I also compare origination-year fixed effects with exposure-year fixed effects be-

tween delinquency and default. While changes in unobserved underwriting, as measured by origination year fixed effects, contribute to increasing delinquencies, their influence on default, actually decreases over time. Similarly, for exposure year fixed effects I find little effect for delinquency but large increases in default over time.

Third, to properly detangle borrowers' decisions to exercise the delinquency option from the default option, I use two-step regressions to examine the two options. Since defaults are mostly only observable post delinquency, I implement a Heckman two-step selection model, following Heckman (1978) and Lekkas et al. (1993). I first estimate a delinquency model-the probability of first time seriously delinquent, and I use this as a variable in the second stage, which looks at all delinquent loans and models the probability of default. The results again show that the factors that trigger borrowers' decisions for delinquency are not the same as those that trigger default. While borrowers' credit and employment status are important in making the decision to skip payments, changes in home equity and overall economy, i.e. negative equity in the home, are more critical factors in determining default, given the estimate of the probability of delinquency.

Fourth, I employ two quasi-natural experiments to differentiate the exercise of the delinquency option from that of the default option. The Home Affordable Modification Program (HAMP) increases Loan modification prospective, and decreases the cost of delinquency option, while should have no effect on default option. Consequently, I conjecture to see an increase in the exercise of delinquency option while no change in default option. HAMP is designed to help modify delinquent loans, lower borrowers' monthly mortgage payments. Only delinquent loans originated before January 1, 2009 are eligible for HAMP, and only a certain number of mortgage servicers are participating in this program. Hence, loans under HAMP have higher probability of loan modification, during program duration from 2009 to 2016. By com-

paring the loans eligible for HAMP with those not, I can identify strategic behavior of delinquency option exercise.

California deficiency statue offers us another quasi-natural experiment to differentiate the exercise of default option from that of delinquency option. Under California Civil Code of Procedure 580b, purchase loans are non-recourse, meaning there is no personal liability after default, while refinance loans are recourse, meaning borrowers are personally liable for their mortgages and lenders can go after them to recover losses after default. The personal liability character of refinance loans largely increases the cost of default option, and decreases the exercise of default option. On the other hand, recourse character of refinance loans hold borrowers personally liable only after they default, and therefore should not affect those borrowers who exercise delinquency option. By comparing the refinance loans with purchase loans, I can identify strategic behavior of default option exercise.

This paper develops as follows: Section 2 discusses the related literature. Section 2 develops the hypotheses to test. Section 2 describes the data source and empirical methodology. Section 2 provides results from the empirical tests. Section 2 concludes.

Literature Reviews

This paper is related to two strings of intersecting literature. One is regarding mortgages studies, specifically the definition of default in the current literature; and the other is related to the transitional probabilities post delinquency. This paper contributes to the literature by differentiating default and delinquency, and the results shed light on the determinants of delinquency and default behaviors respectively.

Mortgage Delinquency and Default

A large number of studies examine mortgage performance, especially default, using different models. However, the differences between default and delinquency were neither clearly recognized nor understood. Though the earlier studies (such as Deng, Quigley and Van Order (2000)) define default based on events where actual losses occur, such as REO or actual claim, recent studies predominately switch to the use of delinquency to various degrees as definition of default ((Archer et al. (2002), Cowan and Cowan (2004), Mian and Sufi (2009), Haughwout et al. (2010), Jagtiani and Henderson (2010), Demyanyk and Van Hemert (2011), Jagtiani and Lang (2011) , Guetter et al. (2011), Eriksen et al. (2013), Chan et al. (2014)).

The reasons behind such switch of default definition from actual loss to delinquency are two folds. The first is because the number of mortgage termination routes post delinquency increases tremendously, as a result of financial innovation. Each ending status, such as REO, short sale, or third party sale, has varying terms and termination procedures. In comparison, delinquency is much more homogeneous, and only varies by the number days since the borrower misses a payment.

The second rationale behind the switch is that the timeline of actual losses has become more difficult to depict. Factors such as legal differences in foreclosure laws affect not only the timeline of actual loss events but also the propensity to default (Pence (2006), Ghent (2012), Mian et al. (2015)). Take foreclosure for example, the length of time between initial mortgage delinquency and completion of foreclosure delinquent status could vary from as little as one or two months in some non-judicial states up to around one year in some judicial states (Mian et al. (2015)). In comparison, the timeline of delinquent is much more straightforward: once a borrower misses a payment, the date is marked as the time of delinquency.

For reasons mentioned above, delinquency status, 30-day, 60-day, and especially 90-day delinquency, has recently become a well-established definition of default in both academic research and industrial practices. Mian and Sufi (2009)) use 30-day or more delinquent as their definitional of default, and find that the expansion in subprime mortgage credit to subprime ZIP codes is associated with the increase in securitization of subprime mortgages. They also adopt a 60-day or more delinquent as a stricter definition to run robustness tests.

Studies, such as Jagtiani and Henderson (2010) Piskorski et al. (2010), and Demyanyk and Van Hemert (2011), use at least 60 days past due as default definition. Demyanyk and Van Hemert (2011) study the quality of loans before and post the 2008 financial crisis, and find the quality of loans deteriorated before the crisis, but were masked by high house price appreciation during that period. In addition, both the Mortgage Banks Association (MBA, (2008)) and the Office of Thrift Supervision use 60-day or more delinquency as default definition.

The majority of recent studies define default as occurrence of 90-day delinquency to examine various aspects of mortgages (e.g. Archer et al. (2002), Cowan and Cowan (2004), Keys et al. (2008), Haughwout et al. (2010), Jagtiani and Henderson (2010), Jagtiani and Lang (2011), Guetter et al. (2011), Eriksen et al. (2013), Chan et al. (2014)). By studying multifamily mortgage default, Archer et al. (2002) find that loan-to-value ratio (LTV) is endogenous to the loan origination and property sale process, while property features better predict defaults. By analyzing early defaults90 day or more days delinquent within the first year after origination, Haughwout et al. (2010) find changes in the economy, especially house price change, were more important in determining the probability of an early default, in addition to credit standards. Jagtiani and Lang (2011) shows that homeowners might default on their mortgage even when they are able to make payment, and negative equity has been the primary

reason for homeowners to default on their mortgage. Eriksen et al. (2013) refine the definition of default as first occurrence of a borrower being 90 days in delinquency. By analyzing borrowers with a second loan, they find that such borrowers are more likely to default on their primary loans conditioning on the attributes of the primary loan, yet less defaults conditioning on the combined attributes.

In particular, the use of 90-day delinquency as default definition is also incorporated in the Basel II criteria when calculate capital requirement for banks. Basel Accord (2004) states that "in the case of qualifying residential mortgage loans, when such loans are past due for more than 90 days they will be risk weighted at 100%, net of specific provisions." The occurrence of 90 day delinquent as definition of default is directly linked with the amount of capital that banks are required to hold. Using the same definition under Basel II framework, Jagtiani and Henderson (2010) study different default prediction models under Basel II and find the calculated amount of capital that banks are required to hold varies considerably.

This is limited empirical evidence that recognize or distinguish delinquency from default. In addition, the factors that affect the delinquency and default option values are relatively unexplored by the literature. The paper thus contributes to the literature by documenting the differences between delinquency and default. The results show that delinquency and default are two related but distinctively different behaviors, and are affected by different factors.

Mortgage Post Delinquency

After documenting that delinquency is different from default, this paper analyzes possible driving factors of delinquency and default post delinquency. Therefore, studies on mortgage termination post delinquency are also relevant. Only a few papers explore the final resolution of loans primarily because of limited data availability

(Chan et al. (2014)).

Most studies link the probability of post-delinquent outcomes with borrower-level and loan-level characteristics. Studies such as Danis and Pennington-Cross (2005), Danis and Pennington (2008), and Pennington-Cross (2010) find that higher credit score and longer period of delinquency are associated with higher probabilities of prepayment and lower probabilities of default.

Capozza and Thomson (2006) study the transition process for subprime mortgages that were seriously delinquent on September 30, 2001. They find that, compared with prime loans, seriously-delinquent subprime loans are about twice as likely to become REO, and that foreclosure is more likely for loans with high LTVs and interest rate premiums. Chan et al (2014) examine the process of mortgage default from delinquent to final resolution of the property in New York City, using a two-stage competing risk hazard model. Their results show that borrowers' credit score, current LTV, house price and income are associated with the foreclosure outcomes. Schmeiser and Gross (2015) also find high LTV is the greatest contributor to foreclosure, by analyzing the subprime mortgages post modification performance.

This study also relates to a growing literature on loan modification post delinquency and some corporate debt literature in corporate finance. Extant theoretical and empirical literature uncovers a strong linkage between the prospect of loan modification and delinquency (Hart and Moore (1994), Djankov et al. (2008), and Favara et al (2012)). Other researches such as Adeline et al.(2009), Piskorsi et al.(2010) and Adeline et al.(2014) investigate the impact of securitization on mortgage modification and termination. By comparing securitized loans with bank-held loans, Piskorski et al. (2010) find that the foreclosure rate of bank-held loan is lower than similar securitized loans. Adeline et al.(2014) find that securitized mortgages are more likely to be modified and less likely to be foreclosured on.

I find that borrower delinquencies are more affected by personal trigger events or local economic shocks, while defaults are more affected by negative equity. This paper thus contributes to the literature by differentiating the delinquency option from the default option and documenting the differences between the two.

Hypotheses Development

Delinquency and Default

Based on the literature, I are interested in differentiating delinquency and default. If delinquency is the same as default, then the relationship between delinquency status and default should be constant over time. Furthermore, by defining delinquency as default, extant literature assumes that the determinants that trigger a borrower's decision to skip a loan payment is the same as the decision to default. Therefore, I propose the first set of hypotheses as following:

Hypothesis 1 H_0: The delinquency option is the same as the default option.

Hypothesis 1 H_a: The delinquency options is not the same as the default option.

Identify Factors that Affect Delinquency and Default

To better examine borrowers' decision making process of delinquency and default, I treat the borrowers choice of whether to stay in delinquency or to default as the exercise of put options. Preceding literature, such as Lekkas et al. (1993), Deng et al. (2000) and Elul et al.(2010), view house equity, measured by updated loan-to-value ratio, as a measure of the extent to which the default option is in-the-money. Similarly, I test the factors that affect the exercise of the delinquency option. Borrowers compare the value of execising the put option with the value of not execising, and

make choices accordingly.

Since delinquency and default are closely related, I examine factors that trigger borrowers decisions of delinquency and default simultaneously. Since defaults are mostly only observable post delinquency, I implement a Heckman two-step selection model to correct for such potential bias (see Heckman (1979) and Lekkas et al. (1993)). I first estimate a delinquency model-the probability of first time seriously delinquent, and I use this as a variable in the second stage, which looks at all delinquent loans and models the probability of default.

I hereby test the second set of hypotheses:

Hypothesis 2 H_0: The same factors trigger borrowers' decisions to skip a payment and to default on the property.

Hypothesis 2 H_a: The factors that trigger borrowers' decisions to skip a payment is not the same as those trigger defaults.

I further illustrate the hypothesis 2 in Table 2.1

Categories	Factors	Effects on Delinq., Compared with Default
Borrowers' Personal Trigger Events	FICO scores, Debt-to-Income, Unemployment, etc.	Stronger
Local Economy Shocks	Local GDP growth, Local House Price Growth, etc.	Stronger
Negative Equity	LTV, CLTV, Updated LTV, etc.	Weaker

Table 2.1
The Effects of Determinants on Delinquency Option Compared with Default Option

Differentiate the Exercise of Delinquency from Default Option

To test the conjecture that delinquency option is different from default option, I employ two quasi-natural experiments to differentiate the exercise of the delinquency

option from that of the default option.

HAMP and Delinquency Option

The first quasi-natural experiment is the Home Affordable Modification Program (HAMP), which aims to lower monthly mortgage payments of delinquent loans. On March 4, 2009, the U.S. Department of the Treasury announced details of the HAMP. Delinquent loans that originated before January 1, 2009 and whose mortgage banks and companies participate in Making Home Affordable (MHA) programs are eligible for HAMP. The application deadline is supposed to be December 30, 2016.

As HAMP aims to reduce delinquent borrowers monthly payments through loan modification, this program also lowers the potential costs of delinquency and increases the value of the delinquency option. I therefore conjecture that compared with non-HAMP loans, loans eligible for HAMP are more likely to delinquent after the initiation of the program.

On the other hand, for those borrowers who choose to strategically exercise the default option, the prospect of loan modification via HAMP should not affect their decision to give up the property. Hence, I conjecture that HAMP may not affect borrowers exercise of the default option after the initiation of the program.

Hypothesis 3 H_0: The prospect of loan modification via HAMP has no effect on the exercise of delinquency option or default option.

Hypothesis 3 H_a: The prospect of loan modification via HAMP increases the exercise of delinquency option, yet may not affect borrowers exercise of the default option after the initiation of the program.

To test the above hypothesis, I only focus on mortgages obtained on or before January 1, 2009. I pair a HAMP eligible loan (i.e. whose mortgage company participating in MHA) with a loan not eligible for HAMP (i.e. whose mortgage company

not participating in MHA), and compare their performance after the initiation of the program in 2009.

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California Deficiency Statue and Default Option

California deficiency statue offers us another quasi-natural experiment to differentiate the exercise of default option from that of delinquency option.

Under California Civil Code of Procedure 580b, purchase loans are non-recourse, meaning there is no personal liability after default, while refinance loans are recourse, meaning borrowers are personally liable for their mortgages and lenders can go after them to recover losses after default. The personal liability character of refinance loans largely increases the cost of default option, and decreases the exercise of default option. I conjecture that compared with purchase loans, refinance loans with recourse character are less likely to default.

On the other hand, recourse character of refinance loans hold borrowers personally liable only after they default, and therefore should not affect those borrowers who exercise delinquency option, with no intention to lose their property. Hence, I conjecture that compared with purchase loans, refinance loans with recourse character are NOT less likely to delinquent.

Hypothesis 4 H_0: Recourse character has no effect on the exercise of delinquency option or default option.

Hypothesis 4 H_a: Compared with purchase loans, refinance loans with recourse character are less likely to default, but NOT less likely to delinquent.

To test the hypothesis, I only focus on loans of California in order to get clean comparison on homogeneous loans. I also drop loans originated after 2013, because there is a change in the regulation and I dont have enough data to study the change.

Specifically, according to newly passed California Code of Civil Procedure 580b(c), for the refinance of purchase loan occurring after January 1, 2013, there is non-recourse feature.

I match a refinance loan with recourse character with a non-recourse purchase loan, and compare their performance after the initiation of the program in 2009.

Data and Methodology

Data and Sample

The goal of this paper is to examine the role of banks on the mortgage transition from delinquency status to other statuses including actual foreclosure or REO. Therefore, I combine data from a number of sources to get information about mortgages and bank fundamentals.

The mortgage loan-level data is from Freddie Mac Single Family Loan-level dataset, at a monthly frequency from 1999 to 2014. The dataset contains a sample of 50000 mortgage loans, randomized from each full vintage year. All loans included are fully amortized 30-year fixed-rate mortgages, with verified or waived documentation (i.e. "full documentation"). Freddie Mac collects origination information for each borrower, such as credit score or debt-to-income (DTI) ratio, as well as for each loan, such as loan-to-value (LTV) ratio or mortgage insurance percentage. For a given loan, Freddie Mac also discloses its monthly performance information, including delinquency and default status.

This dataset also provides seller name and servicer name for each loan. Freddie Mac only discloses the name of seller or servicer with a total original unpaid principal balance (UPB) presenting 1% or more out of all loans for a given calendar quarter.

In the sample I hand match the names with servicers that participate in HAMP.

I construct the final data sets using macroeconomic variables from several data sources at both the state and the Metropolitan statistical area (MSA) levels. MSA-level house price data are from the FHFA House Price Index (HPI) database, which is a weighted, repeat-sales index, measuring average price changes in repeat sales or refinancings on the same single-family houses. Information about state-level GDP growth, 30-year fixed-rate mortgage rates, 10-year Treasury bill rates, and state-level unemployment rates are from Federal Reserve of St. Louis.

To test the first set of hypothesis, I subset the sample into originanation year cohorts, and run regressions on each sample, in order to mitigate potential concerns about changes in underwriting standards over time. The main variable of interest, delinquency, is a dummy that equals 1 if the loan is in a delinquent status i months ago ($i \in \{1, 2, 3, 4, 5, 6\}$). Since being delinquent i yield similar results, I only present results using defintion of delinquency three months ago. All the continuous variables are winsorized within the 5th and 95th percentiles. Detailed definition for the dependent and independent variables are shown in 2.

Empirical Framework

The objective of this paper is to study the predicting power of delinquency status on default, and determinants of variation of such predicting power, in particular the role of banks. Using loan-level sample, I regress the outcome variables on delinquency and bank balance sheet variables, while controlling for loan-, borrower-, and macro-level covariates.

Follow previous literature, such as Capozza et al (1998), Deng, Quigley and Van Order (2000), Capozza and Thomson (2006), and Chan et al (2014), I employ a discrete time hazard framework with competing risks to explore the relationship between

delinquency and default outcomes.

To test hypothesis 1, I consider the following regression model:

$$Y(outcome = i) = MulinomialLogitFunction(\beta_0 + \beta_1 X(variable = j) + \beta_2 BorrowerControls + \beta_3 MacroControls + \beta_4 LoanControls + \sum \xi_i + \sum \zeta_i + \sum \eta_t + \epsilon), \quad (2.1)$$

where $Y \in$({*Prepayment, Default*}, {*Prepayment, Default, Modified, Cured*}, or {*Prepayment, Foreclosure, REO, Repo, Modified, Cured*}). where $X \in$(*Delinquency, Refinance, HAMP, etc*). For example, *Delinquency* is a dummy variable that equals 1 if the loan is in delinquency status; *Controls* include loan characteristics (CLTV, RLTV, number of units, etc.) borrower characteristics (FICO, DTI, etc.), and macroeconomic variables (e.g., GDP growth, 10-yearTbill rate, HPI, etc.). ξ stands for origination-year-fixed effects, ζ stands for exposure-year-fixed effects, and η stands for state-fixed effects.

I also estimate a Heckman selection model to examine determinants of delinquency options and default options.I first estimate a delinquency model-the probability of first time seriously delinquent, and I use this as a variable in the second stage, which looks at all delinquent loans and models the probability of default.

Specifically, I fit the model in step-2

$$Y(outcome) = \beta_0 + \beta_1 BorrowerControls + \beta_2 MacroControls + \beta_3 LoanControls + \sum \zeta_i + \epsilon_1), \quad (2.2)$$

conditional on being delinquent in step-1, asuming that default is observed if

$$\gamma_0 + \gamma_1 BorrowerControls + \gamma_2 MacroControls + \gamma_3 LoanControls + \epsilon_2 > 0), \quad (2.3)$$

The two equations of outcome and delinquency are estimated simultaneously. To get consistent estimates of behavioral default coefficients, I include the Mills ratio of the step-1 selection regression as an additional variable in the step-2 regressions (see Heckman(1976), and Lekkas, Quigley and Van Order (1993)).

In addition, to further distinguish the exercise of delinquency option and default option, I employ a Difference-in-Difference framework to test the effects of two quasi-natural experiments on the options. I first match each HAMP (refinance) loan with another non-HAMP (purchase) loan with similar characteristics, such as FICO, CLTV, DTI, and UPB, etc. Then I run difference-in-difference regressions on the matched sample.

$$Y_{i,j\ ,t} = \beta_0 + \beta_1 Post09 + \beta_2 HAMP \times Post09 + \beta_3 Controls + \sum \xi_i + \sum \zeta_i + \sum \eta_t + \epsilon_{i,j\ ,t}\ , \quad (2.4)$$

where $Y \in \{Delinquency,\ Default,\ etc.\}$.

Results

Summary Statistics

Figure 2.1 shows the summary statistics for the characteristics of mortgage loans at origination in the sample. The charts show histogram as well as both normal

and kernel distributions for loan-to-value ratio (LTV), combined loan-to-value ratio (CLTV), credit score FICO, original interest rate of the loan, original unpaid principle balance (UPB), and debt-to-income ratio (DTI). Both the LTV and CLTV charts show large proportion of loans with a LTV or CLTV value of 80, compared with neighboring bins of the histogram. The proportion of LTV and CLTV being 80 is more than twice that of just 70 or 90, indicating discontinuity in the distribution. Such discontinuity pattern and concentration on 80 is probably due to the fact that borrowers with higher than 80% LTV ratio will need additional insurance on the mortgage, and those with lower than 80% will need down payments upfront. The FICO score has a mean of 725, and is skewed towards higher scores towards the 800-FICO zone, indicating most of the borrowers in the Freddie Mac sample are of good credit. Since all mortgages loans are government-sponsored enterprises (GSE) loans, which are loans issued by Freddie Mac or Fannie Mae etc., the original unpaid principle balances (UPB) are mostly below the jumbo loan cutoff of $417,000, with majority below $250,000. Mortgage interest rates and DTI ratios at origination are generally normally distributed.

Delinquency Option and Default Option

The first question this paper tries to answer is whether delinquency options are the same as default options. To test the first hypothesis, I start with univariate tests and then move on to multivariate tests.

The proportion of loans that become delinquent are very different from that of default. Figure 2.2 shows the simple proportion of delinquency and default out of the whole sample by origination year and exposure year respectively. The patern of delinquency differs from that of default, the trend by origination year also differs from that by exposure year. The proportion of loans that default out of delinquency also

shows similar story.

Delinquent loans do not usually end up with default, and the proportion of delinquent loans that end in default varies each year. Figure 2.3 illustrates the proportions of ending events conditional or unconditional on being 90-day delinquent out of the total loans in each origination year. Each data point in the charts shows the ultimate ending status of the loans originated each year as of September 30, 2014, the data cutoff date. The upper two charts show unconditional proportions, while the bottom two charts show proportions conditional on ever being 90-day delinquent. The left two charts contrast prepayment with default, while the right two charts decompose default into foreclosure, REO and Repo. I see REO taking the largest share, followed by foreclosure. The unconditional charts of ending events show the proportion of default was hovering below 1% between origination year 1999 and 2004, before it started climbing in the 2004 cohort, reaching its peak in 2007 cohort at still lower than 10%. Yet once conditional on being 90-day delinquent, the proportion of default increases to around 50% for the loans originated between 1999 and 2001, decreases in 2002 and 2003, before it climbs up and peaked around 55% in 2006. This leads to loans ever being 90-day delinquent having much higher proportion ending in default, and much lower in prepayment. Yet such proportion varies across the origination years, and follows a different pattern from the unconditional one.

While Figure 2.3 only looks at the ultimate ending status of every loan as of September 30, 2014, the variation of proportion might due to the fact that loans originated in more recent years longer time to default. Accounting for such potential timing bias, Figure 2.4 focuses on a loans performance one to six months after being 60-day or 90-day delinquent. The upper two charts show the proportions of all ending status except for REO are relatively constant from one month to six months, indicating that the fate of delinquent loans is almost decided immediately after being serious

delinquent. The decision on REO, on the other hands, takes some additional two to three months. This echoes the accusation of automated default process in servicing industry, which pushed delinquent loans into foreclosure without taking much time and human efforts. The bottom two charts show the proportions of loan status by origination year, three months after being delinquent. It reveals similar storyline as in Figure 2.3 that the predicting power of delinquent on default and other ending status is constant.

Table 2.2 reports the coefficient estimates from a simplified version of Eq. 2.1, which includes only year- and state-level fixed effects. The dependent variable is a factor that indicating whether the loan is in default, prepayment, or current status. I run separate regressions with competing risks on subsamples of each origination year, cohort, to mitigate potential concerns about changes in underwriting standards over time. Each column shows the estimated coefficient of delinquency from a multinomial logit model with competing risks for a given origination year. Panel A shows the coefficient estimates for 90-day delinquency status three months ago, while Panel B shows those for 60 delinquency three months ago. In Panel A, all the coefficients, except for 2011, are significant at the 1% level. However, the coefficient estimates of delinquency are not constant across different cohorts: the magnitude of the estimates increases from 2.51 in 2001to 3.72 in 2003, and decreases monotonically to 1.81 in 2007. The year 2003 was a watershed time, when private label mortgages started to boom and the quality of loans start to decrease. To sum up, I see delinquency option behave very differently from default option. Panel B also show similar patterns.

TABLE 2.2 ABOUT HERE

To test robustness, I repeat the same tests for 60-day and 90-day delinquency

dummy one month ago, two months ago, and up to six months ago. Figure 2.5 and Figure 2.6 plot the coefficients on delinquency dummies. The two sets of figures nicely illustrate the increase from 2000 to 2003, and drop from 2003 all the way to the deepest swamp in the 2007-2008 financial crisis. In other words, the predicting power of delinquency increases during the market boom, and decreases during the market bust, reaching the trough at the peak of the crisis. Hereby, I conclude that delinquency and default are two related yet but distinctively different behaviors.

Factors that Affect Delinquency and Default Option

Parallel Regressions of Delinquency and Default

To further examine the differences between the delinquency and default option, I construct parallel binomial and multinomial regressions with competing risks for both delinquency and default options, and compare the differences between their coefficients.

Table 2.3 examines the delinquency option using a multinomial logit model with competing risks, following Deng, Quigley, and Van Order (2000). Delinquency hereby is defined as the first time a borrower misses payment for over 90 days. Column (1) to (2) show results controlling for borrower characteristics, origination-year and exposure-year fixed effects. Column (3) to (4) also control for macro-economic variables and loan level variables. This shows the standard methodology in much recent literature to study mortgage default.

Table 2.3 About Here

Table 2.4 About Here

For comparison, I run the same multinomial logit regressions with competing risks on default (see Table 2.4). Default hereby includes terminations of the loans when actual losses occur, i.e. REO, foreclosure and repo. As in previous literatures, I find that the coefficients of FICO credit score are significantly negative in both the delinquency regressions and default regressions. Borrowers with better credit scores are less likely to delinquent or default on their loans. Updated LTV, a proxy for negative equity, on the other hand, attracts significantly positive coefficients. Deeper the options, both delinquency and default, are in the money, more likely the borrowers will exercise the options.

TABLE 2.5 ABOUT HERE

TABLE 2.6 ABOUT HERE

Yet, the magnitude of coefficients of delinquency is significantly different from that of default. To better compare the magnitude of coefficients across default regressions and delinquency regressions, I run another standardized multinomial logit tests, so that the variances of all the independent variables are 1 (see Table **??** and Table 2.6).

Table 2.7 shows the simple difference between the coefficients of standardized regressions on the two options. In other words, I run standardized regressions on delinquency and default respectively with exactly the same controls and fixed effects, and then calculate simple difference as the coefficients of the default regressions minus those of the delinquency regressions.

I find that delinquency is more responsive to FICO scores, debt-to-income ratio, and number of borrowers. For example, FICO scores is negatively associated with delinquency and default, as shown in Table 2.5 andTable 2.6. A positive difference (0.0038) between default and delinquency regressions suggest that default coefficient

of FICO is less negative and smaller in absolute terms, and hence I conclude that FICO scores affect delinquency to a greater degree, compared with default. Updated loan-to-value, on the other hand, is positively associated with default and delinquency. Therefore, the coefficients difference of updated loan-to-value ratio between default and delinquency is also positive, suggesting that updated LTV affects the default option more than the delinquency option.

Table 2.7 About Here

Table 2.8 About Here

To test whether the two sets of regression coefficients are significantly different from each other, I run a combined regression that stack delinquency data with default data, and introduce a dummy variable for grouping (1 for default and 0 for delinquency) to interact with independent variables as in separate regressions. The coefficients from the interaction term of grouping variable and independent variables depict the coefficient differences between delinquency and default with significance. Table 2.8 [1] shows similar results in terms of signs and magnitudes as in Table 2.7. FICO scores attract significantly positive coefficient (0.0038). Given higher FICO scores are associated with less delinquency and default, the result suggests that default coefficient of FICO is significantly less negative than delinquency. In other words, compared with default, delinquency is more responsive to FICO scores. Similar to the results in Table 2.7, updated loan-to-value ratio attracts significantly positive coefficients, meaning that default option is more responsive to updated LTV than delinquency option.

[1] I only show coefficents of the interaction terms between the grouping variable and independent variables to highlight the coefficient differences. Full combined regression results can be provided.

In addition, I repeat the tests on a subsample of data before the crisis. Compared with crisis period, results in Table 2.9 and Table 2.10 show that negative equity is a less important factor before the crisis, while personal trigger events and local economic factors are more important.

TABLE 2.9 ABOUT HERE

TABLE 2.10 ABOUT HERE

Overall, the results show that the exercise of the delinquency option is more sensitive to borrowers personal trigger events and local shocks, while negative equity in the property affects the value of default option to a larger extent.

I also compare origination-year fixed effects with exposure-year fixed effects between delinquency and default. Figure 2.8 shows origination year fixed effects and exposure year fixed effects from multinomial logit models with competing risks of both delinquency and default. In such models, I also control for all the borrower-level, macro-level, and loan-level factors. While changes in unobserved underwriting, as measured by origination year fixed effects, contribute to increasing delinquencies, their influence on default, actually decreases over time. Similarly, for exposure year fixed effects I find little effect for delinquency but large increases in default over time.

As a robustness test, I repeat the same tests using binomial logit models of both delinquency and default. Figure 2.9 show similar patterns as in Figure 2.8. Such results suggest-for data on prime fixed rate mortgages- that focus on delinquency over-estimated the role of unobservable changes in underwriting. When looking at default I find that unobserved underwriting improved through the millennium, but that unexpected increases in the willingness to default were quite important. It looks the focus on low quality borrowers has been misplaced and that the rise in defaults

was more about negative equity and changing attitudes about default than it was about careless underwriting.

Two-Stage Regressions of Delinquency and Default

To properly detangle borrowers' decisions to exercise the delinquency option from the default option, I propose two-step regressions to examine the two options. Since defaults are mostly only observable post delinquency, I implement a Heckman two-step selection model, following Heckman (1978) and Lekkas et al. (1993). First, I estimate a delinquency model-the probability of first time 90-day delinquent, and then use predicted probability of delinquency as an additional variable in the second stage, which models the probability of default post delinquency. I repeat such Heckman selection regression by each origination year, to account for potential changes in the underwriting quality each origination year (Piskorski et al. (2010)).

Table 2.12 show results of two-step model on the whole sample, while Table 2.13show such results on subsample of each origination cohort. Both show similar robust results. The first step shows that FICO score, number of borrower, debt-to-income ratio, GDP growth, and unemployment all attracts significant coefficients in the expected directions. Yet in the second stage, the dominant factor is updated LTV. Borrowers' personal trigger events, such as FICO score, number of borrower, debt-to-income ratio, and local economic factors, such as GDP growth, and local HPI, are also no longer significant. The results show that the factors that trigger borrowers' decisions for delinquency are not the same as those that trigger default.

Table 2.12 About Here

The first-step regressions of Table 2.13 examines the factors of borrowers decision

of delinquency. The coefficients for credit score FICO are significant, negative across all the origination years, indicating that borrowers with higher credit scores are less likely to skip payments and become delinquent in their loans. Unemployment rate attracts significantly positive coefficient estimates, suggesting that borrowers who lost their jobs are more likely to exercise delinquency options. The coefficient estimates for risk premium, illustrated as the difference between original mortgage loan rates and current 10-year Treasury rate, are positively significant. Facing high mortgage interest payments due to high original mortgage, borrowers are more likely to tip toward not making payments. To sum up, the borrowers choice to exercise the delinquency option is largely affected by personal status and trigger events, such as credit rating, divorce, or employment status.

The second-step regressions of Table 2.13, on the other hand, show the factors of borrowers decision of default. The coefficients for credit score FICO turn to be mostly insignificantly positive, suggesting that conditional on being 90-day delinquent, FICO scores no longer have the same significantly negative relationship as in the first step of delinquency regressions. The coefficients for unemployment also have been insignificantly different from zero. The coefficients for home equity, measured by updated loan-to-value ratio, are positively significant, indicating that the more the default option is in-the-money, the borrowers are more likely to exercise the option. To sum up, the borrowers decision to default is less linked with his or her personal status, such as unemployment, but more associated with home equity and house price.

TABLE 2.13 ABOUT HERE

Overall, this is consistent with alternative hypothesis that the factors that trigger borrowers decision of delinquency are not the same as those trigger default. The

results again show that the factors that trigger borrowers' decisions for delinquency are not the same as those that trigger default. While borrowers' credit and employment status are important in making the decision to skip payments, changes in home equity and overall economy, i.e. negative equity in the home, are more critical factors in determining default, given the estimate of the probability of delinquency.

HAMP and Delinquency Option

the Home Affordable Modification Program (HAMP) provides a quasi-natural experiment to separate delinquency option from default option. Loan modification prospective could decrease the cost of delinquency option, while should have no effect on default option. Consequently, I conjecture to see an increase in the exercise of delinquency option while no change in default option. HAMP is designed to help modify delinquent loans, lower borrowers' monthly mortgage payments. Only delinquent loans originated before January 1, 2009 are eligible for HAMP, and only a certain number of mortgage servicers are participating in this program. Hence, loans under HAMP have higher probability of loan modification, during program duration from 2009 to 2016. By comparing the loans eligible for HAMP with those not, I can find strategic behavior of delinquency option exercise.

Table 2.14 shows the difference-in-difference results for HAMP's effect on delinquency option. The coefficient of *HAMP*Post 2009* is significantly positive, meaning that higher probability of loan modification increase the probability of delinquency. [2]

TABLE 2.14 ABOUT HERE

[2]In a separate regression, I also run a placebo test on year 2008, the year before HAMP was initiated, and I don't find similar results.

On the other hand, Table 2.15 shows the difference-in-difference results for HAMP's effect on default option. The coefficient of *HAMP*Post 2009* is not significant, meaning that higher probability of loan modification has no effect on default option.

TABLE 2.15 ABOUT HERE

Overall, the results are consistent with my conjecture, that delinquency option are different from default option, and higher probability of loan modification lowers the cost of delinquency option, hence increases the probability of delinquency, yet has no effect on default option.

California Deficiency Statue and Default Option

California deficiency statue offers us another quasi-natural experiment to differentiate the exercise of default option from that of delinquency option. Under California Civil Code of Procedure 580b, purchase loans are non-recourse, meaning there is no personal liability after default, while refinance loans are recourse, meaning borrowers are personally liable for their mortgages and lenders can go after them to recover losses after default. The personal liability character of refinance loans largely increases the cost of default option, and decreases the exercise of default option. On the other hand, recourse character of refinance loans hold borrowers personally liable only after they default, and therefore should not affect those borrowers who exercise delinquency option.

Table 2.16 shows whether and how refinance loans with recourse character behave differently from purchase loans in terms of the delinquency option. The coefficient of *Refinance* is significantly positive, meaning that refinance loans are more likely to delinquent. This is consistent with previous literature that refinance loans can be

riskier, which predict higher default rates if the exercise of delinquency option and default are not separated.

TABLE 2.16 ABOUT HERE

On the other hand, Table 2.17 shows whether and how refinance loans with recourse character behave differently from purchase loans in terms of the default option. The coefficient of *Refinance* is significantly negative, meaning that refinance loans are much less likely to default. This is contrary to previous literature that refinance loans can be riskier than purchase loans, and suggesting that recourse character of refinance loans significantly affect borrowers' exercise of default option. Recourse character largely reduces default, while does not reduce delinquency.

TABLE 2.17 ABOUT HERE

Overall, the results are consistent with my conjecture, that compared with purchase loans, recourse character reduces borrowers' exercise of the default option, but does not reduce borrowers' exercise of the delinquency option.

The two quasi-natural experiments show two situations where the exercise of delinquency option are separated from the exercise of default option, and borrowers' behavior of delinquency and default are affected by different factors.

Conclusion

This paper first distinguishes delinquency options from default options. By distinguishing borrowers' delinquency option (borrowing by not making payments) from default option (giving up property in exchange for the mortgage), I find that borrow-

ers' delinquency options are more affected by personal trigger events or shocks, while default options are mostly affected by negative equity. Moreover, while origination underwriting standards contributes to increasing delinquencies, its influence on default, on the other hand, is decreasing over the years. As a result studies that have used delinquency in models designed to analyze actual losses appear to have made major errors in understanding causes of financial losses during the Great Recession.

Variable Definitions

Borrower Characteristics

- *Borrower FICO*: Credit Score (Initial FICO), a number, prepared by third parties, summarizing the borrower's creditworthiness
- *Borrower Debt-to-Income Ratio*:The ratio of the borrower's monthly debt payments divided by the total monthly income at origination
- *# Borrowers*: The number of borrowers who are obliged to repay the mortgage

Loan-level Variables

- *Original Loan-To-Value (LTV)*: The ratio of the original mortgage loan amount by the mortgage property's appraised value or purchase price at origination
- *Original Combined Loan-To-Value (CLTV)*: The ratio of the original mortgage loan amount plus any secondary mortgage loan amount by the mortgage property's appraised value or purchase price at origination
- *Revised Loan-To-Value (RLTV)*: Combined Loan-To-Value at origination* (ending balance/Original unpaid principal balance (UPB))/(House Price Index (HPI)/House Price Index at origination)
- *Original Interest rate*: The original interest rate of mortgages
- *Original UPB*: The unpaid principal balance at loan origination
- *Mortgage Insurance Percentage*: The percentage of loss coverage on the loan at origination
- *# Units*: The number of units of a mortgage
- *Occupancy Status*: Occupancy status of the mortgage, indicating whether the property is owner-occupied, second home, or investment property
- *Channel*: The channel through which the loan is originated, indicating whether through retail, broker, or correspondent
- *Prepayment Penalty Mortgage (PPM) Flag*: A dummy variable that if a mortgage has a prepayment penalty
- *Property Type*: The type of the property secured by the mortgage is a condominium, leasehold, planned unit development, cooperative share, manufactured home, or single family home
- *Loan Purpose*: A variable indicating whether the mortgage loan is a cash-out refinance mortgage, no cash-out refinance mortgage, or a purchase mortgage
- *Current Interest Rate*: The current interest rate on the mortgage loan

- *Interest Difference*: The difference between the original interest rate and current interest rate
- *Risk Premium*: The difference between the original interest rate and 30 year mortgage rate
- *Loan Age*: The number of months since the origination month of the mortgage

Macroeconomic Variables

- *30_Year Mortgage Rate*: Contract interest rates on commitments for fixed-rate first mortgages from Primary Mortgage Market Survey data provided by Freddie Mac
- *10_Year Tbill Rate*: The rates on 1-month treasury bills
- *GDP Growth*: The GDP growth rate
- *HPI*: Quarterly FHFA HPI index by MSA

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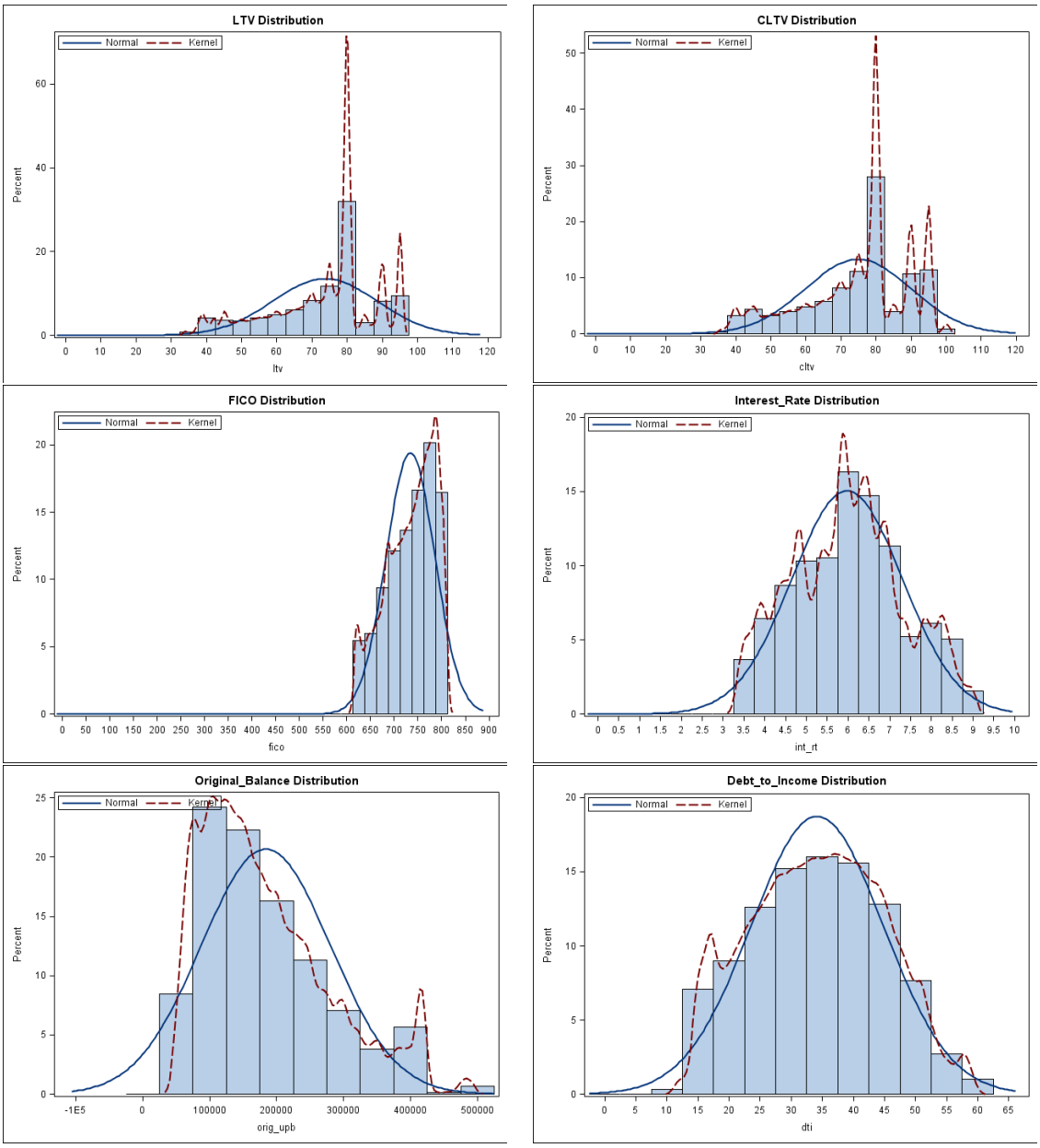

Figure 2.1. Summary of Loan Characteristics at Origination. This figure shows a summary of loan characteristics at origination.The charts show both normal and kernel distributions for loan-to-value ratio (LTV), combined loan-to-value ratio (CLTV), credit score FICO, original interest rate of the loan, originial unpaid principle balance (UPB), and debt-to-income ratio (DTI).

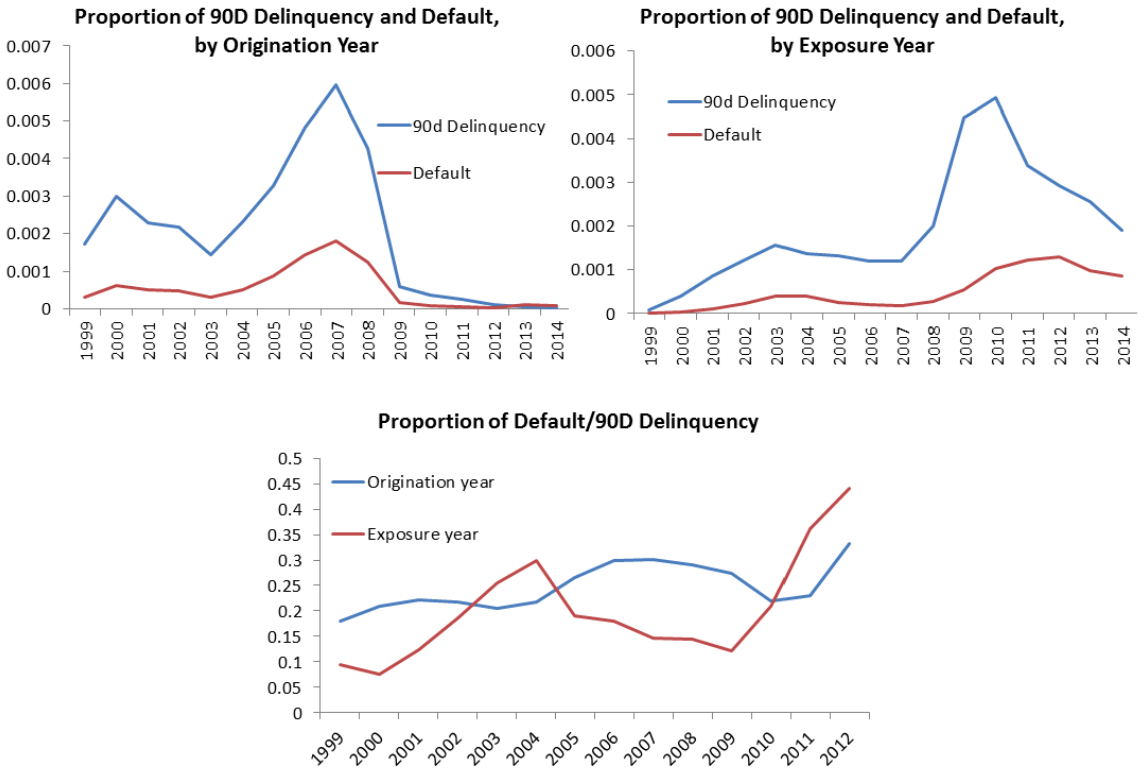

Figure 2.2. Proportion of Default out of 90-day Delinquency by Origination Year and Exposure Year. This figure compares the proportions of default loans out of those being 90-day delinquent, by Origination Year and Exposure Year.

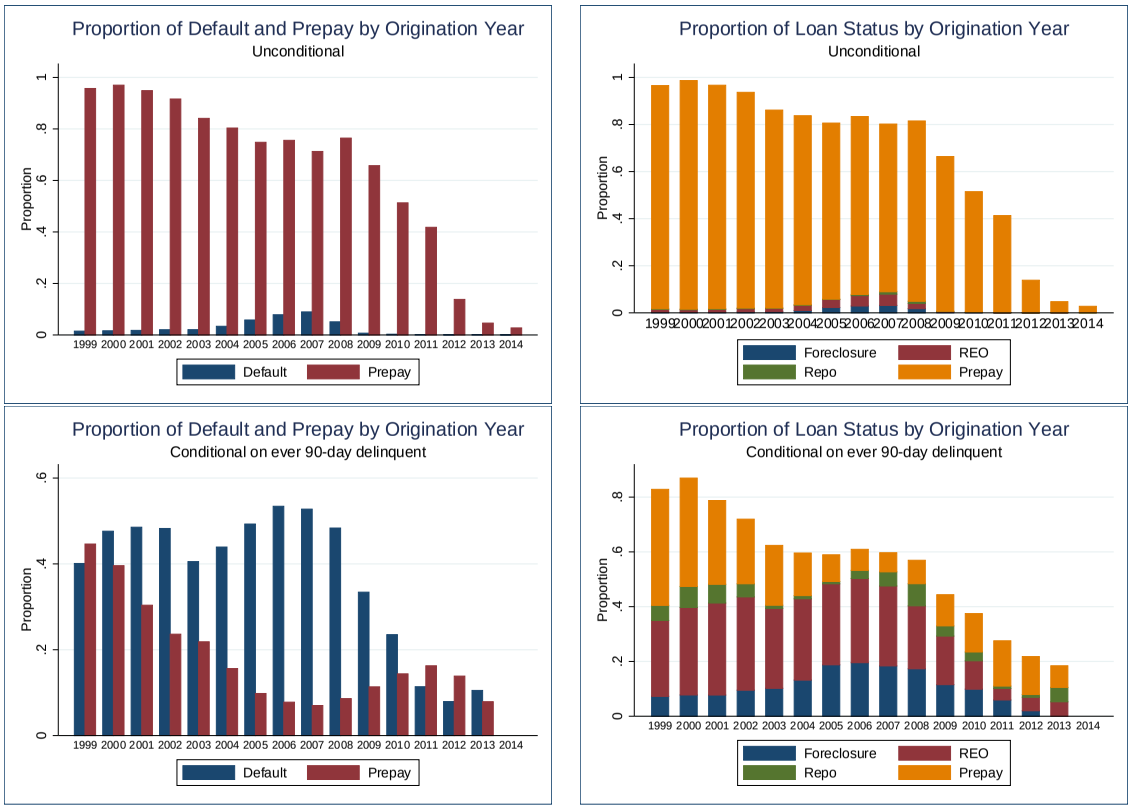

Figure 2.3. Proportion of Loan Ending Status by Origination Year. The top figures show unconditional proportions of loan ending status by origination year. And the bottom two charts show proportions of loan ending status by origination year, conditional on the loan being 90-day delinquent.

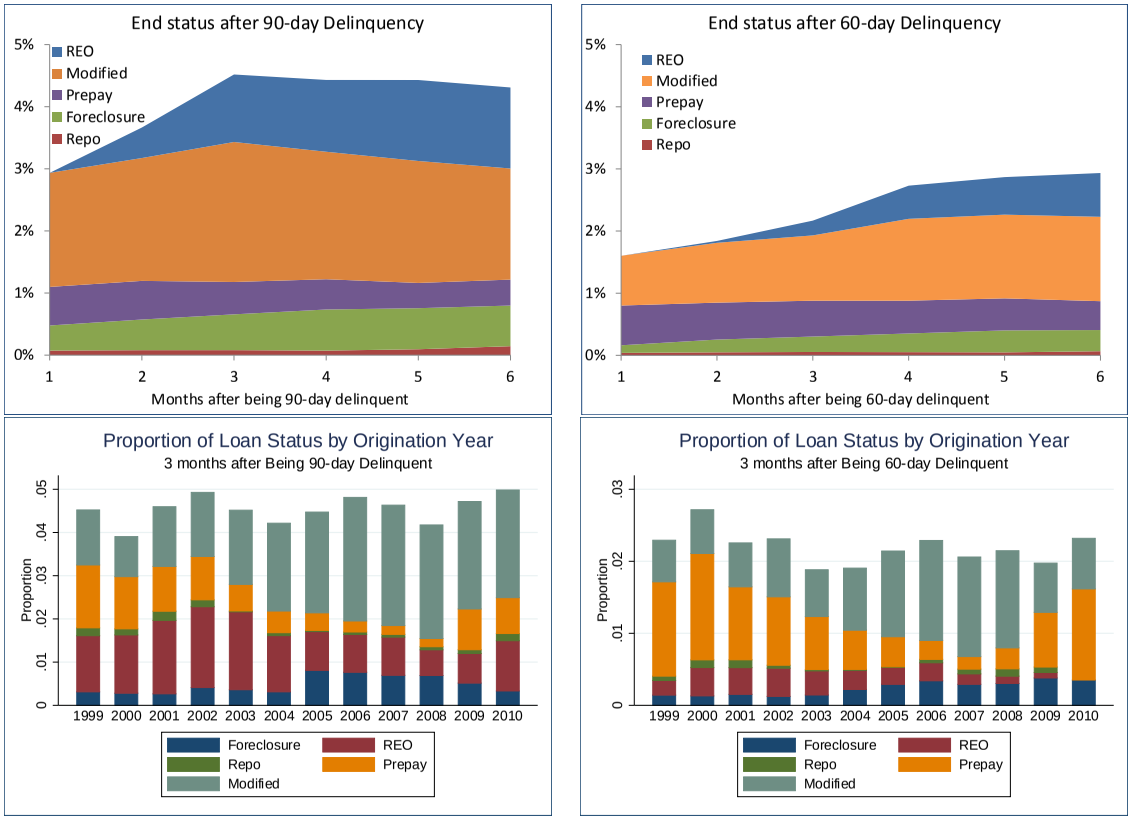

Figure 2.4. Proportion of Loan Status 1-6 months after Being Delinquent. The top figures show loan ending status one to six months after the loan being 90-day and 60-day delinquent. And the bottom two charts show proportions of loan ending status by origination year, three months after the loan being 90-day and 60-day delinquent.

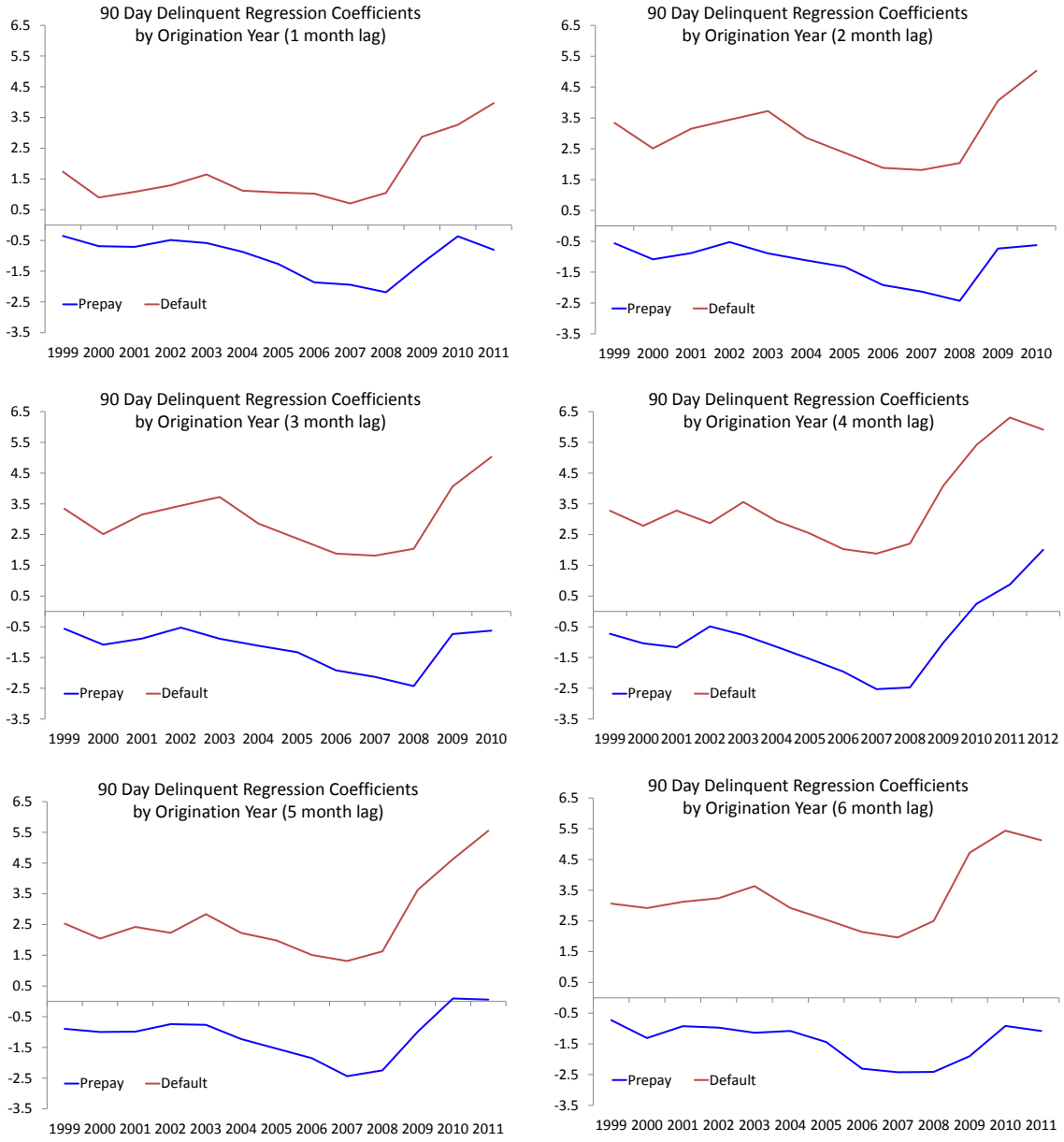

Figure 2.5. Coefficients of Competing Risk Regressions of Ending Status on 90-Day Delinquency. The figures show coefficients of separate competing risk regressions of ending status on 90-day delinquency by each origination year. For example, the first chart show regression coefficients of 90-day delinquency (1 month lag), which is a dummy that equals 1 if a loan is in 90-day delinquency status one month ago, by each origination year.

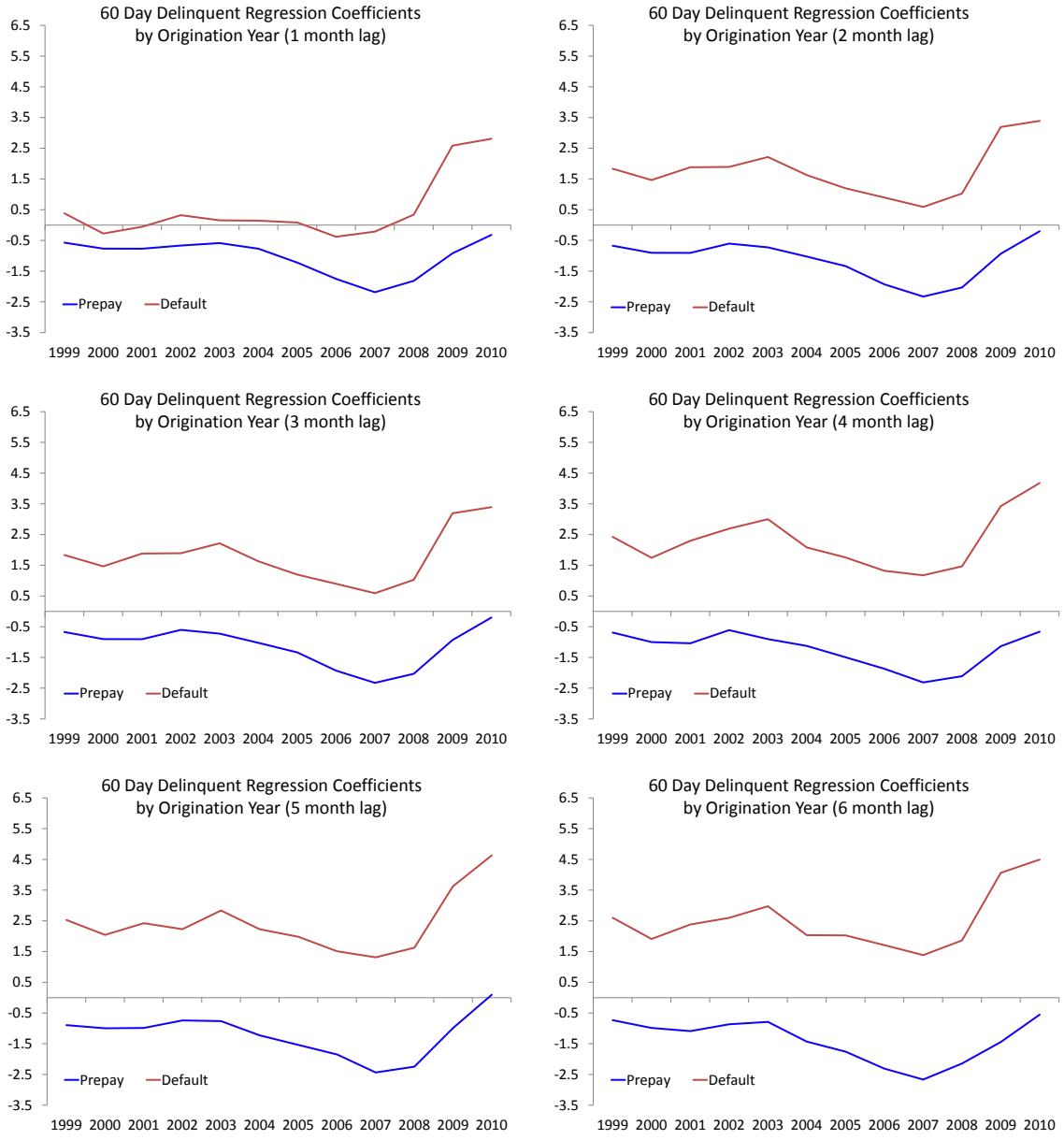

Figure 2.6. Coefficients of Competing Risk Regressions of Ending Status on 60-Day Delinquency. The figures show coefficients of separate competing risk regressions of ending status on 90-day delinquency by each origination year. For example, the first chart show regression coefficients of 60-day delinquency (1 month lag), which is a dummy that equals 1 if a loan is in 60-day delinquency status one month ago, by each origination year.

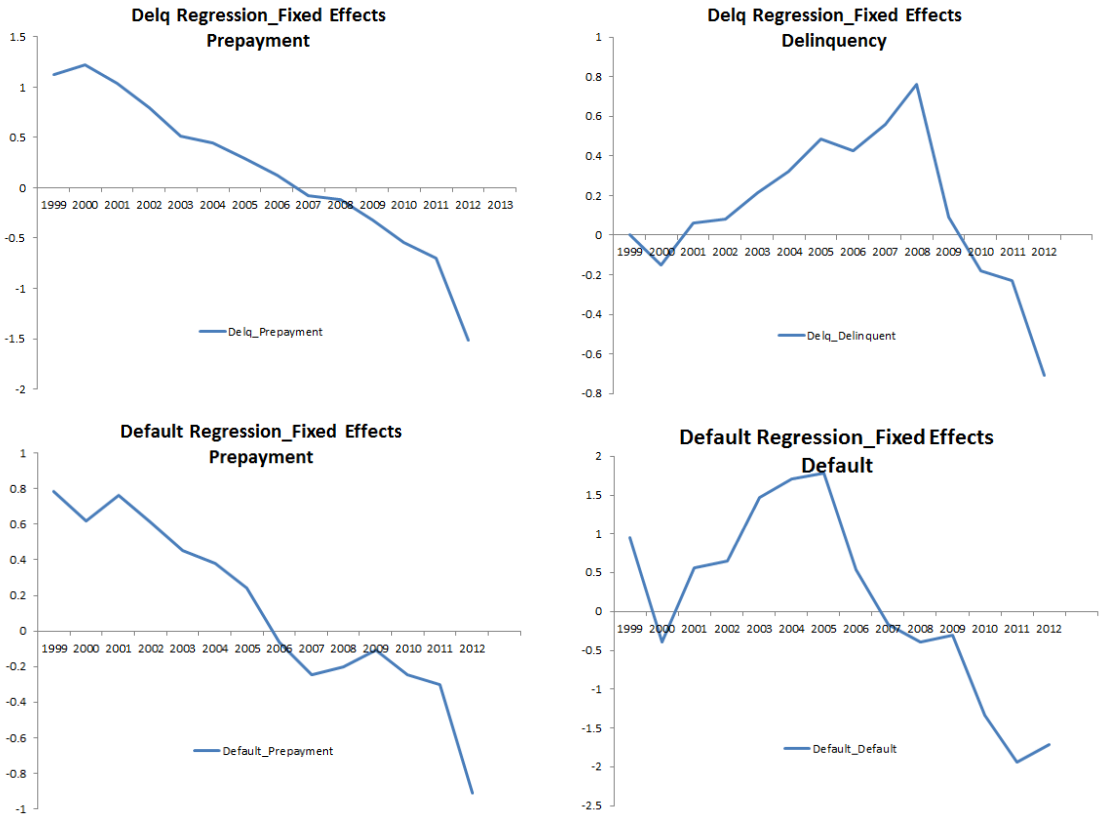

Figure 2.7. Origination Year Fixed Effects Coefficients, by Delinquency and Default. The top two figures show the origination year fixed effects coefficients from a multinomial logit regression model with competing risks on delinquency. And the bottom two charts show origination year fixed effects coefficients from a multinomial logit regression model with competing risks on default.

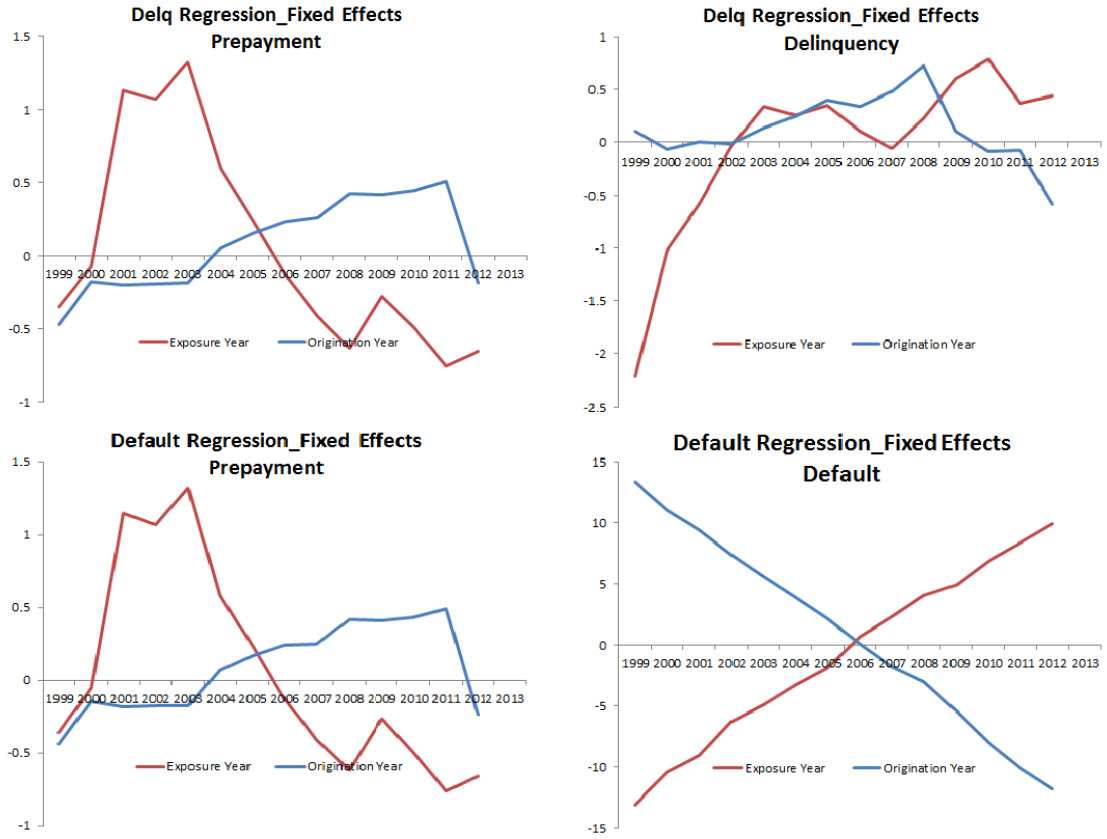

Figure 2.8. Origination Year Fixed Effects and Exposure Year Fixed Effects Coefficients, by Delinquency and Default. The top two figures show the origination year fixed effects and exposure year fixed effects coefficients from a multinomial logit regression model with competing risks on delinquency. And the bottom two charts show origination year fixed effects and exposure year fixed effects coefficients from a multinomial logit regression model with competing risks on default.

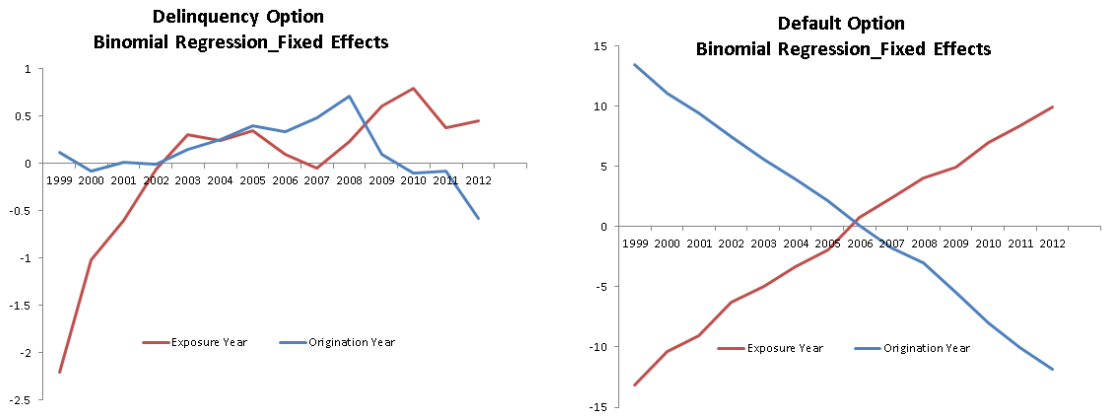

Figure 2.9. Origination Year Fixed Effects and Exposure Year Fixed Effects Coefficients, by Delinquency and Default. The top two figures show the origination year fixed effects and exposure year fixed effects coefficients from a binomial logit regression model on delinquency. And the bottom two charts show origination year fixed effects and exposure year fixed effects coefficients from a binomial logit regression model on default.

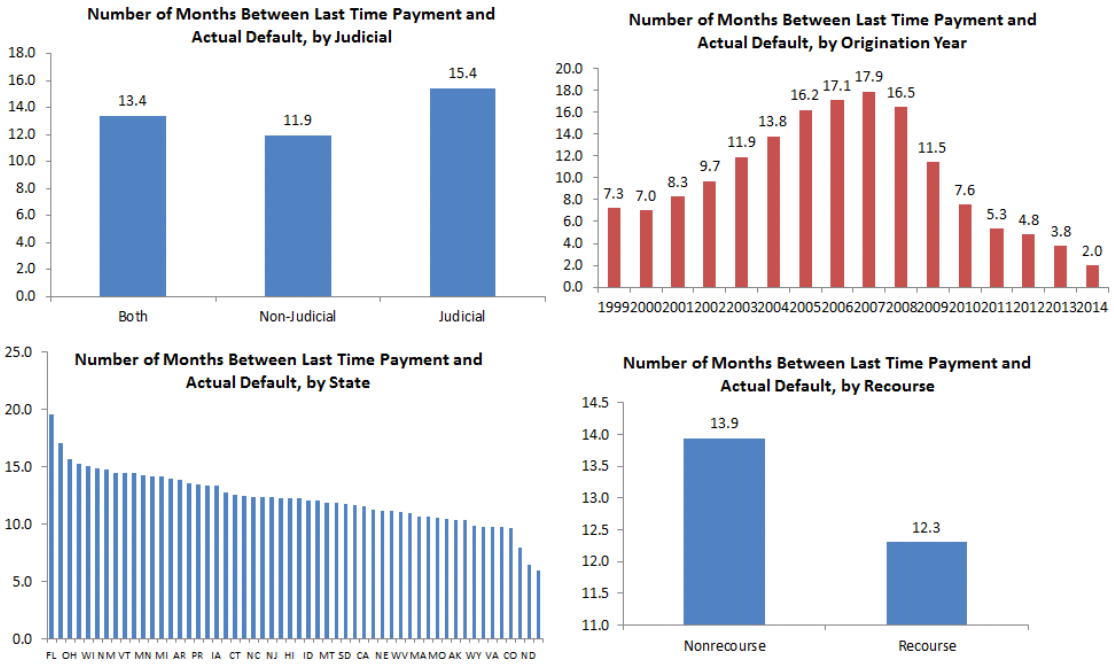

Figure 2.10. Number of Months Between Last Time Payment and Actual Default.

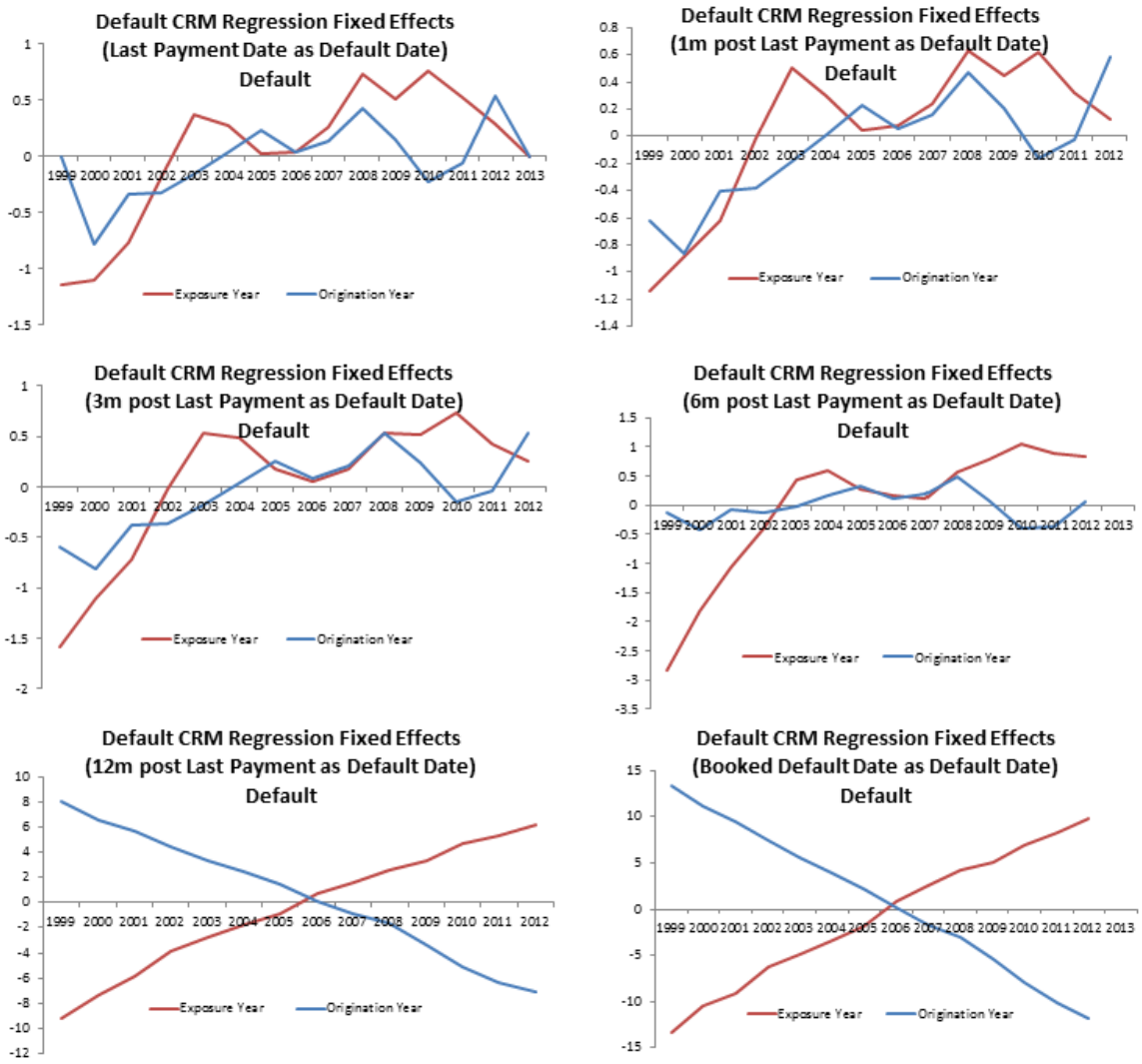

Figure 2.11. Fixed Effects of Origination Year and Exposure Year

Table 2.2
Predicting Power of 90-Day and 60-day Delinquency
This table shows the predicting power of 90-day and 60-day delinquency (three month lag) on final ending status of mortgage loans. Panel A includes the coefficients of separate competing risk regressions of ending status on 90-day delinquency three months ago by each origination year. Panel B includes the coefficients of separate competing risk regressions of ending status on 60-day delinquency three months ago by each origination year. The dependent variable is a factor variable, indicating whether the loan is current, prepaid or default. The regressions use sub-samples from origination year1999 to 2011, and the regressions on 2012-2014 subsamples are not shown due to lack of model validity. *90_Delq_3m* is a dummy variable that equals 1 if the loan is in a 90-day delinquency status three month ago, and 0 otherwise. *60_Delq_3m* is a dummy variable that equals 1 if the loan is in a 60-day delinquency status three month ago, and 0 otherwise. All columns control for both exposure year and state level fixed effects.

Panel A: Default versus 90-Day Delinquency 3 Month Ago

Dep. Var.: *Default*	1999		2000		2001		2002		2003	
	Prepay	Default	Prepay	Default	Prepay	Default	Prepay	Default	Prepay	Default
90_Delq_3m	-0.5630***	3.3413***	-1.0843***	2.5128***	-0.8823***	3.1518***	-0.5244***	3.4422***	-0.8890***	3.7233***
	(0.14)	(0.13)	(0.15)	(0.13)	(0.16)	(0.12)	(0.15)	(0.11)	(0.19)	(0.11)
Constant	-4.2336***	-8.7319***	-4.0637***	-8.5010	-4.047***	-8.477***	-4.0619***	-8.9519*	-4.3287***	-9.2833***
	(0.01)	(2.80)	(0.02)	(5.82)	(0.01)	(2.84)	(0.01)	(4.60)	(0.01)	(3.15)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

	2004		2005		2006		2007		2008	
	Prepay	Default	Prepay	Default	Prepay	Default	Prepay	Default	Prepay	Default
90_Delq_3m	-1.1159***	2.8583***	-1.3282***	2.3708***	-1.9179***	1.8805***	-2.1300***	1.8136***	-2.4300***	2.0404***
	(0.17)	(0.10)	(0.15)	(0.08)	(0.18)	(0.07)	(0.19)	(0.07)	(0.25)	(0.10)
Constant	-4‴.3138***	-8.5494***	-4.3607***	-8.2918***	-4.1429***	-7.4538***	-4.2033***	-7.2948***	-4.0363***	-7.3927***
	(0.01)	(1.35)	(0.010)	(1.41)	(0.01)	(0.69)	(0.01)	(0.64)	(0.01)	(0.62)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

	2009		2010		2011	
	Prepay	Default	Prepay	Default	Prepay	Default
90_Delq_3m	-0.7361***	4.0630***	-0.6241	5.0292***	0.7592**	-8.7338
	(0.30)	(0.27)	(0.45)	(0.34)	(0.36)	(600.8)
Constant	-4.3839***	-10.1304**	-4.4101***	-11.3053*	-4.4445***	-13.4394
	(0.01)	(4.25)	(0.01)	(6.83)	(0.01)	(21.22)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Panel B: Default versus 60-Day Delinquency 3 Month Ago

Dep. Var.: *Default*	1999		2000		2001		2002		2003	
	Prepay	Default	Prepay	Default	Prepay	Default	Prepay	Default	Prepay	Default
90_Delq_3m	-0.6727***	1.8334***	-0.9041***	1.4648***	-0.9069***	1.8803***	-0.6036***	1.8916***	-0.7255***	2.2155***
	(0.09)	(0.16)	(0.09)	(0.14)	(0.10)	(0.14)	(0.11)	(0.14)	(0.12)	(0.14)
Constant	-4.2308***	-8.7145***	-4.0583***	-8.508	-4.0438***	-8.5228*	-4.0601***	-8.8567**	-4.3277***	-9.2132***
	(0.01)	(3.38)	(0.02)	(6.91)	(0.01)	(5.06)	(0.01)	(4.05)	(0.01)	(2.86)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

	2004		2005		2006		2007		2008	
	Prepay	Default	Prepay	Default	Prepay	Default	Prepay	Default	Prepay	Default
90_Delq_3m	-1.0245***	1.6292***	-1.3354***	1.1957***	-1.9308***	0.8972***	-2.3271***	0.5919***	-2.0335***	1.0276***
	(0.11)	(0.12)	(0.11)	(0.10)	(0.13)	(0.08)	(0.15)	(0.09)	(0.15)	(0.11)
Constant	-4.3118***	-8.5266***	-4.3576***	-8.2821***	-4.1383***	-7.4342***	-4.1967***	-7.2692***	-4.0326***	-7.3734***
	(0.01)	(1.30)	(0.01)	(1.56)	(0.01)	(0.57)	(0.01)	(0.54)	(0.01)	(0.53)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

	2009		2010		2011			
	Prepay	Default	Prepay	Default	Prepay	Default		
90_Delq_3m	-0.934***	3.1922***	-0.2013	3.3917***	0.3639	4.8231***	0.5777	5.5694***
	(0.22)	(0.28)	(0.24)	(0.46)	(0.27)	(0.47)	(0.71)	(0.74)
Constant	-4.3834***	-10.1573**	-4.4102***	-11.3368	-4.4445***	-13.4989	-5.1798***	-15.9844
	(0.01)	(4.85)	(0.01)	(8.12)	(0.01)	(21.31)	(0.03)	(47.97)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes		
State FE	Yes	Yes	Yes	Yes	Yes	Yes		

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 2.3
Delinquency Multimonial Logit Regressions with Competing Risks
This table shows the results from Delinquency Multimonial Logit Regressions with Competing Risks. I control for both origination-year-fixed effects and exposure-year-fixed effects in all columns.

Dep. Var.: *Delinquency*	Prepayment	Delinquency	Prepayment	Delinquency	Prepayment	Delinquency
Option	(1)	(2)	(3)	(4)	(5)	(6)
FICO Score	0.0022***	-0.0126***	0.0023***	-0.0127***	0.0026***	-0.0111***
	(0.0000)	(0.0001)	(0.0000)	(0.0001)	(0.0000)	(0.0001)
Combined Loan-to-Value	0.0074***	-0.0014***	0.0073***	0.0032***	0.0047***	0.0089***
	(0.0001)	(0.0005)	(0.0001)	(0.0005)	(0.0001)	(0.0007)
Updated Loan-to-Value Ratio	-0.0102***	0.0278***	-0.0081***	0.0248***	-0.0135***	0.0233***
	(0.0001)	(0.0002)	(0.0001)	(0.0003)	(0.0001)	(0.0003)
# Borrowers=1	-0.2292***	0.497***	-0.2325***	0.4912***	-0.0914***	0.5073***
	(0.0033)	(0.0115)	(0.0034)	(0.0117)	(0.0036)	(0.0121)
Debt-to-Income Ratio	0.0025***	0.0175***	0.0017***	0.0175***	-0.0019***	0.0168***
	(0.0001)	(0.0005)	(0.0001)	(0.0005)	(0.0001)	(0.0005)
GDP Growth			1.1278***	-5.5632***	0.7847***	-5.2656***
			(0.1024)	(0.3400)	(0.1073)	(0.3468)
Unemployment			0.0049***	0.0659***	-0.0339***	0.066***
			(0.0013)	(0.0047)	(0.0015)	(0.0049)
HPI			0.0038***	0.0024***	-0.0003***	0.0019***
			(0.0000)	(0.0002)	(0.0000)	(0.0002)
30-Year Mortgage Rate			-0.6488***	-0.0559***	-0.0343***	0.619***
			(0.0058)	(0.0209)	(0.0077)	(0.0276)
10-Year Tbill Rate			0.0179***	-0.0353***	0.0223***	-0.0171
			(0.0028)	(0.0119)	(0.0029)	(0.0122)
Log (Unpaid Principal Balance)					0.8333***	0.2174***
					(0.0042)	(0.0153)
loan-age					0.0075***	0.0105***
					(0.0003)	(0.0012)
Loan Purpose-Cash out					-0.0853***	0.1755***

					(0.0028)	(0.0090)
Loan Purpose-No Cash out					0.0206***	0.0923***
					(0.0026)	(0.0092)
Original Rate-Current Rate					-0.3336**	-0.363***
					(0.0137)	(0.0313)
Original Rate-30yr Mtg Rate					0.5911	0.6335
					(0.0048)	(0.0168)
Mortgage Insurance%					-0.0001	-0.0002
					(0.0002)	(0.0006)
Condo					-0.0569***	-0.0897***
					(0.0069)	(0.0222)
Channel-Correspondent					-0.0129***	-0.1429
					(0.0073)	(0.0372)
Number of Units					-0.3148***	0.0163***
					(0.0101)	(0.0281)
Nonrecourse State					0.0886***	-0.0299**
					(0.0041)	(0.0145)
# Foreclosure Process Days					0.0004***	0.0002***
					(0.0000)	(0.0000)
Intercept	-6.0759***	-2.0228***	-3.4122***	-2.1055***	-15.4897***	-10.1914***
	(0.0299)	(0.1070)	(0.0555)	(0.1924)	(0.0841)	(0.2965)
Origination Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Exposure Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	31343382	31343382	31343382	31343382	31343382	31343382

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 2.4
Default Multimonial Logit Regressions with Competing Risks
This table shows the results from Default Multimonial Logit Regressions with Competing Risks. I control for both origination-year-fixed effects and exposure-year-fixed effects in all columns.

Dep. Var.: *Default Option*	Prepayment (1)	Default (2)	Prepayment (3)	Default (4)	Prepayment (5)	Default (6)
FICO Score	0.0026***	-0.0072***	0.0027***	-0.0076***	0.0029***	-0.0047***
	(0.0000)	(0.0001)	(0.0000)	(0.0001)	(0.0000)	(0.0002)
Combined Loan-to-Value	0.0091***	0.0082***	0.009***	0.0117***	0.006***	0.0199***
	(0.0001)	(0.0007)	(0.0001)	(0.0008)	(0.0001)	(0.0014)
Updated Loan-to-Value Ratio	-0.0126***	0.0306***	-0.0108***	0.0271***	-0.0155***	0.02***
	(0.0001)	(0.0003)	(0.0001)	(0.0004)	(0.0001)	(0.0006)
# Borrowers=1	-0.2378***	0.4824***	-0.2416***	0.4905***	-0.103***	0.3548***
	(0.0033)	(0.0164)	(0.0034)	(0.0170)	(0.0035)	(0.0239)
Debt-to-Income Ratio	0.0021***	0.0115***	0.0013***	0.0126***	-0.0021***	0.0053***
	(0.0001)	(0.0007)	(0.0001)	(0.0007)	(0.0001)	(0.0011)
GDP Growth			1.1405***	-2.5042***	0.772***	-2.8848***
			(0.1018)	(0.5530)	(0.1067)	(0.7647)
Unemployment			0.0047***	0.0267***	-0.034***	0.0699***
			(0.0013)	(0.0071)	(0.0015)	(0.0099)
HPI			0.0036***	-0.003***	-0.0004***	-0.0028***
			(0.0000)	(0.0003)	(0.0000)	(0.0004)
30-Year Mortgage Rate			-0.6378***	-0.2141***	-0.0621***	-0.4236***
			(0.0058)	(0.0278)	(0.0076)	(0.0528)
10-Year Tbill Rate			0.0207***	-0.0539***	0.0238***	-0.2134***
			(0.0028)	(0.0158)	(0.0029)	(0.0215)
Log (Unpaid Principal Balance)					0.8156***	0.2049***
					(0.0042)	(0.0304)
loan-age					0.0065***	-0.1587***
					(0.0003)	(0.0016)
Loan Purpose-Cash out					-0.087***	0.0666***
					(0.0028)	(0.0182)

Loan Purpose-No Cash out					0.0163***	0.0917***
					(0.0025)	(0.0181)
Original Rate-Current Rate					-0.3603***	0.4984***
					(0.0077)	(0.0069)
Original Rate-30yr Mtg Rate					0.556	0.6458
					(0.0047)	(0.0315)
Mortgage Insurance%					-0.0002	-0.0088
					(0.0002)	(0.0012)
Condo					-0.0459***	0.3998***
					(0.0068)	(0.0381)
Channel-Correspondent					-0.0074***	-0.6093***
					(0.0073)	(0.0654)
Number of Units					-0.301***	0.2115***
					(0.0100)	(0.0489)
Nonrecourse State					0.0927***	0.1912***
					(0.0041)	(0.0278)
# Foreclosure Process Days					0.0003***	-0.0007***
					(0.0000)	(0.0001)
Intercept	-6.316***	-7.9307***	-3.6907***	-5.5404***	-15.3877***	-7.8625***
	(0.0298)	(0.1539)	(0.0552)	(0.2916)	(0.0838)	(0.5680)
Origination Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Exposure Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	32507755	32507756	32507757	32507758	32507759	32507760

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 2.5
Standardized Delinquency Multimonial Logit Regressions with Competing Risks
This table shows the results from Standardized Delinquency Multimonial Logit Regressions with Competing Risks. I control for both origination-year-fixed effects and exposure-year-fixed effects in all columns.

Dep. Var.: *Delinquency*	Prepayment	Delinquency	Prepayment	Delinquency	Prepayment	Delinquency
Option	(1)	(2)	(3)	(4)	(5)	(6)
FICO Score	0.0022***	-0.0126***	0.0023***	-0.0127***	0.0026***	-0.0111***
	(0.0000)	(0.0001)	(0.0000)	(0.0001)	(0.0000)	(0.0001)
Combined Loan-to-Value	0.0074***	-0.0014***	0.0073***	0.0032***	0.0047***	0.0089***
	(0.0001)	(0.0005)	(0.0001)	(0.0005)	(0.0001)	(0.0007)
Updated Loan-to-Value	-0.0102***	0.0278***	-0.0081***	0.0248***	-0.0135***	0.0233***
	(0.0001)	(0.0002)	(0.0001)	(0.0003)	(0.0001)	(0.0003)
# Borrowers=1	-0.2292***	0.497***	-0.2325***	0.4912***	-0.0914***	0.5073***
	(0.0033)	(0.0115)	(0.0034)	(0.0117)	(0.0036)	(0.0121)
Debt-to-Income Ratio	0.0025***	0.0175***	0.0017***	0.0175***	-0.0019***	0.0168***
	(0.0001)	(0.0005)	(0.0001)	(0.0005)	(0.0001)	(0.0005)
GDP Growth			1.1278***	-5.5632***	0.7847***	-5.2656***
			(0.1024)	(0.3400)	(0.1073)	(0.3468)
Unemployment			0.0049***	0.0659***	-0.0339***	0.066***
			(0.0013)	(0.0047)	(0.0015)	(0.0049)
HPI			0.0038***	0.0024***	-0.0003***	0.0019***
			(0.0000)	(0.0002)	(0.0000)	(0.0002)
30-Year Mortgage Rate			-0.6488***	-0.0559***	-0.0343***	0.619***
			(0.0058)	(0.0209)	(0.0077)	(0.0276)
10-Year Tbill Rate			0.0179***	-0.0353***	0.0223***	-0.0171
			(0.0028)	(0.0119)	(0.0029)	(0.0122)
Log (Unpaid Principal Balanc)					0.8333***	0.2174***
					(0.0042)	(0.0153)
loan-age					0.0075***	0.0105***
					(0.0003)	(0.0012)
Loan Purpose-Cash out					-0.0853***	0.1755***

					(0.0028)	(0.0090)
Loan Purpose-No Cash out					0.0206***	0.0923***
					(0.0026)	(0.0092)
Original Rate-Current Rate					-0.3336**	-0.363***
					(0.0137)	(0.0313)
Original Rate-30yr Mtg Rate					0.5911	0.6335
					(0.0048)	(0.0168)
Mortgage Insurance %					-0.0001	-0.0002
					(0.0002)	(0.0006)
Condo					-0.0569***	-0.0897***
					(0.0069)	(0.0222)
Channel-Correspondent					-0.0129***	-0.1429
					(0.0073)	(0.0372)
cnt-units					-0.3148***	0.0163***
					(0.0101)	(0.0281)
Nonrecourse State					0.0886***	-0.0299**
					(0.0041)	(0.0145)
# Foreclosure Process Days					0.0004***	0.0002***
					(0.0000)	(0.0000)
Intercept	-6.0759***	-2.0228***	-3.4122***	-2.1055***	-15.4897***	-10.1914***
	(0.0299)	(0.1070)	(0.0555)	(0.1924)	(0.0841)	(0.2965)
Origination Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Exposure Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	31343382	31343382	31343382	31343382	31343382	31343382

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 2.6
Standardized Default Multimonial Logit Regressions with Competing Risks
This table shows the results from Standardized Default Multimonial Logit Regressions with Competing Risks. I control for both origination-year-fixed effects and exposure-year-fixed effects in all columns.

Dep. Var.: *Default Option*	Prepayment (1)	Default (2)	Prepayment (3)	Default (4)	Prepayment (5)	Default (6)
FICO Score	0.0026***	-0.0072***	0.0027***	-0.0076***	0.0029***	-0.0047***
	(0.0000)	(0.0001)	(0.0000)	(0.0001)	(0.0000)	(0.0002)
Combined Loan-to-Value Ratio	0.0091***	0.0082***	0.009***	0.0117***	0.006***	0.0199***
	(0.0001)	(0.0007)	(0.0001)	(0.0008)	(0.0001)	(0.0014)
Updated Loan-to-Value Ratio	-0.0126***	0.0306***	-0.0108***	0.0271***	-0.0155***	0.02***
	(0.0001)	(0.0003)	(0.0001)	(0.0004)	(0.0001)	(0.0006)
# Borrowers=1	-0.2378***	0.4824***	-0.2416***	0.4905***	-0.103***	0.3548***
	(0.0033)	(0.0164)	(0.0034)	(0.0170)	(0.0035)	(0.0239)
Debt-to-Income Ratio	0.0021***	0.0115***	0.0013***	0.0126***	-0.0021***	0.0053***
	(0.0001)	(0.0007)	(0.0001)	(0.0007)	(0.0001)	(0.0011)
GDP Growth			1.1405***	-2.5042***	0.772***	-2.8848***
			(0.1018)	(0.5530)	(0.1067)	(0.7647)
Unemployment			0.0047***	0.0267***	-0.034***	0.0699***
			(0.0013)	(0.0071)	(0.0015)	(0.0099)
HPI			0.0036***	-0.003***	-0.0004***	-0.0028***
			(0.0000)	(0.0003)	(0.0000)	(0.0004)
30-Year Mortgage Rate			-0.6378***	-0.2141***	-0.0621***	-0.4236***
			(0.0058)	(0.0278)	(0.0076)	(0.0528)
10-Year Tbill Rate			0.0207***	-0.0539***	0.0238***	-0.2134***
			(0.0028)	(0.0158)	(0.0029)	(0.0215)
Log (Unpaid Principal Balanc)					0.8156***	0.2049***
					(0.0042)	(0.0304)
loan-age					0.0065***	-0.1587***
					(0.0003)	(0.0016)
Loan Purpose-Cash out					-0.087***	0.0666***

					(0.0028)	(0.0182)
Loan Purpose-No Cash out					0.0163***	0.0917***
					(0.0025)	(0.0181)
int-diff					-0.3603***	0.4984***
					(0.0077)	(0.0069)
Risk Premium					0.556	0.6458
					(0.0047)	(0.0315)
Mortgage Insurance Percentage					-0.0002	-0.0088
					(0.0002)	(0.0012)
Condo					-0.0459***	0.3998***
					(0.0068)	(0.0381)
Channel-Correspondent					-0.0074***	-0.6093***
					(0.0073)	(0.0654)
cnt-units					-0.301***	0.2115***
					(0.0100)	(0.0489)
Nonrecourse State					0.0927***	0.1912***
					(0.0041)	(0.0278)
# Foreclosure Process Days					0.0003***	-0.0007***
					(0.0000)	(0.0001)
Intercept	-6.316***	-7.9307***	-3.6907***	-5.5404***	-15.3877***	-7.8625***
	(0.0298)	(0.1539)	(0.0552)	(0.2916)	(0.0838)	(0.5680)
Origination Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Exposure Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	32507755	32507756	32507757	32507758	32507759	32507760

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 2.7
Coefficients Differences between Delinquency Model and Default Model
This table shows the coefficients differences between standardized delinquency regressions and default regressions.

Dep. Var.:	Prepayment	Default-Delq.	Prepayment	Default-Delq.	Prepayment	Default-Delq.
Delinquency Option	(1)	(2)	(3)	(4)	(5)	(6)
FICO Score	0.0002	0.0037	0.0002	0.0037	0.0002	0.0038
Combined Loan-to-Value	0.0011	0.0102	0.0011	0.0110	0.0006	0.0145
Updated Loan-to-Value Ratio	-0.0015	0.0035	-0.0016	0.0016	-0.0009	0.0022
# Borrowers=1	-0.0010	0.0704	-0.0011	0.0663	-0.0029	0.0024
Debt-to-Income Ratio	-0.0003	-0.0043	-0.0002	-0.0041	-0.0001	-0.0031
GDP Growth			-0.0516	-3.5020	-0.0499	-3.7938
Unemployment			0.0006	0.0086	0.0010	-0.0018
HPI			-0.0002	-0.0020	-0.0001	-0.0015
30-Year Mortgage Rate			0.0056	0.0369	-0.0185	0.2322
10-Year Tbill Rate			0.0033	-0.0020	0.0020	-0.0071
Log (UPB)					-0.0136	-0.2525
loan-age					-0.0009	-0.0027
Loan Purpose-Cash out					-0.0003	0.0117
Loan Purpose-No Cash out					-0.0027	0.0232
int-diff					-0.0321	0.3432
Risk Premium					-0.0205	0.1950
Mortgage Insurance %					0.0000	-0.0027
Condo					0.0116	0.2591
Channel-Correspondent					0.0038	-0.1033
cnt-units					0.0135	0.1608
Nonrecourse State					0.0011	0.1489
# Foreclosure Process Days					0.0000	-0.0009

Table 2.8
Coefficients Differences between Delinquency Model and Default Model with Significance
This table shows the coefficients differences between delinquency Model and default Model with significance.

Dep. Var.: *Delinquency Option*	Prepayment (1)	Default-Delq. (2)	Prepayment (3)	Default-Delq. (4)	Prepayment (5)	Default-Delq. (6)
FICO Score	0.0003***	0.0038***	0.0004***	0.0039***	0.0002***	0.0038***
	(0.0000)	(0.0001)	(0.0000)	(0.0001)	(0.0000)	(0.0002)
Combined Loan-to-Value	0.0007***	0.0108***	0.0005**	0.0092***	0.0006**	0.0139***
	(0.0002)	(0.0008)	(0.0002)	(0.0009)	(0.0002)	(0.0012)
Updated Loan-to-Value Ratio	-0.001***	0.0033***	-0.0009***	0.004***	-0.0009***	0.0038***
	(0.0001)	(0.0003)	(0.0001)	(0.0004)	(0.0002)	(0.0005)
# Borrowers=1	-0.0055	0.0539***	-0.0031	0.0688***	-0.003	0.0042
	(0.0047)	(0.0199)	(0.0048)	(0.0200)	(0.0050)	(0.0208)
Debt-to-Income Ratio	-0.0005**	-0.0039***	-0.0003	-0.0037***	-0.0001	-0.003***
	(0.0002)	(0.0009)	(0.0002)	(0.0009)	(0.0002)	(0.0009)
GDP Growth			-0.0791	-2.8385***	-0.1123	-2.9553***
			(0.1068)	(0.3648)	(0.1116)	(0.3720)
Unemployment			0.0003	0.0033	0.0007	0.001
			(0.0015)	(0.0059)	(0.0016)	(0.0061)
HPI			0.00001***	-0.0013***	-0.0001	-0.001***
			(0.0000)	(0.0003)	(0.0000)	(0.0003)
30-Year Mortgage Rate			0.0202	0.3179***	-0.0044	0.2747***
			(0.0034)	(0.0174)	(0.0044)	(0.0243)
10-Year Tbill Rate			0.0006***	-0.0815***	0.0025	-0.1021***
			(0.0018)	(0.0103)	(0.0020)	(0.0108)
Log (Unpaid Principal Balance)					-0.0131**	-0.2799***
					(0.0059)	(0.0259)
loan-age					-0.0006***	-0.0043***
					(0.0001)	(0.0004)

Loan Purpose-Cash out	-0.0004	0.0162
	(0.0040)	(0.0156)
Loan Purpose-No Cash out	-0.0027	0.0237
	(0.0036)	(0.0157)
Original Rate-Current Rate	-0.0386**	0.2972***
	(0.0153)	(0.0329)
Original Rate-30yr Mtg Rate	-0.0198***	0.0242***
	(0.0039)	(0.0172)
Mortgage Insurance%		-0.0031***
	(0.0002)	(0.0010)
Condo	0.0114	0.2573***
	(0.0097)	(0.0353)
Channel-Correspondent	-0.0003	-0.0966
	(0.0096)	(0.0618)
Number of Units	0.0133	0.1714***
	(0.0143)	(0.0456)
Nonrecourse State	0.0014	0.1303***
	(0.0057)	(0.0235)
# Foreclosure Process Days		-0.0009***
	(0.0000)	(0.0001)

Table 2.9
Delinquency Multimonial Logit Regressions with Competing Risks Pre-2006
This table shows the results from Delinquency Multimonial Logit Regressions with Competing Risks pre-2006 before the financial crisis. I control for both origination-year-fixed effects and exposure-year-fixed effects in all columns.

Dep. Var.: *Delinquency Option*	Prepayment (1)	Delinquency (2)	Prepayment (3)	Delinquency (4)	Prepayment (5)	Delinquency (6)
FICO Score	0.0006***	-0.0199***	0.0008***	-0.0199***	0.0014***	-0.0174***
	(0.0000)	(0.0003)	(0.0000)	(0.0003)	(0.0000)	(0.0003)
Combined Loan-to-Value	0.012***	0.0053***	0.0056***	0.0136***	0.0031***	0.0087***
	(0.0003)	(0.0023)	(0.0003)	(0.0023)	(0.0004)	(0.0028)
Updated Loan-to-Value Ratio	-0.0111***	0.0278***	0.0004	0.0169***	-0.0023***	0.0188***
	(0.0003)	(0.0021)	(0.0004)	(0.0023)	(0.0004)	(0.0025)
# Borrowers=1	-0.1693***	0.7275***	-0.163***	0.7229***	-0.0647***	0.643***
	(0.0053)	(0.0298)	(0.0053)	(0.0298)	(0.0057)	(0.0314)
Debt-to-Income Ratio	0.0072***	0.013***	0.0058***	0.0134***	0.0025***	0.0135***
	(0.0002)	(0.0015)	(0.0002)	(0.0015)	(0.0002)	(0.0015)
GDP Growth			-0.2746*	-1.6921**	-0.3573**	0.9703
			(0.1666)	(0.8649)	(0.1792)	(0.9304)
Unemployment			0.0394***	0.2058***	0.0004	0.235***
			(0.0030)	(0.0180)	(0.0034)	(0.0193)
HPI			0.0065***	-0.0025***	0.0031***	-0.0012*
			(0.0000)	(0.0005)	(0.0001)	(0.0006)
30-Year Mortgage Rate			-0.603***	-0.0979*	0.2198***	0.6726***
			(0.0097)	(0.0562)	(0.0124)	(0.0696)
10-Year Tbill Rate			-0.0236***	-0.0249	-0.021***	-0.0182***
			-0.00378	(0.0210)	(0.0039)	(0.0217)
Log (Unpaid Principal Balance)					0.7728***	-0.0276***
					(0.0071)	(0.0407)
loan-age					0.0193***	0.0291***
					(0.0005)	(0.0031)
Loan Purpose-Cash out					-0.0324***	0.132***

					(0.0047)	(0.0266)
Loan Purpose-No Cash out					-0.0091	0.1214
					(0.0042)	(0.0221)
Original Rate-Current Rate					-0.1621	-0.6274
					(0.0237)	(0.066)
Original Rate-30yr Mtg Rate					0.7813***	0.7215***
					(0.0072)	(0.0396)
Mortgage Insurance%					-0.0021***	0.0076***
					(0.0003)	(0.0017)
Condo					0.0682***	-0.2626***
					(0.0107)	(0.0735)
Channel-Correspondent					0.1886***	0.8107
					(0.1846)	(0.7098)
Number of Units					-0.1955***	0.2287***
					(0.0147)	(0.0676)
Nonrecourse State					0.066***	-0.2094***
					(0.0067)	(0.0403)
# Foreclosure Process Days					0.0003***	0.0003***
					(0.0000)	(0.0004)
Intercept	-5.3918***	2.0223***	-2.8836***	2.5567***	-16.7005***	-4.4168***
	(0.0460)	(0.2777)	(0.0891)	(0.5176)	(0.1382)	(0.7765)
Origination Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Exposure Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	31343382	31343382	31343382	31343382	31343382	31343382

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 2.10
Default Multimonial Logit Regressions with Competing Risks Pre-2006
This table shows the results from Default Multimonial Logit Regressions with Competing Risks pre-2006 before the financial crisis. I control for both origination-year-fixed effects and exposure-year-fixed effects in all columns.

Dep. Var.: *Default Option*	Prepayment (1)	Default (2)	Prepayment (3)	Default (4)	Prepayment (5)	Default (6)
FICO Score	0.0007***	-0.0159***	0.0009***	-0.0158***	0.0015***	-0.015***
	(0.0000)	(0.0005)	(0.0000)	(0.0005)	(0.0000)	(0.0008)
Combined Loan-to-Value	0.0124***	-0.0313***	0.006***	-0.0326***	0.0037***	0.0036***
	(0.0003)	(0.0042)	(0.0003)	(0.0044)	(0.0004)	(0.0072)
Updated Loan-to-Value Ratio	-0.0117***	0.0913***	-0.0003	0.0947***	-0.0032***	0.0269***
	(0.0003)	(0.0039)	(0.0004)	(0.0043)	(0.0004)	(0.0062)
# Borrowers=1	-0.1722***	0.784***	-0.1659***	0.7797***	-0.0697***	0.836***
	(0.0053)	(0.0502)	(0.0053)	(0.0502)	(0.0057)	(0.0810)
Debt-to-Income Ratio	0.0071***	0.0103***	0.0057***	0.0101***	0.0024***	0.0064***
	(0.0002)	(0.0025)	(0.0002)	(0.0025)	(0.0002)	(0.0038)
GDP Growth			-0.2298	-1.6597	-0.3264***	1.3185***
			(0.1655)	(1.4509)	(0.1780)	(2.4210)
Unemployment			0.0384***	0.0811***	-0.0002***	0.1608***
			(0.0030)	(0.0313)	(0.0034)	(0.0493)
HPI			0.0065***	0.0033***	0.0031***	0.0005***
			(0.0000)	(0.0011)	(0.0001)	(0.0016)
30-Year Mortgage Rate			-0.5976***	-0.0628	0.2015***	1.3048***
			(0.0096)	(0.0933)	(0.0123)	(0.1697)
10-Year Tbill Rate			-0.0214***	-0.2059***	-0.0187***	-0.1798***
			(0.0037)	(0.0365)	(0.0039)	(0.0565)
Log (Unpaid Principal Balance)					0.7609***	0.2271***
					(0.0070)	(0.1019)
loan-age					0.0185***	-0.01***
					(0.0005)	(0.0074)
Loan Purpose-Cash out					-0.0319***	-0.1322***
					(0.0046)	(0.0738)

Loan Purpose-No Cash out					-0.0131***	0.2526***
					(0.0041)	(0.0565)
Original Rate-Current Rate					-0.1267***	1.916***
					(0.0220)	(0.0518)
Original Rate-30yr Mtg Rate					0.7587	1.5187
					(0.0072)	(0.0964)
Mortgage Insurance%					-0.0023	0.0006
					(0.0003)	(0.0045)
Condo					0.0748***	0.516***
					(0.0106)	(0.1351)
Channel-Correspondent					0.1967***	2.016***
					(0.1816)	(1.0059)
Number of Units					-0.1836***	0.4699***
					(0.0145)	(0.1211)
Nonrecourse State					0.0674***	-0.0852***
					(0.0067)	(0.0998)
# Foreclosure Process Days					0.0003***	0.0003***
					(0.0000)	(0.0004)
Intercept	-5.463***	-4.7368***	-3.0088***	-3.2352***	-16.5562***	-14.0105***
	(0.0458)	(0.4928)	(0.0886)	(0.9126)	(0.1374)	(1.9622)
Origination Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Exposure Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	32507755	32507756	32507757	32507758	32507759	32507760

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 2.11
Coefficients Differences between Delinquency Model and Default Model Pre-2006
This table shows the coefficients differences between delinquency Model and default Model.

Dep. Var.: *Delinquency Option*	Prepayment (1)	Default-Delq. (2)	Prepayment (3)	Default-Delq. (4)	Prepayment (5)	Default-Delq. (6)
FICO Score	0.000	0.002***	0.000	0.0021***	0.000	0.0029***
	(0.0000)	(0.0006)	(0.0000)	(0.0006)	(0.0000)	(0.0007)
Combined Loan-to-Value	-0.0003	-0.0062	-0.0003	-0.0058	0.0008	0.0007
	(0.0004)	(0.0041)	(0.0004)	(0.0042)	(0.0006)	(0.0066)
Updated Loan-to-Value Ratio	0.0003	0.0266***	0.0003	0.0237***	-0.001	0.0211***
	(0.0003)	(0.0032)	(0.0004)	(0.0036)	(0.0006)	(0.0053)
# Borrowers=1	0.0019	0.1778***	0.002	0.1729***	0.001	0.1007
	(0.0079)	(0.0595)	(0.0079)	(0.0595)	(0.0085)	(0.0627)
Debt-to-Income Ratio	0.000	-0.0037	0.000	-0.003	0.000	-0.0021
	(0.0003)	(0.0030)	(0.0003)	(0.0030)	(0.0003)	(0.0030)
GDP Growth			0.0504	-4.4187***	-0.0289	-5.2473***
			(0.2262)	(1.6702)	(0.2448)	(1.7833)
Unemployment			-0.0024	-0.1137***	-0.0024	-0.1247***
			(0.0041)	(0.0333)	(0.0047)	(0.0351)
HPI			0.0001	-0.0085***	-0.0001	-0.0069***
			(0.0001)	(0.0015)	(0.0001)	(0.0017)
30-Year Mortgage Rate			0.0062	-0.3244***	-0.0054	-0.2629***
			(0.0085)	(0.0634)	(0.0101)	(0.0730)
10-Year Tbill Rate			0.0015	0.0129	0.0029	-0.0005
			(0.0027)	(0.0190)	(0.0029)	(0.0207)
Log (Unpaid Principal Balance)					-0.0088	-0.3274***
					(0.0104)	(0.0812)
loan-age					-0.0009**	-0.0064**
					(0.0004)	(0.0029)

Loan Purpose-Cash out	0.0017	0.0444
	(0.0070)	(0.0553)
Loan Purpose-No Cash out	-0.0026	0.1186***
	(0.0062)	(0.0432)
Original Rate-Current Rate	0.0008	0.0759
	(0.0327)	(0.1128)
Original Rate-30yr Mtg Rate	-0.0145**	0.1076**
	(0.0065)	(0.0453)
Mortgage Insurance%	0.000	0.0009
	(0.0004)	(0.0038)
Condo	0.0033	0.0589
	(0.0158)	(0.1507)
Channel-Correspondent	0.0438	0.3503
	(0.2635)	(1.2280)
Number of Units	0.0103	0.3003***
	(0.0221)	(0.1151)
Nonrecourse State	0.0033	0.0406
	(0.0098)	(0.0764)
# Foreclosure Process Days		-0.0009**
	(0.0000)	(0.0003)

Table 2.12
Two-Step Model with Competing Risks of Delinquency and Default
This table shows the results from Two-Step Models with Competing Risks of Delinquency and Default. I control for both origination-year-fixed effects and exposure-year-fixed effects.

	Step One		Step Two	
	Prepayment	Delinquency	Prepayment	Default
Dep. Var.: *Two-Stage*	(1)	(2)	(3)	(4)
FICO Score	0.0023***	-0.012***	0.0024***	0.0124**
	(0.0000)	(0.0001)	(0.0007)	(0.0010)
Combined Loan-to-Value	0.0073***	0.0032***	-0.011***	0.0067
	(0.0001)	(0.0005)	(0.0037)	(0.0058)
Updated Loan-to-Value Ratio	-0.008***	0.0248***	-0.030***	0.0177***
	(0.0001)	(0.0003)	(0.0031)	(0.0027)
# Borrowers=1	-0.232***	0.4912***	-0.158**	-0.124
	(0.0034)	(0.0117)	(0.0732)	(0.1013)
Debt-to-Income Ratio	0.0017***	0.0175***	-0.006***	0.0008
	(0.0001)	(0.0005)	(0.0033)	(0.0046)
GDP Growth	1.1278***	-5.563***	4.2213***	-0.275
	(0.1024)	(0.3400)	(1.4793)	(2.0715)
Unemployment	0.0049***	0.0659***	-0.124***	-0.120**
	(0.0013)	(0.0047)	(0.0247)	(0.0310)
HPI	0.0038***	0.0024***	0.0034***	-0.002
	(0.0000)	(0.0002)	(0.0010)	(0.0020)
30-Year Mortgage Rate	-0.648***	-0.055***		
	(0.0058)	(0.0209)		
10-Year Tbill Rate	0.0179***	-0.035***		
	(0.0028)	(0.0119)		
Log (UPB)			0.5612***	0.4706***
			(0.0837)	(0.1284)
loan-age			-0.013***	0.0132***
			(0.0019)	(0.0035)
Loan Purpose-Cash out			-0.280***	-0.103
			(0.0584)	(0.0786)
Loan Purpose-No Cash out			-0.151***	0.0584
			(0.0556)	(0.0807)
Original Rate-Current Rate			0.2418	-0.551*
			(0.1707)	(0.3061)
Original Rate-30yr Mtg Rate			0.041	0.3534***
			(0.0585)	(0.0936)
Nonrecourse State			-0.148*	0.2384**
			(0.0862)	(0.1118)
# Foreclosure Process Days			-0.000*	-0.002***
			(0.0003)	(0.0007)
Intercept	-3.412***	-2.105***	-9.265	-23.73
	(0.0555)	(0.1924)	(4.855)	(2.6905)
Origination Year FE	Yes	Yes	Yes	Yes
Exposure Year FE	Yes	Yes	Yes	Yes
N	32507755	32507755	32507755	32507755

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 2.13
Heckman Selection Model: Determinants of Delinquency and Default
This table shows the results from Heckman selection model. The dependent variable in the first step is a dummy that equals 1 if first time 90-day delinquency, and 0 otherwise. The dependent variable in the second step is a dummy that equals 1 if the loan results in default (foreclosure, REO or Repo), and 0 otherwise.Both steps are simulataneously estimated to account for possible selection bias. Each regression is based on a subsample by each origination year. All columns in the first step control for exposure year fixed effects, and the standard errors are clustered the loan level.

Panel A: Heckman Selection Second Step

Dep. Var.: *Default*	1999	2000	2001	2002	2003	2004	2005
	1999	2000	2001	2002	2003	2004	2005
Credit Score FICO/100	0.0019	0.0074**	0.0052*	0.0117***	0.0146***	0.0105***	0.0150***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Updated Loan-To-Value	0.0004***	0.0003***	0.0002**	0.0001*	0.0002***	0.0001***	0.0001***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Unemployment Rate	0.0005	0.0008	0.0004	0.0007	0.0001	0.0004	-0.0003
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
House Price Index	0	0	-0.0001**	-0.0002***	-0.0001***	-0.0001***	-0.0001***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
constant	-0.0206	-0.0553**	-0.0229	-0.0451**	-0.0759***	-0.0474***	-0.0661***
	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)
lnsigma	-2.2204***	-2.0999***	-2.0860***	-2.0996***	-2.1819***	-2.1366***	-2.0356***
	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Dep. Var.: *Default*	2006	2007	2008	2009	2010	2011
Credit Score FICO/100	0.0141***	0.0127***	0.0101***	0.0233**	0.015	0.0195
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)
Updated Loan-To-Value	0.0001***	0.0000*	0.0002***	0.0005***	0.0003	0.0001
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Unemployment Rate	-0.0013***	-0.0003	0.0002	-0.0025	-0.0013	-0.0043
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
House Price Index	-0.0001***	-0.0001***	-0.0001***	-0.0001	-0.0001	0.0001
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

constant	-0.0520***	-0.0377***	-0.0421***	-0.1299**	-0.0743	-0.0925
	(0.01)	(0.01)	(0.01)	(0.04)	(0.07)	(0.09)
lnsigma	-1.9795***	-1.9954***	-1.9960***	-1.9501***	-2.0204***	-2.2410***
	(0.01)	(0.01)	(0.01)	(0.04)	(0.07)	(0.13)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Panel B: Heckman Selection First Step

Dep. Var.: *90day Delinq.*	1999	2000	2001	2002	2003	2004	2005
	1999	2000	2001	2002	2003	2004	2005
Credit Score FICO/100	-0.8536***	-0.8625***	-0.8032***	-0.8118***	-0.8160***	-0.7051***	-0.7126***
	(0.05)	(0.05)	(0.04)	(0.04)	(0.03)	(0.03)	(0.02)
LTVombined Loan-To-Value	-0.0132	0.0115	0.0005	-0.0006	0.0029	-0.0067*	0
	(0.02)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)
Original Loan-To-Value	0.0267	0.006	0.0162	0.0174**	0.0031	0.0061	-0.0034
	(0.02)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)
Updated Loan-To-Value	-0.0053***	-0.0070***	-0.0042**	-0.0036**	0.0055***	0.0113***	0.0140***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
GDP growth by State	-1.9020***	-0.5945	-3.2725***	-3.6480***	-2.5112***	-2.6905***	-0.5753**
	(0.47)	(0.58)	(0.49)	(0.44)	(0.32)	(0.26)	(0.21)
Unemployment Rate	0.0232*	0.0435***	0.0127	0.0413***	0.0207***	0.0109*	0.0096*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)
Original Rate-Current Rate	0.3993***	0.4758***	0.4977***	0.3977***	0.4286***	0.4508***	0.4720***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)
constant	2.6701***	1.9650***	1.9611***	1.9603***	2.5514***	1.9706***	1.9771***
	(0.36)	(0.41)	(0.34)	(0.32)	(0.26)	(0.21)	(0.16)
athrho	0.001	-0.0187	-0.0354*	-0.0504***	-0.0526***	-0.0419***	-0.0426***
	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)

Dep. Var.: *90day Delinq.*	2006	2007	2008	2009	2010	2011
Credit Score FICO/100	-0.6473***	-0.6597***	-0.7353***	-0.8346***	-0.7759***	-0.7584***
	(0.02)	(0.02)	(0.02)	(0.06)	(0.07)	(0.09)
Original CLTV	0.0002	0.0031*	0.0101***	0.0013	-0.0182*	0.0174*
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)
Original Loan-To-Value	-0.0079***	-0.0175***	-0.0372***	-0.01	0.0206*	0.0023
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)
Updated Loan-To-Value	0.0170***	0.0216***	0.0331***	0.0166***	-0.0008	-0.0108***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
GDP growth by State	1.6530***	2.7528***	3.2471***	-1.7638**	-4.2978**	-5.9319***
	(0.21)	(0.20)	(0.27)	(0.67)	(1.31)	(1.26)
Unemployment Rate	0.0235***	0.0138***	0.0185***	-0.0411***	-0.0774***	-0.0471**

	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.02)
Original Rate-Current Rate	0.4883***	0.4661***	0.4398***	0.4330***	0.4220***	0.1900***
	(0.01)	(0.01)	(0.01)	(0.02)	(0.03)	(0.06)
constant	1.2217***	1.5328***	2.1860***	3.1109***	3.1269***	2.2487**
	(0.15)	(0.14)	(0.18)	(0.47)	(0.53)	(0.73)
athrho	-0.0343***	-0.0451***	-0.0232	-0.0672	-0.0355	-0.1183
	(0.01)	(0.01)	(0.01)	(0.04)	(0.09)	(0.09)

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 2.14
Effects of HAMP on Delinquency Option.
This table shows the results from difference-in-difference regressions on delinquency option facing increased probability of modification. I control for both origination-year-fixed effects, exposure-year-fixed effects, and state-fixed effects in all columns.

	Post YR2009		*Year 2009*	
Dep. Var.:	Prepayment	Delinquency	Prepayment	Delinquency
Delinquency Option	(1)	(2)	(3)	(4)
HAMP×Post 2009	-0.057***	0.476***	0.210***	0.448***
	(0.02)	(0.06)	(0.01)	(0.04)
HAMP	-0.375***	-0.254***	-0.387***	-0.274***
	(0.00)	(0.03)	(0.00)	(0.03)
Post 2009	5.826***	-4.388***	-0.705***	0.382**
	(0.30)	(1.21)	(0.05)	(0.16)
FICO Score	0.002***	-0.014***	0.002***	-0.011***
	(0)	(0.00)	(0)	(0.00)
Combined Loan-to-Value	0.011***	0.011***	0.005***	0.012***
	(0.00)	(0.00)	(0.00)	(0.00)
Loan-to-Value$\bar{80}$	0.009	-0.112***	0.001	-0.095***
	(0.00)	(0.02)	(0.00)	(0.01)
Updated Loan-to-Value	-0.019***	0.027***	-0.013***	0.023***
	(0.00)	(0.00)	(0.00)	(0.00)
# Borrowers=1	-0.060***	0.622***	-0.078***	0.501***
	(0.00)	(0.01)	(0.00)	(0.01)
Debt-to-Income Ratio	0.001***	0.016***	-0.001***	0.016***
	(0.00)	(0.00)	(0.00)	(0.00)
GDP Growth	1.783***	-2.763***	2.110***	-3.542***
	(0.16)	(0.60)	(0.13)	(0.42)
Unemployment	-0.037***	0.131***	-0.044***	0.140***
	(0.00)	(0.01)	(0.00)	(0.00)
HPI	0.001***	0.001***	0.001***	0.001***
	(0.00)	(0.00)	(0)	(0.00)
30-Year Mortgage Rate	0.273***	0.514***	0.058***	0.636***
	(0.01)	(0.04)	(0.00)	(0.03)

10-Year Tbill Rate	0.002	-0.045**	0.009**	-0.021
	(0.00)	(0.01)	(0.00)	(0.01)
Log (Unpaid Principal Balance)	0.766***	0.202***	0.776***	0.243***
	(0.00)	(0.02)	(0.00)	(0.01)
loan-age	0.007***	0.018***	0.008***	0.008***
	(0.00)	(0.00)	(0.00)	(0.00)
Loan Purpose-Cash out	-0.060***	0.138***	-0.081***	0.164***
	(0.00)	(0.01)	(0.00)	(0.01)
Loan Purpose-No Cash out	-0.023***	0.114***	-0.019***	0.091***
	(0.00)	(0.01)	(0.00)	(0.01)
Original Rate-Current Rate	-0.136***	-0.634***	-0.319***	-0.353***
	(0.02)	(0.05)	(0.01)	(0.03)
Original Rate-30yr Mtg Rate	0.788***	0.752***	0.574***	0.650***
	(0.00)	(0.02)	(0.00)	(0.01)
Mortgage Insurance %	0.001***	-0.002	-0.001*	-0.002**
	(0.00)	(0.00)	(0.00)	(0.00)
Condo	-0.028***	-0.117***	-0.083***	-0.090***
	(0.00)	(0.03)	(0.00)	(0.02)
Channel-Correspondent	0.319***	-0.394***	0.086***	-0.286***
	(0.02)	(0.09)	(0.01)	(0.04)
Number of Units	-0.310***	0.099**	-0.348***	0.024
	(0.01)	(0.04)	(0.01)	(0.03)
Nonrecourse State	-0.240*	-0.676	-0.033	-0.467
	(0.13)	(0.42)	(0.10)	(0.32)
# Foreclosure Process Days	0.003***	0.000	0.003***	0.000
	(0.00)	(0.00)	(0.00)	(0.00)
Intercept	-16.528***	-7.332***	-14.924***	-10.864***
	(0.14)	(0.53)	(0.12)	(0.38)
Origination Year FE	Yes	Yes	Yes	Yes
Exposure Year FE	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes
N	32507755	32507756	32507757	32507758

Robust t-statistics in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 2.15
Effects of HAMP on Default Option.
This table shows the regression results of HAMP on default option. I match each HAMP loan with a non-HAMP loan on similar FICO CLTV DTI and Log (Unpaid Principal Balance). I control for both origination-year-fixed effects and exposure-year-fixed effects in all columns.

		Binomial			*Multinomial*	
Dep. Var.:	Default	Default	Default	Default	Default	Default
Default Option	(1)	(2)	(3)	(4)	(5)	(6)
HAMP × Post 2009	0.368	0.393	-0.151	0.223	0.214	-0.375
	(1.44)	(1.54)	(-0.48)	(0.86)	(0.86)	(-1.18)
HAMP	-1.387**	-1.365*	3.364**	-1.283**	-1.325*	4.025***
	(-2.37)	(-1.77)	(2.50)	(-2.12)	(-1.70)	(3.26)
Post 2009	-1.125***	-1.134***	-0.327	-1.072***	-1.008***	-0.273
	(-5.37)	(-5.52)	(-1.43)	(-4.90)	(-4.97)	(-1.16)
FICO Score	0.008***	0.008***	0.010***	0.008***	0.008***	0.011***
	(4.75)	(4.52)	(4.26)	(4.51)	(4.43)	(4.34)
Combined Loan-to-Value	0.009	0.015*	0.033**	0.014*	0.018**	0.023*
	(1.21)	(1.94)	(2.20)	(1.88)	(2.36)	(1.74)
Updated Loan-to-Value	0.011**	0.005	0.008	0.009***	0.002	0.009
	(2.09)	(0.86)	(1.02)	(2.77)	(0.54)	(1.53)
Loan-to-Value=80	-0.147	-0.191	-0.485	-0.188	-0.214	-0.474
	(-0.83)	(-1.06)	(-1.31)	(-1.08)	(-1.20)	(-1.29)
# Borrowers=1	0.119	0.106	-0.401	0.072	0.045	-0.501**
	(0.66)	(0.58)	(-1.52)	(0.42)	(0.26)	(-2.12)
Debt to Income Ratio	-0.013	-0.012	-0.014	-0.019**	-0.018**	-0.017
	(-1.54)	(-1.48)	(-1.12)	(-2.21)	(-2.07)	(-1.45)
GDP Growth		0.287	11.055		4.024	7.952
		(0.06)	(1.40)		(0.83)	(1.06)
Unemployment		0.029	0.023		0.122	0.017
		(0.27)	(0.17)		(1.54)	(0.16)
HPI		-0.010*	-0.003		-0.008**	-0.002
		(-1.95)	(-0.43)		(-2.56)	(-0.40)
30 Year Mortgage Rate		0.059	-1.959***		0.099	-2.101***
		(0.22)	(-3.21)		(0.37)	(-3.42)

10 Year Tbill Rate		0.052	0.101		0.078	0.138
		(0.30)	(0.55)		(0.44)	(0.72)
Log (Unpaid Principal Balance)			-0.102			-0.228
			(-0.30)			(-0.76)
loan age			-0.142***			-0.162***
			(-9.29)			(-10.16)
Loan Purpose-Cash out			0.955**			0.948**
			(2.34)			(2.35)
Loan Purpose-No Cash out			0.962**			1.084***
			(2.32)			(2.71)
Original Rate-Current Rate			0.404***			0.698***
			(8.77)			(13.26)
Original Rate-30yr Mortg.			-0.122			-0.142
			(-0.41)			(-0.48)
Mortgage Insurance%			-0.030**			-0.030**
			(-2.21)			(-2.25)
Condo			0.263			0.270
			(0.50)			(0.53)
Channel-Correspondent			-0.096			-0.359
			(-0.12)			(-0.45)
Number of Units			-0.270			-0.283
			(-0.81)			(-0.89)
Nonrecourse State			-23.472**			-0.208
			(-2.46)			(-0.47)
# Foreclosure Process Days			-6.914**			0.306
			(-2.00)			(1.08)
Process Days			0.091**			-0.006**
			(2.33)			(-2.31)
Intercept	-9.541***	-8.592***	-6.589	-9.453***	-9.565***	2.103
	(-5.62)	(-2.94)	(-1.19)	(-6.27)	(-3.40)	(0.45)
Origination Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Exposure Year FE	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes
N	44,339	41,691	41,332	45,764	43,437	43,073

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 2.16
California Recourse Law and Delinquency Option.
This table shows the results from regressions on delinquency option in California, where refinance loans are recourse while purchase non-recourse. I match each refinance loan with a purchase loan on similar FICO CLTV DTI and Log (Unpaid Principal Balance). I control for both origination-year-fixed effects and exposure-year-fixed effects in all columns.

		Binomial			*Multinomial*	
Dep. Var.:	Default	Default	Default	Default	Default	Default
Default Option	(1)	(2)	(3)	(4)	(5)	(6)
Refinance	0.452***	0.438***	0.438***	0.304***	0.380***	0.432***
	(9.96)	(9.03)	(9.03)	(7.15)	(8.58)	(9.22)
FICO Score	-0.011***	-0.010***	-0.010***	-0.012***	-0.013***	-0.010***
	(-29.90)	(-26.88)	(-26.88)	(-34.37)	(-35.07)	(-27.35)
Loan-to-Value Ratio	-0.004	-0.003	-0.003	-0.047***	-0.023***	-0.024***
	(-0.99)	(-0.66)	(-0.66)	(-12.69)	(-6.01)	(-5.77)
Loan-to-Value=80	-0.029	0.011	0.011	-0.089**	-0.088**	0.025
	(-0.67)	(0.21)	(0.21)	(-2.04)	(-2.00)	(0.47)
Combined Loan-to-Value	0.017***	0.013***	0.013***	0.047***	0.031***	0.025***
	(12.22)	(9.41)	(9.41)	(68.26)	(33.87)	(28.05)
Updated Loan-to-Value	0.029***	0.027***	0.027***	0.034***	0.033***	0.029***
	(7.91)	(7.01)	(7.01)	(9.39)	(9.03)	(7.58)
# Borrowers=1	0.489***	0.511***	0.511***	0.584***	0.539***	0.548***
	(14.06)	(14.32)	(14.32)	(17.01)	(15.27)	(15.33)
Debt-to-Income Ratio	0.017***	0.015***	0.015***	0.025***	0.022***	0.019***
	(9.86)	(8.74)	(8.74)	(13.26)	(12.19)	(10.71)
GDP Growth		-60.544***	-60.544***		-9.684***	-10.896***
		(-3.22)	(-3.22)		(-12.59)	(-13.95)
Unemployment		0.223***	0.223***		0.218***	0.204***
		(5.76)	(5.76)		(14.59)	(13.19)
30-Year Mortgage Rate		0.431***	0.431***		-0.109***	0.525***
		(4.96)	(4.96)		(-3.11)	(12.54)
10-Year Tbill Rate		0.000	0.000		-0.004	-0.076***
		(0.00)	(0.00)		(-0.19)	(-3.72)

Log (Unpaid Principal Balance)		0.371***	0.371***			0.548***
		(7.43)	(7.43)			(10.68)
Loan Age		0.006	0.006			0.006***
		(1.50)	(1.50)			(8.00)
Original Rate-Current Rate		-0.253**	-0.253**			-0.131
		(-2.44)	(-2.44)			(-1.58)
Original Rate-30yr Mtg Rate		0.468***	0.468***			0.708***
		(9.39)	(9.39)			(23.19)
Mortgage Insurance %		0.002	0.002			0.007***
		(0.82)	(0.82)			(2.65)
Condo		-0.309***	-0.309***			-0.205***
		(-4.52)	(-4.52)			(-3.02)
Number of Units		-0.204***	-0.204***			-0.213***
		(-2.97)	(-2.97)			(-3.19)
Intercept	-5.381***	-12.486***	-12.486***	-2.507***	-3.277***	-14.262***
	(-9.08)	(-11.81)	(-11.81)	(-8.10)	(-7.20)	(-16.89)
Origination Year FE	Yes	Yes	Yes	No	No	No
Exposure Year FE	Yes	Yes	Yes	No	No	No
N	3,060,192	2,543,462	2,543,462	3,410,556	2,751,516	2,691,324

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 2.17
California Recourse Law and Default Option.
This table shows the results from regressions on default option in California, where refinance loans are recourse while purchase non-recourse. I match each refinance loan with a purchase loan on similar FICO CLTV DTI and Log (Unpaid Principal Balance). I control for both origination-year-fixed effects and exposure-year-fixed effects in all columns.

		Binomial			*Multinomial*	
Dep. Var.:	Default	Default	Default	Default	Default	Default
Default Option	(1)	(2)	(3)	(4)	(5)	(6)
Refinance	-2.579***	-2.584***	-3.691***	-2.010**	-2.094***	-2.190***
	(-2.80)	(-3.04)	(-3.01)	(-2.54)	(-2.68)	(-3.24)
FICO Score	0.014*	0.015*	0.024**	0.011	0.013**	0.013**
	(1.75)	(1.73)	(2.29)	(1.56)	(2.20)	(2.11)
Loan-to-Value Ratio	0.145**	0.151***	0.175***	0.043	0.050	0.100
	(2.43)	(2.61)	(2.60)	(0.63)	(0.78)	(1.36)
Loan-to-Value=80	1.218	1.190	-0.125	1.204*	1.363**	0.576
	(1.48)	(1.59)	(-0.14)	(1.88)	(2.09)	(0.55)
Combined Loan-to-Value	-0.032	-0.032	-0.008	-0.032***	-0.044***	-0.057***
	(-0.52)	(-0.53)	(-0.14)	(-6.03)	(-3.32)	(-3.74)
Updated Loan-to-Value	-0.115***	-0.119***	-0.136***	-0.010	-0.015	-0.009
	(-4.54)	(-4.13)	(-7.27)	(-0.14)	(-0.22)	(-0.13)
# Borrowers=1	-0.913	-0.950	-1.752**	-1.295*	-1.341*	-1.663**
	(-1.16)	(-1.27)	(-2.42)	(-1.86)	(-1.86)	(-2.44)
Debt-to-Income Ratio	-0.006	-0.005	-0.011	-0.022	-0.018	-0.023
	(-0.14)	(-0.11)	(-0.30)	(-0.88)	(-0.68)	(-0.76)
GDP Growth		111.218	356.466		-13.479	-19.944
		(0.49)	(1.07)		(-1.08)	(-1.57)
Unemployment		-0.575	-0.239		0.054	0.018
		(-0.62)	(-0.33)		(0.26)	(0.08)
30-Year Mortgage Rate		0.345	0.371		-0.270	0.097
		(0.23)	(0.22)		(-0.48)	(0.11)
10-Year Tbill Rate		-0.345	-0.091		0.232	0.149
		(-0.57)	(-0.17)		(0.89)	(0.40)

Log (Unpaid Principal Balance)			1.752**			0.312
			(2.17)			(0.43)
Loan Age			-0.295***			-0.014
			(-3.04)			(-1.25)
Original Rate-Current Rate			0.555***			0.622*
			(3.06)			(1.90)
Original Rate-30yr Mtg Rate			2.350**			0.673
			(2.32)			(1.07)
Mortgage Insurance %			-0.087*			-0.087**
			(-1.83)			(-2.20)
Condo			1.486			1.585**
			(1.53)			(2.00)
Number of Units			0.529			0.435
			(0.36)			(0.89)
Intercept	-11.024**	-7.971	-39.294**	-12.184***	-13.481**	-22.150**
	(-2.13)	(-0.77)	(-2.19)	(-2.61)	(-2.54)	(-2.06)
Observations	3,421	3,421	3,416	6,053	5,396	5,378
Origination Year FE	Yes	Yes	Yes	No	No	No
Exposure Year FE	Yes	Yes	Yes	No	No	No
N	3,421	3,421	3,416	6,053	5,396	5,378

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Chapter 3

What do Basel and Risk Management Miss: Transitional Probabilities and the Role of Banks

Abstract

The literature have conventionally overlooked the effects of mortgage banks as sellers or servicers on loan performance. This paper analyzes the role of banks as sellers or servicers the transition probabilities from delinquency to default and other outcomes. Banks' balance sheet health and business incentive structure play a crucial role in the change in predicting power of delinquency. For banks with higher retail funding, higher equity ratio, better credit rating, and less servicing automation, their loans have lower transitional probabilities from delinquency to default, and higher probabilities to get modified.

Key words:

JEL classification:

Introduction

The recent financial crisis of 2007–2008 was a crisis of mortgages and banks. Triggered by a sharp decline in the house prices, massive delinquencies and defaults of mortgages and related securities further prompted great losses in banks, leading to a global-level financial crisis. Basel II framework and risk management modeling were in place to ensure that banks hold a sufficient buffer capital in a time like this. Yet, the recent crisis indicates that such framework is insufficient and inadequate in that the roles of banks as sellers and servicers.

This study examines the accuracy and predicting power of using delinquency as default definition, and determinants of transitional probabilities from delinquent to default and other outcomes, in particular, banks. I aim to understand the roles of bank in the transitional process from serious delinquency (i.e., 60-day or 90-day delinquency) to default and other loan resolutions. Banks are important intermediaries for the mortgages industry, as they not only underwrite and sell the mortgage loans, but also act as servicers, making crucial decisions about whether to extend credit, modify a delinquent loan, or push it into default, such as foreclosure or REO (Piskorski et al. (2010), Levitin and Towmey (2011), and Dagher and Kazimov (2015)). Legal articles such as Levitin and Towmey (2011) have wider coverage of the role of banks in mortgages, compared with those in finance journals. Effects of banks characteristics and behaviors on the transitional probabilities can thus shed light on why delinquency is not a sufficient proxy for default, and how loans transition from delinquency to default and other outcomes.

The relevance of this research is underscored by the fact that despite tremendous efforts after the crisis to develop a better Basel framework and credit risk modeling, there has still been dissatisfaction with the adequacy of calculated Capital Adequacy

Ratio (CCAR) (see Jagtiani and Henderson (2010)). Both regulators and practitioners can benefit from a better understand of banks' role as mortgage sellers and servicers. The role of banks in the transitional process from delinquency to default and other outcomes suggest additional factors to consider when examine mortgage loans and related securities.

I use the loan-level single family dataset from Freddie Mac, matched with bank-level information from Compustat Bank and North America database. The richness of the data allows me to analyze how the predicting power of delinquency varies across time, and how bank balance sheet health and business incentive structures affect post-delinquency transitional probabilities.

I first investigate the effects of banks on the transitional probabilities to default and other outcomes. Given that banks as servicers have very different incentive structures from banks lender, I should observe loans with the same bank as both seller and servicer should behave differently from the others. While I don't find evidence to support Levitin and Towmey (2011)'s statement that principal-agent problem resulting from incentive structures increases credit risk, the results suggest that banks serving only as servicer focuses on reducing the prepayment risk, compare with banks serving both as seller and servicer.

Secondly, I analyze the impact of bank's servicing business model on transitional probabilities. Recent legal cases against mortgage servicers suggest that some bank servicers automate the process of default, with neither personal knowledge nor hands-on loss mitigation of the delinquent loans. Using market shares as a proxy for economic of scales and servicing automation, I find that, for banks with larger market shares, the loans they service have significantly higher propensity to transition from delinquency to default, and lower propensity to get modified.

Thirdly, I study the effects of bank balance sheet health on the transitional prob-

abilities from delinquency to default and other outcomes. Several studies document how banks' balance sheet health, in particular core deposits to assets (CDA) ratio, capital ratio, and credit rating, can affect banks' credit extension and loan performance (e.g. Khwanja and Mian (2008), Paravisini (2008), He et al (2012), and Dagher and Kazimov (2015)). In addition, since loan modifications can be costly for the banks (Piskorski et al. (2010) and Levitin and Towmey (2011)), banks with more abundant funding (i.e. higher CDA ratio or equity ratio) can afford higher costs and are more likely to modify mortgage loans that are in serious delinquency. The results show that for banks with higher CDA ratio, higher equity ratio, and better credit rating, their loans have lower transitional probabilities from delinquency to default, and higher probabilities to get modified.

Last but not least, I zoom in on one particular bank, Countrywide, which faced potential bankruptcy risk during the subprime mortgage crisis and got taken over by Bank of America. It was one of the biggest mortgage banks before the crisis. In 2006, Countrywide financed 20% of all mortgages in the United States. I look at only the loans either originated or serviced by Countrywide in order to understand the roles this bank play during the crisis. The results point out that it is bad servicing rather than bad loans that lead Countrywide to turmoil.

This paper develops as follows: Section 3 discusses the related literature. Section 3 develops the hypotheses to test. Section 3 describes the data source and empirical methodology. Section 3 provides results from the empirical tests. Section 3 concludes.

Literature Reviews

This paper is related to two strings of literature that intersect together. One is regarding mortgages studies, specifically the definition of default in the current litera-

ture and the Basel Accord II as well as the transitional probabilities post delinquency; and the other is related to the effects of banks' balance sheet health and reputation on banks' behaviors. The intersection between the two different strings of literature is much less well studied. This paper contributes to the literature by documenting the insufficiency of current definition of default, and the results shed light on the roles of banks in the process of loans entering from serious delinquency to actual losses.

Mortgage Default and Termination

When a mortgage borrower misses his or her monthly payment for a certain amount of time, such loan is usually marked as delinquent. For example, if a borrower misses the payment for three months, the loan is in 90-day delinquency. From the point of being in delinquent status going onwards, the mortgage might transit to several different situations or states, as illustrated by Figure 3.1. (1) If the borrower is able to and decides to make payment again, the mortgage will no longer be delinquent, but become current and get "cured". (4) If the borrower not only starts to make payments, but also pays off the remaining portion of the mortgage once for all, such mortgages get terminated via prepayment. (2) On the other hand, the borrower might be still unable to make the payment and falls into more severe delinquency. (3) In that case, the mortgage servicers might step in and interfere with the mortgage and modify loan contractual terms and structures, such as rates and principal reduction, so it can avoid an immediate foreclosure. (5) In the case of Real Estate Owned (REO), the lender takes tile of the property and will try to sell the property on its own. (6) If the mortgage gets pushed through foreclosure process, it could undergo short sale, third party sale, charge off or note sale. (7) Or the mortgage originators might be obliged to repurchase (Repo) the mortgages that are either in serious delinquency or violate terms and warranties, prior to the property disposition.

REO, foreclosure, and repo are the cases when actual losses take place.

Mortgage Modification and Termination

After documenting that delinquency is not a constant and perfect predictor of the final resolution of the loans, this paper analyzes possible determinants of post-delinquent outcomes. Therefore, studies on mortgage modification and termination are also relevant. Only a few papers explore the final resolution of loans primarily because of limited data availability (Chan et al. (2014)).

Most studies link the probability of post-delinquent outcomes with borrower-level and loan-level characteristics. Studies such as Danis and Pennington-Cross (2005), Danis and Pennington (2008), and Pennington-Cross (2010) find that higher credit score and longer period of delinquency are associated with higher probabilities of prepayment and lower probabilities of default.

Capozza and Thomson (2006) study the transition process for subprime mortgages that were seriously delinquent on September 30, 2001. They find that, compared with prime loans, seriously-delinquent subprime loans are about twice as likely to become REO, and that foreclosure is more likely for loans with high LTVs and interest rate premiums. Chan et al (2014) examine the process of mortgage default from delinquent to final resolution of the property in New York City, using a two-stage competing risk hazard model. Their results show that borrower's credit score, current LTV, house price and income are associated with the foreclosure outcomes. Schmeiser and Gross (2015) also find high LTV is the greatest contributor to foreclosure, by analyzing the subprime mortgages post modification performance.

Other researches such as Adeline et al.(2009), Piskorsi et al.(2010) and Adeline et al.(2014) investigate the impact of securitization on mortgage modification and termination. By comparing securitized loans with bank-held loans, Piskorski et al.

(2010) find that the foreclosure rate of bank-held loan is lower than similar securitized loans. Adeline et al.(2014) find that securitized mortgages are more likely to be modified and less likely to be foreclosured on.

Yet the role of banks in determining a loan's path after delinquency towards their final resolution is relatively unexplored. The paper thus contributes to the literature by documenting that banks' balance sheet health leads to lower transitional probabilities from delinquency to default, and higher probabilities from delinquency to modification.

Bank Health and Bank Behavior

A large body of theoretical literature analyzes how bank balance sheet health affects bank lending behaviors. The literature generally agree that banks core deposit ratio, capital availability, and credit rating have significant effects on banks' credit extension and their securities performance (e.g. Khwanja and Mian (2008), Paravisini (2008), He et al (2012), and Dagher and Kazimov (2015)). Using residential subprime loans from an anonymous subprime lender, Cowan and Cowan (2004) find default correlation is substantial for this single lender, and the significance of such default correlation increases as the internal credit rating declines. Guetter et al. (2011) assess how sponsor, servicer, and underwriters' characteristics affect the default rates of mortgage-backed securities and home equity loans. Their results indicate that the larger and healthier the sponsor is, the lower the default frequency of the securitized loans. He et al (2012) Initial yields on both AAA-rated and non-AAA rated mortgage-backed security (MBS) tranches sold by large issuers are higher than yields on similar tranches sold by small issuers during the market boom years of 2004 to 2006. Dagher and Kazimov (2015) find that banks with lower core deposit to assets (CDA) have higher rejection rate of mortgage applications. The shift from CDA to short-term

rollover wholesale funds increases banks' vulnerability to the market wide shock.

Yet very few studies systematically examine the how bank health is associated with banks' role as mortgage loan sellers or servicers during the process from delinquency to final resolution. Servicers of mortgages make the crucial decision whether to foreclose a delinquent mortgage, and they start to interfere with a certain loan usually after its being serious delinquency (Piskorski et al. (2010)). However, such topic is of greater importance and coverage in the legal articles. Levitin and Towmey (2011) examine the incentive structure and business model of the mortgage servicing industry from a legal perspective, and state that misalignment of interests between the servicer and lender would lead to increased foreclosure rates.

This is limited empirical evidence on the discrepancies between using delinquency status as default definition, versus using the actual loss. In addition, the transition from initial delinquency to final resolution of the mortgage loans when actual loss occurs is relatively unexplored by the literature. Even fewer studies analyze the role of banks play in the default process from delinquency to actual loss. This paper thus contributes to the literature by documenting that for banks with higher CDA ratio, higher equity ratio, and better credit rating, their loans have lower transitional probabilities from delinquency to default, and higher probabilities to get modified. The results can shed light on how to improve risk management and stress tests that involve mortgage loans.

Hypotheses Development

Role of Banks in Loan Transitional Probabilities

I next move on to examine the determinants of the transition probabilities from delinquency to default and any other state. This will shed light on the reasons why the predicting power of delinquency status on actual default varies across time, if it is inconstant. As literature review above suggests, banks as servicers play a crucial role in determining the final resolutions of a mortgage loan after it is in serious delinquency (i.e. 60-day or 90-day payments past due). They make decisions about whether to modify the terms and rates of the delinquent loan or to push it into foreclosure process. Yet the role of banks in the loan transitions from delinquent to default and other status is relatively unexplored by the literature. Therefore, I focus on the effects of banks on loan transitional probabilities post delinquency, controlling for other determinants already examined by previous researches, such as LTV, house price, and income.

Incentive structure

Servicer collects fees, which are annually about 20 to 50 basis points of the remaining balance of loans, and they need to pay costs and efforts in loan modifications, which could be as high as $1000 per loan (Piskorski et al. (2010)). Lenders, on the other hand, sometimes are still bounded by mortgage repo clause in case loans perform poorly, even after they sold the loans to GSEs.

According to Levitin and Towmey (2011) and some other legal articles, servicers' compensation structures create a principal-agent problem between the banks and investors, and because they share no credit risk on the loans, but only prepayment

risk, they tend to foreclosure more often and more uneconomically. On the other hand, according to practitioners, servicers do have an incentive to keep the loans alive so as to continue to collect servicing fees from the remaining balance. In addition, servicers care more about prepayment risks than sellers, because in case of a prepayment, the seller still retain the principle, while the servicer no longer gets servicing fees. To test the theory, I created a *SameDummy* that equals 1 if servicer and lender are the same. Same servicer as the lender could potentially reduce information asymmetry and mitigate the principal-agent problem. If consistent with Levitin and Towmey (2011), the results would show that loans with the same servicer and lender default less, compared with those with different servicer and lender. Otherwise, the results would suggest concurrence with practitioners point of view that servicers still have an incentive to keep the loan in the pool.

Hypothesis 1 H_0: Loans with the same servicer and lender are not less likely to default (yet more likely to prepay) conditional on being delinquent, compared with loans with different servicer and lenders.

Hypothesis 1 H_a: Loans with the same servicer and lender are less likely to default conditional on being delinquent, compared with loans with different servicer and lenders.

Economic of Scale or Hazard Automation

Recent legal cases against mortgage servicers, especially the Stern scandal in 2010[1] , suggest that some servicers automate the process of default, with neither personal knowledge nor hands-on loss mitigation of the loan. Such servicing economic of scales, on one hand, mean more efficiency and cost saving benefits; and on the other hand, discourage modification and encourage "manufactured" foreclosure. I hereby test the

[1]Also see *Floridas High-Speed Answer to a Foreclosure Mess*, New York Times, September 4, 2010.

effects of servicing economic of scales using market share as a proxy.

Hypothesis 2 H_0: Market shares of servicing have no impact on the modification or default of delinquent loans.

Hypothesis 2 H_a: Banks with larger market shares of servicing are less likely to modify and more likely to push the delinquent loans into default.

Healthier Banks and Better Loans

Several studies document how banks' balance sheet health, in terms of CDA ratio, capital ratio, and credit rating can affect banks' credit extension and loan performance (e.g. Khwanja and Mian (2008), Paravisini (2008), He et al (2012), and Dagher and Kazimov (2015)). In addition, since loan modifications can be costly for the banks (Piskorski et al. (2010) and Levitin and Towmey (2011)), banks with more abundant funding (i.e. higher CDA ratio or equity ratio) can afford higher costs and are more likely to modify mortgage loans that are in serious delinquency. I empirically test the effects of bank balance sheet health on the transitional probabilities of delinquent loans.

Hypothesis 3 H_0: Banks' balance sheet health has no effect on the transitional probabilities of delinquent loans.

Hypothesis 3 H_a: Healthier banks with more abundant funding are more likely to modify delinquent loans, and have lower default rates consequently.

Countrywide: Bad Servicing or Bad Loans

I zoom in on Countrywide, because it was one of the biggest mortgage banks before the crisis, yet got in turmoil during the subprime mortgage crisis. The case study of Countrywide might shed light on the roles mortgage banks play during the crisis. Hence, I only examine the loans either originated or serviced by Countrywide

in order to better understand the roles this bank play during the crisis.

Hypothesis 4 H_0: Countrywide servicing have no effect on its loans' performance.

Hypothesis 4 H_a: Countrywide servicing have negative effects on its loans' performance.

Data and Methodology

Data and Sample

The goal of this paper is to examine the role of banks on the mortgage transition from delinquency status to other statuses including actual foreclosure or REO. Therefore, I combine data from a number of sources to get information about mortgages and bank fundamentals.

The mortgage loan-level data is from Freddie Mac Single Family Loan-level dataset, at a monthly frequency from 1999 to 2014. The dataset contains a sample of 50000 mortgage loans, randomized from each full vintage year. All loans included are fully amortized 30-year fixed-rate mortgages, with verified or waived documentation (i.e. "full documentation"). Freddie Mac collects origination information for each borrower, such as credit score or debt-to-income (DTI) ratio, as well as for each loan, such as loan-to-value (LTV) ratio or Mortgage Insurance %. For a given loan, Freddie Mac also discloses its monthly performance information, including delinquency and default status.

This dataset also provides seller name and servicer name for each loan. Freddie Mac only discloses the name of seller or servicer with a total original unpaid principal balance (UPB) presenting 1% or more out of all loans for a given calendar quarter. In

the sample I hand match the names with their Compustat and Call Report identifiers, and collect detailed information regarding bank fundamentals.

I construct the final data sets using macroeconomic variables from several data sources at both the state and the Metropolitan statistical area (MSA) levels. MSA-level house price data are from the FHFA House Price Index (HPI) database, which is a weighted, repeat-sales index, measuring average price changes in repeat sales or refinancings on the same single-family houses. Information about state-level GDP growth, 30-year fixed-rate mortgage rates, 10-year Treasury bill rates, and state-level unemployment rates are from Federal Reserve of St. Louis.

Empirical Framework

The objective of this paper is to study the predicting power of delinquency status on default, and determinants of variation of such predicting power, in particular the role of banks. Using loan-level sample, I regress the outcome variables on delinquency and bank balance sheet variables, while controlling for loan-, borrower-, and macro-level covariates.

Follow previous literature, such as Capozza et al (1998), Deng, Quigley and Van Order (2000), Capozza and Thomson (2006), and Chan et al (2014), I employ a discrete time hazard framework with competing risks to explore the relationship between delinquency and default outcomes.

To test hypotheses 1-3, I employ a similar model as follows:

$$\begin{aligned} Y(outcome = i) = MulinomialLogisticFunction(&\beta_0 + \beta_1 BankLevelVariables \\ &+ \beta_2 LoanBorrowerControls + \beta_3 MacroControls \\ &+ \sum \xi_i + \sum \zeta_i + \sum \eta_t + \epsilon), \end{aligned} \quad (3.1)$$

where $Y \in \{$*Prepayment, Default*$\}$, *Prepayment, Default, Modified, Cured*$\}$, or *Prepayment, Foreclosure, REO, Repo, Modified, Cured*$\}$.$BankLevelVariables \in \{$*CDA, Rating, EquityRatio, SameDummy, etc.*$\}$; *Controls* include loan characteristics (CLTV, RLTV, number of units, etc.) borrower characteristics (FICO, DTI, etc.), and macroeconomic variables (e.g., GDP growth, 10-yearTbill rate, HPI, etc.). ξ stands for origination-year-fixed effects, ζ stands for exposure-year-fixed effects, and η stands for state-fixed effects.

Results

Summary

Figure 3.2 shows the summary statistics for the characteristics of mortgage loans at origination in the sample. The charts show histogram as well as both normal and kernel distributions for loan-to-value ratio (LTV), combined loan-to-value ratio (CLTV), credit score FICO, original interest rate of the loan, original unpaid principle balance (UPB), and debt-to-income ratio (DTI). Both the LTV and CLTV charts show large proportion of loans with a LTV or CLTV value of 80, compared with neighboring bins of the histogram. The proportion of LTV and CLTV being 80 is more than twice that of just 70 or 90, indicating discontinuity in the distribution. Such discontinuity pattern and concentration on 80 is probably due to the fact that higher than 80% LTV ratio means the borrower will need additional insurance on the mortgage loan, and lower than 80% means more down payments upfront. The FICO score has a mean of 725, and is skewed towards higher scores towards the 800-FICO zone, indicating most of the borrowers in the Freddie Mac sample are of good credit. Since all mortgages loans are government-sponsored enterprises (GSE) loans, which

are loans issued by Freddie Mac or Fannie Mae etc., the original unpaid principle balances (UPB) are mostly below the jumbo loan cutoff of $417,000, with majority below $250,000. Mortgage interest rates and DTI ratios at origination are generally normally distributed.

Default Outcome Post Delinquency

These findings naturally raise the question of why the predicting power of delinquency varies over time, and whether banks behaviors play an important role in the transitional probabilities from delinquency to other outcomes, including default.

Table 3.1 reports the regression results for default outcome three months 90-day delinquency, which tests hypotheses 1-3 about the effects of banks on default. The columns (1) - (3) show OLS results, while columns (4) - (6) report binomial logistic regression results. Column (7) - (9) show results from multinomial logistic regressions with competing risk.

TABLE 3.1 ABOUT HERE

The coefficient of SameDummy, that equals 1 if seller and servicer are the same, is insignificantly different from zero, indicating that whether seller and servicer are the same have no effect on default probability. This result fail to reject Hypothesis 1 H_0 with confidence, and embrace practitioners point of view that servicers do have an incentive to keep the mortgage loans alive.

The coefficients of servicer market shares are significantly positive across all models. The estimates suggest that for banks with larger share of the servicing business, their loans have higher probability of default. These results suggest that automation of servicing tend to encourage "manufactured" defaults, reject Hypothesis 2 H_0 and

confirm Hypothesis 2 H_a with reasonable confidence that banks with larger market shares of servicing (with higher propensity of servicing automation) are more likely to push the delinquent loans into default.

To test hypothesis 3, the effects of bank health on default, I include bank level variables, such as bank size, bank equity ratio, bank credit rating, and bank core deposits to assets ratio (CDA). The coefficients for bank CDA is significantly negative. This indicates that for banks with higher core deposits to assets, their loans have lower propensity to default post delinquency. In other words, if a bank is funded more through traditional retail deposits rather than whole sale funding, they are less likely to default their loans. The coefficients for bank credit rating and equity ratio is also significantly negative, suggesting that for banks with investment grade rating and higher equity ratio, their loans have lower probability of default. Taken together, these results reject Hypothesis 3 H_0, and provide strong evidence that Healthier banks with more abundant funding are more likely to modify delinquent loans, and have lower default rates consequently.

Modification Outcome Post Delinquency

Table 3.2 presents the results for loan modification outcome three months after being 90-day delinquent. The columns (1) - (3) show OLS results, while columns (4) - (6) report binomial logistic regression results. Column (7) - (9) show results from multinomial logistic regressions with competing risk.

Table 3.2 About Here

The coefficient estimates of Servicer Type (1=Bank) are significantly negative, indicating that banks servicers are less likely to modify their loans, compared with

mortgage servicing firms. The coefficients of bank CDA and credit rating are both significantly positive. These results suggest that banks with higher core deposits to assets and lower default prospective have higher propensity to modify their loans in delinquency. As Piskorski et al. (2010) and Levitin and Towmey (2011) documented, mortgage loan modification is a costly process, and a decision based on the cost and income structures of each bank. Therefore, banks with more stable low-risk retail funding and brighter prospect have better capacity to modify their loans in serious delinquency.

Taken together, these estimates further confirm Hypothesis 3 H_a, providing evidence that banks' balance sheet health positively impact their loan modification behavior.

Prepayment Outcome Post Delinquency

Table 3.3 shows the results for loan prepayment outcome three months after being 90-day delinquent. Again, the columns (1) - (3) show OLS results, while columns (4) - (6) report binomial logistic regression results. Column (7) - (9) show results from multinomial logistic regressions with competing risk.

TABLE 3.3 ABOUT HERE

The coefficients of *SameDummy* are significantly positive. These estimates suggest that, for a loan with the same servicer and seller, it has higher propensity to end in prepayment. This proposes an alternative hypothesis from Hypothesis 1 about incentive structures. The incentive structure of banks as servicers proposes that they share more prepayment risk, compared with credit risks. Standalone servicing banks make more efforts to reduce prepayment risk, compared with banks that both

underwrite and service the loans.

The coefficient estimates of Servicer Type (1=Bank) are significantly positive, indicating that banks servicers are less likely to modify their loans, compared with mortgage servicing firms. Yet the coefficient of bank core deposits to assets ratio is significantly negative. Higher ratio of retail funding through core deposits could decrease not only credit risk, but also prepayment risk. Again, this table provides evidence that banks plays an important role in the transition process from delinquency to final resolutions of the loans.

Loan Resolutions Post Delinquency

Table 3.4 reports the results for loan final resolutions three months after being 90-day delinquent. Specifically, I decompose default category into foreclosure, REO, and Repo. All columns show results from multinomial logistic regressions with competing risks. Column (2) and (3) show results for transitional probabilities of modification and prepayment post delinquency, and are similar to the patterns in Table 3.2 and Table 3.3. Column (4) - (6) show results for the transitional probabilities of foreclosure, REO, and Repo, respectively. Repo is a separate category that relates to repurchase clause with the underwriter, while foreclosure and REO are of similar calibers.

TABLE 3.4 ABOUT HERE

The coefficient estimates for foreclosure and REO are significantly positive, echoing the results from Table 3.1 that servicer market shares, as a proxy for automation and economics of scales, increase the probabilities of foreclosure and REO.

In column (5) specifically, coefficients for bank core deposits to assets (CDA), credit rating, and equity ratio are all significantly negative. The estimates suggest

that banks with higher core deposits ratio, better credit rating, and higher equity ratio have lower REO transitional probabilities from delinquency. This further confirms the Hypothesis 3 H_a with reasonable degree of confidence that banks with better balance sheet health have lower default propensity.

Countrywide: Bad Servicing or Bad Loans

I focus on Countrywide, one of the biggest mortgage banks that Table 3.5 reports the results from multinomial logit regressions with competing risks for loans that are either originated or serviced by Countrywide. Countrywide as both seller and servicer attracts significantly positive coefficients, while Countrywide as seller only attracts significantly negative coefficients. Compared with the reference group, loans serviced by Countrywide yet issued by other banks, loans both issued and serviced by Countrywide are more likely to default. On the other hand, loans issued by Countrywide yet serviced by other banks, are less likely to default. Overall, this result suggests that Countrywide servicing increases the probability of default.

TABLE 3.5 ABOUT HERE

To better understand whether bad servicing or bad underwriting standards lead to large defaults during the crisis, I introduce interaction terms between Countrywide as servicer or seller factor variable and post origination year 2005 or exposure year 2005. [2] Exposure year dummy can be interpreted as change in economic environments, while origination year dummy can be interpreted as change in underwriting standards. The interaction terms between Countrywide as both servicer and seller factor variable

[2] I also test interaction between Countrywide as servicer or seller factor variable and post year 2003 and post year 2006, which are also crucial cutoff time periods, and got robust results as year 2005.

and post exposure year 2005 attract positive and significant coefficients, meaning the effects of Countrywide on its loans performance become stronger post 2005. (See Table 3.6.)

TABLE 3.6 ABOUT HERE

On the other hand, in Table 3.7, the interaction terms between Countrywide as servicer or seller factor variable and post origination year 2005 are not significant. This result suggests that there is no big change in Countrywides underwriting standards.

TABLE 3.7 ABOUT HERE

To further disentangle the effects of Countrywide servicing on the loan performance, I focus on only loans issued by Countrywide, and match each loan serviced by Countrywide with another loan serviced by other banks, by run a propensity score matching in terms of FICO, CLTV, DTI, and UPD. Table 3.8 shows the results from multinomial logit regressions on default on the matched sample. Countrywide as Servicer term attracts significantly positive coefficients, suggesting that Countrywide servicing increases the probability of default.

TABLE 3.8 ABOUT HERE

Conclusion

This paper first examines the predicting power of delinquency status on default, which is hereby defined as ending events where actual losses occur, and then analyze

the roles of banks in the transition probabilities from delinquency to default and other outcomes. Running a multinomial logistic model with competing risks, I find that the predicting power of delinquency status on default is not constant, leading to potential bias in PD, LGD, and Capital Adequacy Ratio calculation when using delinquency as default definition. Results show such errors would be more serious underestimation during market downturns, as in the 2007 financial crisis. Moreover, banks' balance sheet health and business incentive structure play a crucial role in the change in predicting power of delinquency. For banks with higher retail funding, higher equity ratio, better credit rating, and less servicing automation, their loans have lower transitional probabilities from delinquency to default, and higher probabilities to get modified.

Variable Definitions

Bank-level Variables

- *Tier-1 Capital*: The ratio of the bank's Tier-1 risk adjusted capital/total asset
- *Non-performing Assets*: The ratio of non-performing assets/total asset
- *Bank Size*: Log(total asset)
- *Bank Equity Ratio*: The ratio of bank's equity/total asset
- *Bank Rating*: A dummy variable that equals 1 if the bank is rated investment grade, and 0 otherwise
- *BankDummy*: A dummy variable that equals 1 if the seller or servicer is a bank, and 0 a mortgage servicing firm
- *SameDummy*: A dummy variable that equals 1 if the seller and the servicer of a particular is the same

Borrower Characteristics

- *Borrower FICO*: Credit Score (Initial FICO), a number, prepared by third parties, summarizing the borrower's creditworthiness
- *Borrower Debt-to-Income Ratio*:The ratio of the borrower's monthly debt payments divided by the total monthly income at origination
- *# Borrowers*: The number of borrowers who are obliged to repay the mortgage

Loan-level Variables

- *Original Loan-To-Value (LTV)*: The ratio of the original mortgage loan amount by the mortgage property's appraised value or purchase price at origination
- *Original Combined Loan-To-Value (CLTV)*: The ratio of the original mortgage loan amount plus any secondary mortgage loan amount by the mortgage property's appraised value or purchase price at origination
- *Revised Loan-To-Value (RLTV)*: Combined Loan-To-Value at origination* (ending balance/Original unpaid principal balance (UPB))/(House Price Index (HPI)/House Price Index at origination)
- *Original Interest rate*: The original interest rate of mortgages
- *Original UPB*: The unpaid principal balance at loan origination
- *Mortgage Insurance %*: The percentage of loss coverage on the loan at origination

- *# Units*: The number of units of a mortgage
- *Occupancy Status*: Occupancy status of the mortgage, indicating whether the property is owner-occupied, second home, or investment property
- *Channel*: The channel through which the loan is originated, indicating whether through retail, broker, or correspondent
- *Prepayment Penalty Mortgage (PPM) Flag*: A dummy variable that if a mortgage has a prepayment penalty
- *Property Type*: The type of the property secured by the mortgage is a condominium, leasehold, planned unit development, cooperative share, manufactured home, or single family home
- *Loan Purpose*: A variable indicating whether the mortgage loan is a cash-out refinance mortgage, no cash-out refinance mortgage, or a purchase mortgage
- *Current Interest Rate*: The current interest rate on the mortgage loan
- *Interest Difference*: The difference between the original interest rate and current interest rate
- *Risk Premium*: The difference between the original interest rate and 30 year mortgage rate
- *Loan Age*: The number of months since the origination month of the mortgage

Macroeconomic Variables

- *30_Year Mortgage Rate*: Contract interest rates on commitments for fixed-rate first mortgages from Primary Mortgage Market Survey data provided by Freddie Mac
- *10_Year Tbill Rate*: The rates on 1-month treasury bills
- *GDP Growth*: The GDP growth rate
- *HPI*: Quarterly FHFA HPI index by MSA

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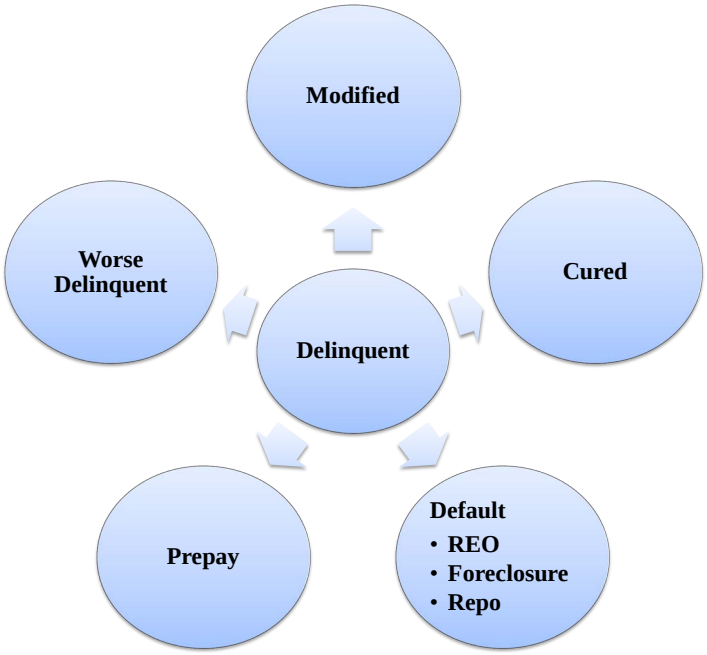

Figure 3.1. Loans' Paths after Delinquency towards Final Resolutions. This figure shows different paths of a mortgage loan after being delinquent towards the final resolution. (1) If the borrower is able to and decides to make payment again, the mortgage will no longer be delinquent, but become current and get "cured". (4) If the borrower not only starts to make payments, but also pays off the remaining portion of the mortgage once for all, such mortgages get terminated via prepayment. (2) On the other hand, the borrower might be still unable to make the payment and falls into more severe delinquency. (3) In that case, the mortgage servicers might step in and interfere with the mortgage and modify loan contractual terms and structures, such as rates and principal reduction, so it can avoid a immediate foreclosure. (5) In the case of Real Estate Owned (REO), the lender takes tile of the property and will try to sell the property on its own. (6) If the mortgage gets pushed through foreclosure process, it could undergo short sale, third party sale, charge off or note sale. (7) Or the mortgage originators might be obliged to repurchase (Repo) the mortgages that are either in serious delinquency or violate terms and warranties, prior to the property disposition. REO, foreclosure, and repo are the cases when actual loss takes place, therefore bracketed under default.

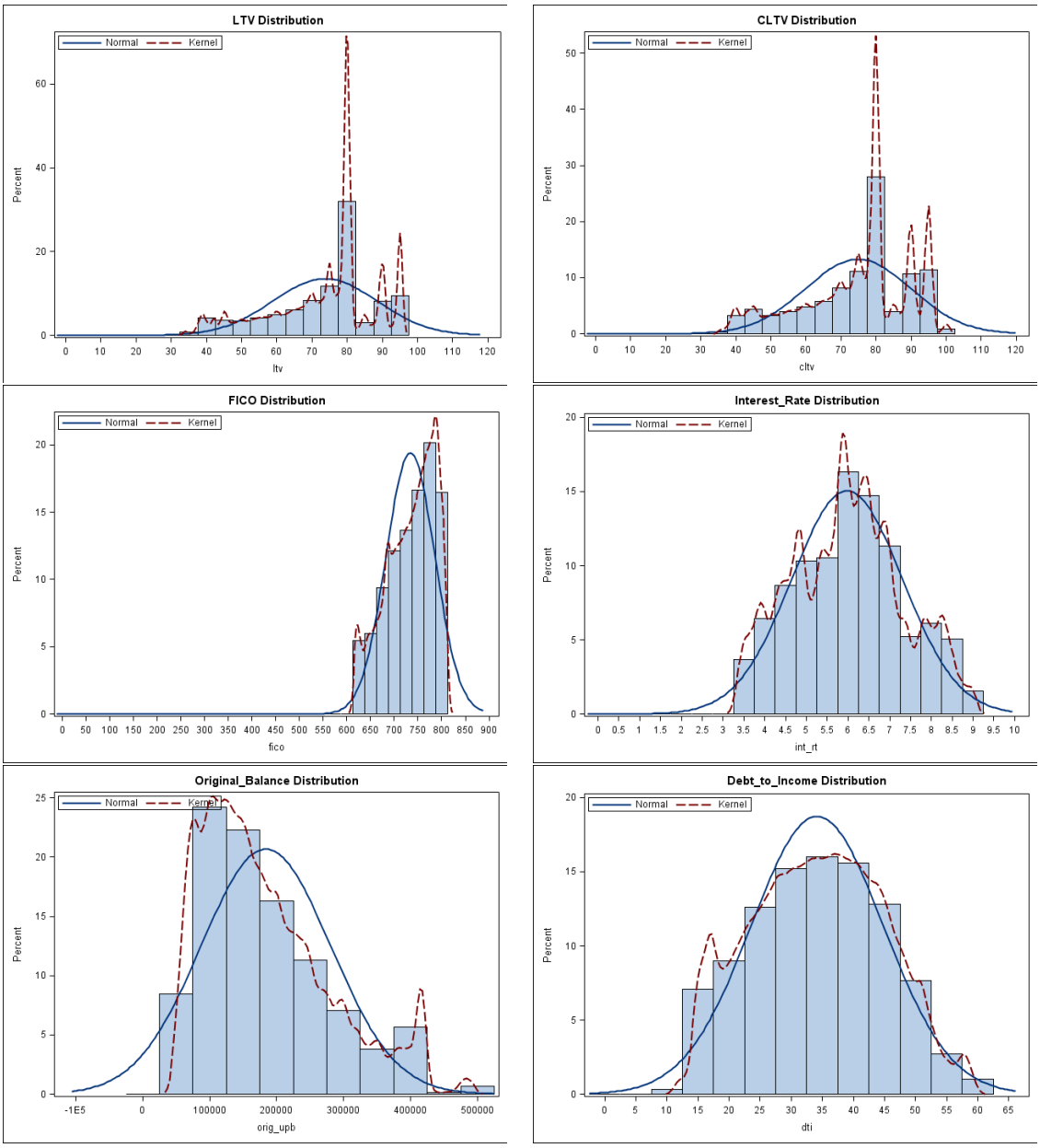

Figure 3.2. Summary of Loan Characteristics at Origination. This figure shows a summary of loan characteristics at origination.The charts show both normal and kernel distributions for loan-to-value ratio (LTV), combined loan-to-value ratio (CLTV), credit score FICO, original interest rate of the loan, originial unpaid principle balance (UPB), and debt-to-income ratio (DTI).

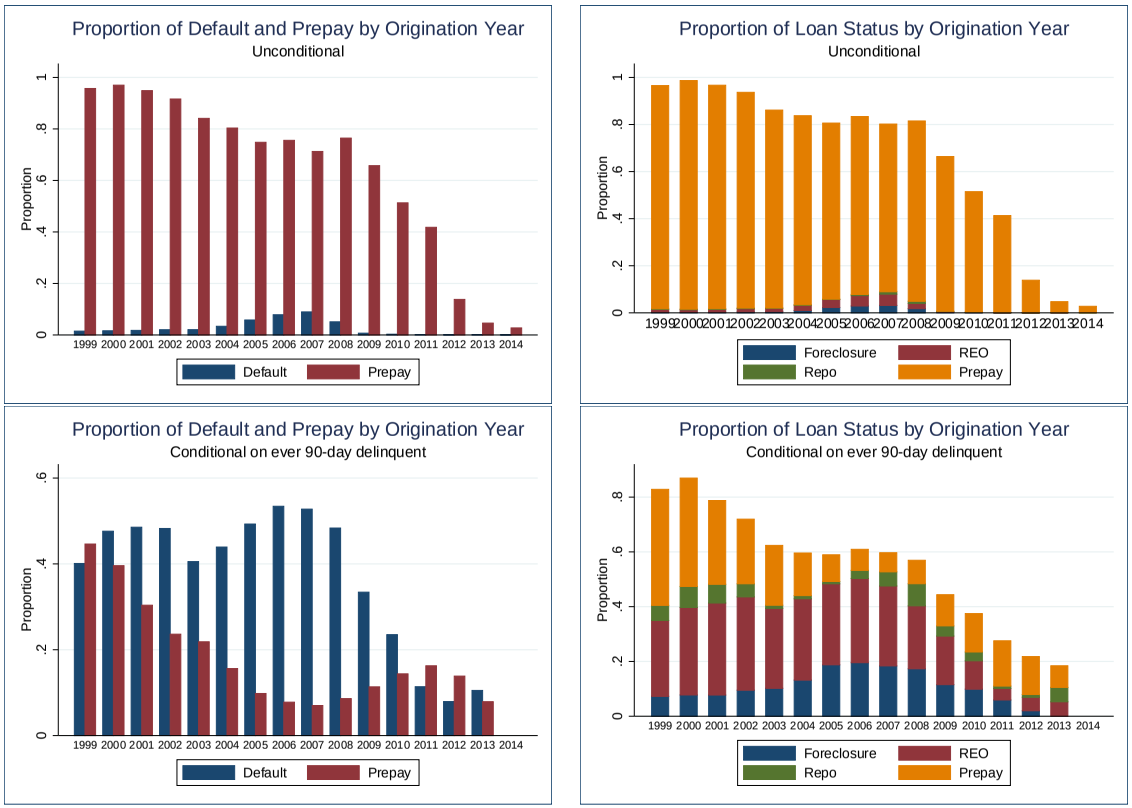

Figure 3.3. Proportion of Loan Ending Status by Origination Year. The top figures show unconditional proportions of loan ending status by origination year. And the bottom two charts show proportions of loan ending status by origination year, conditional on the loan being 90-day delinquent.

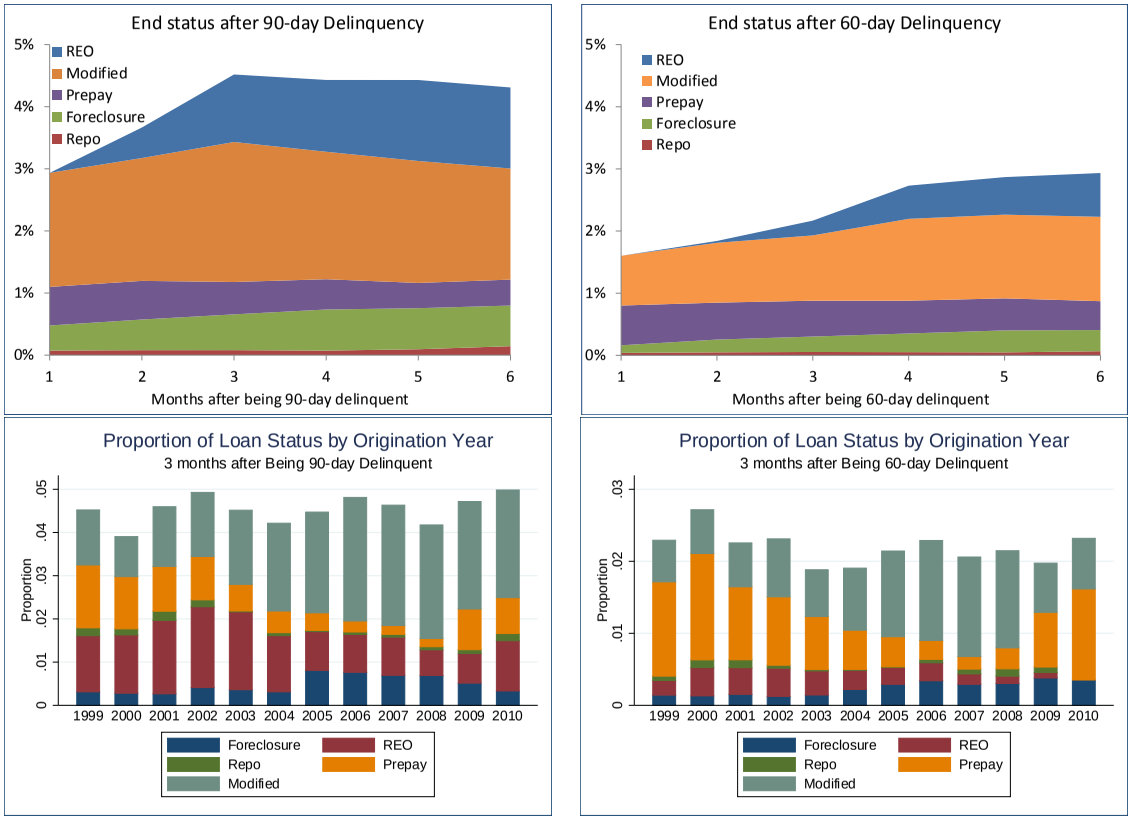

Figure 3.4. Proportion of Loan Status 1-6 months after Being Delinquent. The top figures show loan ending status one to six months after the loan being 90-day and 60-day delinquent. And the bottom two charts show proportions of loan ending status by origination year, three months after the loan being 90-day and 60-day delinquent.

Table 3.1
Loan Default

This table shows the effect of bank balance sheet health on the probability of default three months after the mortgage loan being 90-day delinquent. The dependent variable in columns (1) -(6) is a dummy variable that equals 1 if the mortgage loan is modified, and 0 otherwise. The dependent in column (7)- (9) is a factor variable that equals 0 if the mortgage loan is cured, 1 if stays delinquent, 2 if gets prepaid, 3 if is in default, and 6 if get modified. The sample spans from 1999 to 2014. All regressions in column (1) - (6) use origination-year-, exposure-year-, and state-fixed effects, while regressions in (7)-(9) only controls for exposure-year-fixed effects due to converging issues while estimating multinomial logistic regressions.

	OLS			Binomial			Multinomial		
Dep. Var.: *Default*	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Bank Core Deposit Ratio	-0.030***	-0.036***	0.041***	-1.351**	-1.660***	0.169	-1.063*	-1.506**	1.207
	(-2.62)	(-3.07)	(4.24)	(-2.17)	(-2.63)	(0.20)	(-1.70)	(-2.40)	(1.51)
Bank Credit Rating	-0.025***	-0.026***	-0.031***	-0.640***	-0.665***	-1.040***	-0.614***	-0.631***	-1.093***
	(-3.25)	(-3.30)	(-5.76)	(-3.08)	(-3.21)	(-3.73)	(-2.99)	(-3.09)	(-4.21)
Bank Size	-0.005	-0.006	-0.003	-0.128	-0.088	0.172	-0.292	-0.263	0.079
	(-0.89)	(-0.88)	(-0.44)	(-0.24)	(-0.16)	(0.23)	(-0.58)	(-0.51)	(0.13)
Bank Equity Ratio	-0.001***	-0.001**	0.002***	-0.072***	-0.064**	-0.023	-0.074***	-0.067**	-0.041
	(-2.72)	(-2.36)	(5.13)	(-2.60)	(-2.26)	(-0.58)	(-2.77)	(-2.47)	(-1.16)
Servicer Type (1=Bank/0=Non Bank)	0.062***	0.065***	0.020	2.574**	2.588**	1.805	2.774**	2.835**	1.763
	(3.57)	(3.50)	(1.31)	(2.11)	(2.09)	(1.09)	(2.36)	(2.39)	(1.40)
Servicer Market Shares	0.054***	0.056***	0.033***	3.046***	3.190***	2.335**	2.083***	2.332***	2.807***
	(3.75)	(3.80)	(2.95)	(3.74)	(3.90)	(2.26)	(3.08)	(3.47)	(3.15)
Seller Type (1=Bank/0=Non Bank)	0.002	0.002	-0.002	0.184	0.183	0.162	0.244	0.229	0.083
	(0.74)	(0.82)	(-0.88)	(1.06)	(1.05)	(0.67)	(1.43)	(1.34)	(0.37)
Seller Market Shares	-0.007	-0.005	-0.045***	-0.522	-0.470	-0.192	0.624	0.585	1.259
	(-0.48)	(-0.36)	(-3.85)	(-0.65)	(-0.59)	(-0.17)	(0.86)	(0.81)	(1.34)
Servicer Seller Type(1=Same/0=Different)	0.005**	0.005**	-0.006***	0.227**	0.249**	-0.330**	0.150	0.211*	-0.628***
	(2.23)	(2.35)	(-3.36)	(2.01)	(2.20)	(-2.00)	(1.40)	(1.96)	(-4.08)
FICO Score	0.000***	0.000***	0.000***	0.007***	0.008***	0.011***	0.007***	0.007***	0.010***
	(7.20)	(7.29)	(9.02)	(8.12)	(8.21)	(8.56)	(7.67)	(7.80)	(8.78)
Loan-to-Value Ratio	0.000	-0.000	-0.000	0.005	0.003	-0.026*	0.006	0.001	-0.004
	(0.13)	(-0.09)	(-0.91)	(0.53)	(0.26)	(-1.77)	(0.60)	(0.08)	(-0.25)
Loan-to-Value=80	0.001	0.001	0.003	0.094	0.064	0.210	0.085	0.052	0.247
	(0.54)	(0.33)	(1.45)	(0.96)	(0.64)	(1.10)	(0.87)	(0.53)	(1.35)
Combined Loan-to-Value	0.000	0.000	0.000*	0.017*	0.017*	0.022**	0.016*	0.017**	0.010
	(1.51)	(1.42)	(1.86)	(1.93)	(1.91)	(2.04)	(1.93)	(1.96)	(0.97)
Updated Loan-to-Value	0.000*	0.000	-0.000**	0.004*	0.002	0.011***	0.004*	0.003	-0.001
	(1.72)	(0.99)	(-2.47)	(1.87)	(0.88)	(3.34)	(1.82)	(1.35)	(-0.26)

# Borrowers=1	0.000	-0.000	-0.007***	-0.010	-0.013	-0.377***	-0.026	-0.022	-0.580***
	(0.12)	(-0.01)	(-5.39)	(-0.11)	(-0.15)	(-2.91)	(-0.29)	(-0.25)	(-4.89)
Debt-to-Income Ratio	-0.000***	-0.000***	-0.000***	-0.013***	-0.012***	-0.014**	-0.013***	-0.011***	-0.018***
	(-3.26)	(-2.85)	(-4.81)	(-3.20)	(-2.88)	(-2.46)	(-3.14)	(-2.72)	(-3.40)
GDP Growth		0.120**	0.064*		5.634**	6.151*		6.163**	3.441
		(2.54)	(1.71)		(2.27)	(1.75)		(2.49)	(1.10)
Unemployment		-0.001	-0.000		-0.053	-0.069		-0.062*	-0.068
		(-1.16)	(-0.50)		(-1.42)	(-1.46)		(-1.71)	(-1.57)
HPI index by MSA		-0.000***	-0.000***		-0.011***	-0.005*		-0.011***	-0.009***
		(-7.27)	(-4.26)		(-6.62)	(-1.68)		(-6.67)	(-3.32)
30-Year Mortgage Rate		-0.003	-0.033***		-0.176	-0.604*		-0.203	-0.256
		(-1.17)	(-10.87)		(-1.15)	(-1.95)		(-1.32)	(-1.14)
10-Year Tbill Rate		0.001	-0.014***		0.048	0.040		0.065	0.179*
		(0.74)	(-9.50)		(0.59)	(0.34)		(0.82)	(1.73)
Log (Unpaid Principal Balance)			-0.010***			-0.272*			-0.532***
			(-5.98)			(-1.75)			(-3.92)
Loan Age			-0.008***			-0.125***			-0.049***
			(-52.58)			(-17.31)			(-12.79)
Loan Purpose-Cash out			0.007***			0.440**			0.542***
			(3.69)			(2.57)			(3.50)
Loan Purpose-No Cash out			0.005***			0.447***			0.480***
			(3.04)			(2.64)			(3.11)
Original Rate-Current Rate			0.036***			0.452***			1.008***
			(25.81)			(16.64)			(35.02)
Original Rate - 30yr Mortgage Rate			0.002			0.319**			0.251**
			(1.14)			(2.10)			(2.54)
Mortgage Insurance %			-0.000			-0.007			-0.012
			(-1.19)			(-0.70)			(-1.27)
Condo			0.008**			0.461**			0.557***
			(2.41)			(2.16)			(2.73)
Channel=Correspondent			-0.031***			-0.715			-1.180***
			(-6.19)			(-1.64)			(-3.25)
Number of Units			0.004			0.323			0.291
			(1.25)			(1.49)			(1.36)
Nonrecourse State			0.005***			0.555***			0.576***
			(2.86)			(3.99)			(4.37)
# Foreclosure Process Days			-0.000***			-0.004***			-0.007***
			(-9.97)			(-4.17)			(-6.30)
Intercept	-0.089	-0.074	0.416	-12.033***	-8.578*	-4.508	-9.892**	-6.357	-3.420
	(.)	(-1.19)	(.)	(-2.69)	(-1.79)	(-0.65)	(-2.35)	(-1.41)	(-0.60)
Observations	31,225	30,625	30,491	31,011	30,442	30,316	31,225	30,625	30,491

Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Orig Year FE	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No
State FE	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 3.2
Loan Modification
This table shows the effect of bank balance sheet health on the probability of modification three months after the mortgage loan being 90-day delinquent. The dependent variable in columns (1) -(6) is a dummy variable that equals 1 if the mortgage loan is modified, and 0 otherwise. The dependent in column (7)- (9) is a factor variable that equals 0 if the mortgage loan is cured, 1 if stays delinquent, 2 if gets prepaid, 3 if is in default, and 6 if get modified. The sample spans from 1999 to 2014. All regressions in column (1) - (6) use origination-year-, exposure-year-, and state-fixed effects, while regressions in (7)-(9) only controls for exposure-year-fixed effects due to converging issues while estimating multinomial logistic regressions.

	OLS			Binomial			Multinomial		
Dep. Var.: *Modification*	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Bank Core Deposit Ratio	0.041***	0.042***	0.045***	2.049***	2.116***	2.223***	1.919***	2.113***	2.498***
	(3.35)	(3.44)	(3.59)	(3.33)	(3.40)	(3.54)	(3.24)	(3.48)	(3.99)
Bank Credit Rating	0.010***	0.009***	0.010***	0.800**	0.745*	0.797**	0.923**	0.858**	0.885**
	(2.92)	(2.64)	(2.65)	(2.03)	(1.88)	(1.97)	(2.35)	(2.17)	(2.19)
Bank Size	-0.005	0.000	0.003	-0.116	0.099	0.234	-0.199	0.015	0.148
	(-0.53)	(0.04)	(0.29)	(-0.39)	(0.31)	(0.72)	(-0.67)	(0.05)	(0.46)
Bank Equity Ratio	0.000	0.000	0.000	0.019	0.009	0.008	0.019	0.012	0.019
	(0.71)	(0.25)	(0.22)	(0.71)	(0.34)	(0.29)	(0.80)	(0.49)	(0.74)
Servicer Type (1=Bank/0=Non Bank)	-0.041**	-0.050**	-0.057***	-2.329***	-2.711***	-3.135***	-2.370***	-2.797***	-3.279***
	(-2.15)	(-2.48)	(-2.82)	(-2.86)	(-3.18)	(-3.60)	(-2.90)	(-3.26)	(-3.74)
Servicer Market Shares	0.026	0.029*	0.029*	0.970	1.139	1.100	1.247**	1.272**	0.940
	(1.64)	(1.82)	(1.76)	(1.28)	(1.49)	(1.43)	(1.99)	(1.98)	(1.38)
Seller Type (1=Bank/0=Non Bank)	0.002	0.002	0.002	0.101	0.087	0.096	0.056	0.058	0.065
	(0.64)	(0.54)	(0.62)	(0.68)	(0.58)	(0.64)	(0.39)	(0.40)	(0.44)
Seller Market Shares	-0.011	-0.013	-0.014	-0.329	-0.431	-0.485	-0.738	-0.756	-0.492
	(-0.68)	(-0.80)	(-0.85)	(-0.43)	(-0.55)	(-0.62)	(-1.18)	(-1.18)	(-0.73)
Servicer Seller Type(1=Same/0=Different)	-0.002	-0.003	-0.002	-0.148	-0.168	-0.140	-0.020	-0.067	-0.124
	(-1.04)	(-1.24)	(-1.05)	(-1.28)	(-1.44)	(-1.21)	(-0.21)	(-0.68)	(-1.14)
FICO Score	-0.000**	-0.000**	-0.000**	-0.002**	-0.002**	-0.002**	-0.002**	-0.002**	-0.002**
	(-2.32)	(-2.11)	(-2.14)	(-2.24)	(-2.00)	(-2.23)	(-2.32)	(-1.97)	(-1.96)
Loan-to-Value Ratio	0.000***	0.000**	0.000*	0.024**	0.021**	0.020*	0.022**	0.020**	0.022*
	(2.79)	(2.43)	(1.85)	(2.37)	(2.08)	(1.66)	(2.23)	(2.05)	(1.84)
Loan-to-Value=80	-0.002	-0.001	-0.001	-0.068	-0.061	-0.041	-0.067	-0.060	-0.030
	(-0.86)	(-0.74)	(-0.35)	(-0.73)	(-0.66)	(-0.33)	(-0.72)	(-0.64)	(-0.25)
Combined Loan-to-Value	-0.001***	-0.001***	-0.000***	-0.025***	-0.025***	-0.024**	-0.025***	-0.026***	-0.027***
	(-3.31)	(-3.27)	(-2.94)	(-2.65)	(-2.62)	(-2.38)	(-2.66)	(-2.72)	(-2.63)
Updated Loan-to-Value	0.000***	0.000***	0.000***	0.007***	0.010***	0.011***	0.007***	0.010***	0.009***
	(3.64)	(4.12)	(4.03)	(3.88)	(4.24)	(4.26)	(4.56)	(4.93)	(3.75)

# Borrowers=1	-0.003	-0.002	-0.002	-0.120	-0.114	-0.064	-0.110	-0.106	-0.081
	(-1.52)	(-1.40)	(-0.84)	(-1.55)	(-1.45)	(-0.79)	(-1.42)	(-1.34)	(-1.00)
Debt-to-Income Ratio	0.000***	0.000***	0.000***	0.017***	0.017***	0.018***	0.018***	0.017***	0.017***
	(4.78)	(4.60)	(4.60)	(4.68)	(4.53)	(4.70)	(4.92)	(4.67)	(4.50)
GDP Growth		0.052	0.059		2.748	3.337		3.223	3.423
		(1.07)	(1.18)		(1.21)	(1.41)		(1.42)	(1.45)
Unemployment		-0.000	-0.000		-0.013	-0.006		-0.023	-0.009
		(-0.41)	(-0.16)		(-0.41)	(-0.17)		(-0.72)	(-0.26)
HPI index by MSA		0.000**	0.000*		0.003**	0.003*		0.003**	0.002
		(2.18)	(1.85)		(2.14)	(1.84)		(2.30)	(1.60)
30-Year Mortgage Rate		0.011***	0.007*		0.499***	0.285		0.463***	0.370**
		(3.71)	(1.79)		(3.65)	(1.61)		(3.37)	(2.35)
10-Year Tbill Rate		-0.001	-0.001		-0.067	-0.062		-0.046	-0.049
		(-0.56)	(-0.70)		(-0.77)	(-0.69)		(-0.53)	(-0.56)
Log (Unpaid Principal Balance)			0.003			0.147			0.161
			(1.20)			(1.42)			(1.56)
Loan Age			-0.000*			-0.000			-0.005*
			(-1.75)			(-0.05)			(-1.93)
Loan Purpose-Cash out			-0.003			-0.138			-0.092
			(-1.11)			(-1.26)			(-0.84)
Loan Purpose-No Cash out			-0.000			-0.005			0.009
			(-0.07)			(-0.04)			(0.08)
Original Rate-Current Rate			-0.006***			-0.394***			-0.211***
			(-8.87)			(-6.18)			(-3.00)
Original Rate - 30yr Mortgage Rate			-0.003			-0.184*			-0.054
			(-1.48)			(-1.70)			(-0.68)
Mortgage Insurance %			0.000			0.003			0.002
			(0.54)			(0.50)			(0.37)
Condo			-0.005			-0.231			-0.233
			(-1.46)			(-1.33)			(-1.34)
Channel=Correspondent			-0.013**			-0.644*			-0.634**
			(-2.29)			(-1.83)			(-1.97)
Number of Units			-0.006**			-0.468			-0.497*
			(-2.45)			(-1.62)			(-1.72)
Nonrecourse State			-0.003			-0.128			-0.116
			(-1.32)			(-1.32)			(-1.20)
# Foreclosure Process Days			-0.000			-0.000			-0.001
			(-0.89)			(-0.83)			(-1.17)
Intercept	0.052	-0.093	-0.044	-3.056	-6.833**	-7.682**	-1.127	-5.111*	-6.496**
	(.)	(-1.23)	(.)	(-1.13)	(-2.22)	(-2.30)	(-0.44)	(-1.75)	(-2.03)
Observations	31,225	30,625	30,491	31,129	30,542	30,416	31,225	30,625	30,491
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Orig Year FE	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
State FE	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 3.3
Loan Prepayment
This table shows the effect of bank balance sheet health on the probability of prepayment three months after the mortgage loan being 90-day delinquent. The dependent variable in columns (1) -(6) is a dummy variable that equals 1 if the mortgage loan is modified, and 0 otherwise. The dependent in column (7)- (9) is a factor variable that equals 0 if the mortgage loan is cured, 1 if stays delinquent, 2 if gets prepaid, 3 if is in default, and 6 if get modified. The sample spans from 1999 to 2014. All regressions in column (1) - (6) use origination-year-, exposure-year-, and state-fixed effects, while regressions in (7)-(9) only controls for exposure-year-fixed effects due to converging issues while estimating multinomial logistic regressions.

	OLS			Binomial			Multinomial		
Dep. Var.: *Prepayment*	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Bank Core Deposit Ratio	-0.027***	-0.024***	-0.027***	-4.006***	-3.924***	-4.485***	-3.862***	-3.650***	-4.211***
	(-3.62)	(-3.21)	(-3.58)	(-3.43)	(-3.33)	(-3.61)	(-3.48)	(-3.26)	(-3.48)
Bank Credit Rating	0.001	0.000	-0.001	0.098	0.062	0.003	0.215	0.151	0.056
	(0.10)	(0.09)	(-0.22)	(0.32)	(0.20)	(0.01)	(0.72)	(0.49)	(0.17)
Bank Size	-0.005**	-0.004	-0.004	-1.299*	-1.128	-0.988	-1.175*	-0.995	-0.945
	(-1.98)	(-1.62)	(-1.47)	(-1.94)	(-1.58)	(-1.36)	(-1.87)	(-1.51)	(-1.37)
Bank Equity Ratio	-0.000	-0.001	-0.001*	-0.052	-0.070*	-0.096**	-0.060	-0.074*	-0.097**
	(-1.11)	(-1.34)	(-1.67)	(-1.34)	(-1.76)	(-2.24)	(-1.61)	(-1.89)	(-2.37)
Servicer Type (1=Bank/0=Non Bank)	0.024***	0.023***	0.025***	5.752***	5.584***	5.619***	5.046***	4.828***	5.073***
	(3.02)	(2.81)	(3.16)	(3.49)	(3.29)	(3.29)	(3.38)	(3.13)	(3.11)
Servicer Market Shares	0.021**	0.021**	0.023**	2.105	1.882	2.194	1.644	1.350	1.531
	(2.22)	(2.20)	(2.34)	(1.48)	(1.31)	(1.52)	(1.44)	(1.17)	(1.24)
Seller Type (1=Bank/0=Non Bank)	-0.000	-0.000	-0.001	0.245	0.267	0.281	0.305	0.315	0.381
	(-0.25)	(-0.34)	(-0.46)	(0.80)	(0.87)	(0.84)	(1.03)	(1.06)	(1.20)
Seller Market Shares	-0.010	-0.011	-0.010	0.572	0.603	0.743	1.503	1.421	1.864
	(-0.97)	(-1.08)	(-0.96)	(0.41)	(0.42)	(0.51)	(1.23)	(1.15)	(1.44)
Servicer Seller Type(1=Same/0=Different)	0.005***	0.004***	0.004***	0.517**	0.475**	0.462**	0.655***	0.573***	0.556***
	(3.05)	(2.86)	(2.83)	(2.56)	(2.30)	(2.18)	(3.37)	(2.90)	(2.59)
FICO Score	0.000***	0.000***	0.000***	0.006***	0.007***	0.007***	0.006***	0.007***	0.007***
	(3.83)	(4.04)	(3.95)	(4.04)	(4.32)	(4.42)	(4.16)	(4.32)	(4.44)
Loan-to-Value Ratio	-0.000	-0.000	-0.000	-0.002	-0.008	-0.013	0.002	-0.002	-0.006
	(-0.57)	(-0.83)	(-0.96)	(-0.11)	(-0.41)	(-0.57)	(0.11)	(-0.09)	(-0.26)
Loan-to-Value=80	0.001	0.001	0.001	0.108	0.073	0.217	0.125	0.094	0.193
	(0.65)	(0.59)	(1.21)	(0.61)	(0.40)	(0.93)	(0.71)	(0.52)	(0.84)
Combined Loan-to-Value	0.000	0.000	-0.000	0.013	0.014	0.004	0.008	0.009	-0.003
	(0.03)	(0.16)	(-0.52)	(0.71)	(0.80)	(0.21)	(0.42)	(0.47)	(-0.15)
Updated Loan-to-Value	-0.000***	-0.000***	-0.000***	-0.043***	-0.037***	-0.041***	-0.043***	-0.038***	-0.040***
	(-7.06)	(-4.23)	(-4.03)	(-9.27)	(-7.04)	(-6.43)	(-9.54)	(-7.30)	(-6.57)

# Borrowers=1	-0.000	0.000	0.000	0.000	0.018	0.051	0.005	0.013	0.020
	(-0.05)	(0.08)	(0.04)	(0.00)	(0.12)	(0.30)	(0.03)	(0.08)	(0.12)
Debt-to-Income Ratio	0.000	0.000	0.000	0.011	0.009	0.006	0.011	0.009	0.005
	(1.41)	(0.96)	(0.59)	(1.47)	(1.17)	(0.79)	(1.51)	(1.24)	(0.72)
GDP Growth		0.078***	0.068**		8.425**	7.057		9.098**	7.569*
		(2.65)	(2.32)		(2.09)	(1.63)		(2.30)	(1.81)
Unemployment		0.000	0.000		0.013	-0.044		0.002	-0.050
		(1.58)	(0.70)		(0.20)	(-0.64)		(0.03)	(-0.76)
HPI index by MSA		0.000***	0.000**		0.006***	0.002		0.006***	0.003
		(3.58)	(2.46)		(2.84)	(0.88)		(2.79)	(1.03)
30-Year Mortgage Rate		0.000	0.002		0.052	0.138		0.072	0.135
		(0.24)	(1.02)		(0.18)	(0.40)		(0.25)	(0.43)
10-Year Tbill Rate		0.001	0.001		0.134	0.167		0.154	0.140
		(1.20)	(1.21)		(1.10)	(1.27)		(1.26)	(1.10)
Log (Unpaid Principal Balance)			0.002*			0.618***			0.560***
			(1.88)			(3.11)			(2.94)
Loan Age			0.000***			0.028*			0.001
			(2.70)			(1.72)			(0.28)
Loan Purpose-Cash out			0.003**			0.428*			0.473**
			(2.32)			(1.88)			(2.07)
Loan Purpose-No Cash out			0.001			0.260			0.258
			(0.96)			(1.16)			(1.15)
Original Rate-Current Rate			-0.000**			-0.326**			-0.172
			(-2.17)			(-2.23)			(-0.92)
Original Rate - 30yr Mortgage Rate			0.001			0.046			0.043
			(0.72)			(0.22)			(0.34)
Mortgage Insurance %			0.000			0.014			0.011
			(1.23)			(1.24)			(0.96)
Condo			0.002			0.357			0.311
			(1.01)			(1.16)			(1.03)
Channel=Correspondent			-0.000			-0.179			0.180
			(-0.19)			(-0.31)			(0.33)
Number of Units			-0.001			-0.025			-0.074
			(-0.53)			(-0.08)			(-0.25)
Nonrecourse State			0.001			0.115			0.128
			(0.90)			(0.57)			(0.65)
# Foreclosure Process Days			0.000			0.000			-0.000
			(0.27)			(0.13)			(-0.16)
Intercept	0.015	0.021	0.002	3.222	-0.322	-7.674	0.901	-3.544	-8.989
	(.)	(0.34)	(0.00)	(0.52)	(-0.05)	(-1.01)	(0.16)	(-0.54)	(-1.28)
Observations	31,225	30,625	30,491	31,012	30,443	30,310	31,225	30,625	30,491
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Orig Year FE	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
State FE	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 3.4
Multinomial Logistic Regressions on Loan Resolutions Post Delinquency
This table shows the effect of bank balance sheet health on the probability of different ending states three months after the mortgage loan being 90-day delinquent. The dependent is a factor variable that equals 0 if the mortgage loan is cured, 1 if stays delinquent, 2 if gets prepaid, 3 if is in default, and 6 if get modified. The sample spans from 1999 to 2014. All regressions control for exposure-year-fixed effects.

Dep. Var.: *Loan Resolutions*	Cure (1)	Modified (2)	Prepay (3)	Foreclosure (4)	REO (5)	Repo (6)
Bank Core Deposit Ratio	1.962***	2.168***	-4.137***	-0.044	-1.710**	1.553
	(7.61)	(3.51)	(-3.47)	(-0.04)	(-1.99)	(0.53)
Bank Credit Rating	0.727***	0.833**	0.074	-0.215	-0.740***	-0.836
	(6.81)	(2.10)	(0.24)	(-0.41)	(-2.84)	(-1.38)
Bank Size	-0.108	0.091	-0.897	0.327	-0.310	-1.307
	(-0.70)	(0.28)	(-1.31)	(0.22)	(-0.44)	(-1.30)
Bank Equity Ratio	-0.012	0.017	-0.084**	-0.071	-0.115***	-0.062
	(-1.06)	(0.65)	(-2.02)	(-1.27)	(-3.27)	(-0.63)
Servicer Type (1=Bank/0=Non Bank)	-2.223***	-2.956***	4.786***	1.543	2.982*	2.569
	(-5.81)	(-3.45)	(2.95)	(0.48)	(1.80)	(1.17)
Servicer Market Shares	0.441	1.042	1.558	2.583**	3.505***	4.126
	(1.59)	(1.55)	(1.31)	(2.09)	(3.73)	(1.12)
Seller Type (1=Bank/0=Non Bank)	-0.207	-0.513	1.644	0.015	-0.129	-0.555
	(-0.79)	(-0.78)	(1.28)	(0.01)	(-0.13)	(-0.15)
Seller Market Shares	-0.041	0.075	0.282	0.277	0.087	-0.972
	(-0.71)	(0.52)	(0.89)	(1.03)	(0.34)	(-1.24)
Servicer Seller Type(1=Same/0=Different)	0.012	-0.093	0.623***	-0.317*	0.445***	0.221
	(0.27)	(-0.93)	(3.10)	(-1.79)	(2.87)	(0.45)
Credit Score FICO/100	-0.114***	-0.134	0.753***	1.228***	0.330**	0.297
	(-2.97)	(-1.54)	(4.83)	(8.01)	(2.53)	(0.65)
Original Combined Loan-To-Value	-0.007***	-0.016***	-0.008	0.007	0.008	-0.049
	(-3.67)	(-3.17)	(-0.91)	(0.67)	(0.98)	(-1.40)
Original Debt-to-Income Ratio	-0.001	0.017***	0.006	-0.012*	0.000	-0.024
	(-0.53)	(4.36)	(0.74)	(-1.76)	(0.07)	(-1.51)
Updated Loan-To-Value	-0.012***	0.035***	0.066**	0.056***	0.075***	0.015
	(-3.43)	(3.21)	(2.00)	(3.39)	(3.21)	(0.28)
Updated Loan-To-Value Squared	0.000*	-0.000**	-0.001***	-0.000**	-0.000***	-0.000
	(1.95)	(-2.39)	(-3.41)	(-2.25)	(-3.34)	(-0.01)

Original UPB	0.050	0.137	0.647***	0.166	-1.034***	-0.169
	(1.28)	(1.50)	(3.87)	(0.97)	(-7.05)	(-0.41)
Mortgage Insurance %	0.001	0.008*	0.012	-0.031***	0.020***	0.033
	(0.29)	(1.91)	(1.41)	(-3.86)	(3.06)	(1.48)
Number of Units	-0.079	-0.308	-0.089	-0.040	0.034	0.126
	(-0.75)	(-1.08)	(-0.31)	(-0.14)	(0.08)	(0.24)
Prepayment Penalty	-0.021	-15.449***	-15.900***	-14.907***	-12.841***	-16.625***
	(-0.02)	(-29.08)	(-23.17)	(-22.17)	(-13.46)	(-17.17)
OccpySts=Owner Occupied	0.427***	0.918***	0.118	-0.727***	-0.765***	-1.954***
	(4.30)	(2.94)	(0.31)	(-2.69)	(-3.67)	(-3.80)
OccpySts=Second Home	0.103	0.268	-0.321	-0.886**	-0.330	-16.256***
	(0.67)	(0.60)	(-0.46)	(-2.10)	(-0.96)	(-39.84)
LoanPurpose=No Cash-out Refinance	0.126***	-0.078	0.523**	0.405**	-0.082	0.737
	(2.73)	(-0.73)	(2.36)	(2.08)	(-0.46)	(1.46)
LoanPurpose=Purchase	-0.020	0.006	0.194	0.422**	0.045	0.764
	(-0.43)	(0.05)	(0.87)	(2.07)	(0.26)	(1.55)
GDP growth by State	0.689	3.070	8.026**	16.299***	-9.080***	-5.112
	(0.67)	(1.32)	(1.99)	(3.80)	(-2.59)	(-0.42)
Unemployment Rate	-0.033**	-0.036	-0.024	-0.025	0.050	-0.179
	(-2.50)	(-1.13)	(-0.37)	(-0.47)	(0.97)	(-0.95)
10-Year Tbill Rate	-0.172**	0.426**	0.306	0.184	-0.303	0.234
	(-2.37)	(2.50)	(0.89)	(0.59)	(-1.27)	(0.31)
Original Rate-Current Rate	-0.296***	0.466***	0.170	-0.128	-0.183	0.331
	(-4.42)	(2.94)	(0.53)	(-0.45)	(-0.82)	(0.50)
Original Rate - 30yr Mortgage Rate	0.156***	-0.468***	-0.083	0.386	0.047	-0.062
	(2.67)	(-3.41)	(-0.28)	(1.46)	(0.23)	(-0.10)
# Days to Process Foreclosure	-0.001***	-0.000	-0.000	-0.004***	-0.028***	0.004**
	(-3.38)	(-0.81)	(-0.32)	(-4.35)	(-16.97)	(2.43)
Constant	1.661	-8.073***	-13.450*	-24.738*	7.963	7.897
	(1.12)	(-2.61)	(-1.95)	(-1.92)	(1.26)	(0.62)
Observations	30491	30491	30491	30491	30491	30491
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Orig Year FE	No	No	No	No	No	No
State FE	No	No	No	No	No	No

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 3.5
Multinomial Logistic Regressions on Countrywide as Seller and/or Servicer
This table shows the effect of Countrywide as seller or servicer on the probability of default. The sample spans from 1999 to 2014. All regressions control for origination-year-, exposure-year-, and state- fixed effects.

Dep. Var.: *Countrywide*	Prepay (1)	Default (2)	Prepay (3)	Default (4)	Prepay (5)	Default (6)
Countrywide-Both Seller and Servicer	1.277***	1.777***	1.271***	1.803***	1.261***	0.909**
	(0.04)	(0.35)	(0.04)	(0.35)	(0.04)	(0.35)
Countrywide-Seller Only	-1.823***	-2.228***	-1.832***	-2.317***	-1.833***	-2.008***
	(0.04)	(0.35)	(0.04)	(0.35)	(0.04)	(0.36)
FICO Score	0.003***	-0.006***	0.004***	-0.007***	0.003***	-0.005***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Loan-to-Value Ratio	0.009***	-0.007	0.009***	-0.002	0.015***	-0.003
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
Loan-to-Value=80	0.024	-0.018	0.022	-0.038	-0.043*	-0.021
	(0.01)	(0.05)	(0.01)	(0.05)	(0.02)	(0.10)
Combined Loan-to-Value	0.004**	0.013**	0.003	0.013**	-0.005**	0.022***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Updated Loan-to-Value	-0.016***	0.030***	-0.013***	0.028***	-0.016***	0.017***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
# Borrowers=1	-0.217***	0.402***	-0.217***	0.419***	-0.074***	0.354***
	(0.01)	(0.05)	(0.01)	(0.05)	(0.01)	(0.07)
Debt-to-Income Ratio	-0.002**	0.008***	-0.002***	0.007***	-0.004***	-0.004
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
GDP Growth			0.591	-3.597*	0.521	3.862
			(0.54)	(2.14)	(0.54)	(2.85)
Unemployment			-0.039***	0.093**	-0.065***	0.124**
			(0.01)	(0.04)	(0.01)	(0.06)
HPI			0.004***	0.001	0.001***	-0.003
			(0.00)	(0.00)	(0.00)	(0.00)
30-Year Mortgage Rate			-0.412***	-0.463***	-0.222***	-1.285***
			(0.02)	(0.08)	(0.03)	(0.16)
10-Year Tbill Rate			0.081***	-0.124**	0.124***	-0.213***
			(0.01)	(0.05)	(0.01)	(0.07)
Log (Unpaid Principal Balanc)					0.662***	0.318***
					(0.02)	(0.10)
loan-age					0.024***	-0.147***
					(0.00)	(0.00)
Loan Purpose-Cash out					-0.096***	-0.007

					(0.01)	(0.05)
Loan Purpose-No Cash out					-0.005	0.155**
					(0.01)	(0.06)
int-diff					-0.882***	0.455***
					(0.05)	(0.02)
Risk Premium					0.121***	0.260***
					(0.02)	(0.09)
Mortgage Insurance %					-0.003**	-0.005
					(0.00)	(0.00)
Condo					-0.130***	0.224*
					(0.03)	(0.13)
Channel-Correspondent					0.109**	-0.360
					(0.04)	(0.23)
cnt-units					-0.305***	0.118
					(0.04)	(0.16)
Nonrecourse State					0.256	24.087
					(0.56)	(9.81)
# Foreclosure Process Days					0.002*	0.037***
					(0.00)	(0.00)
Intercept	-5.842***	-7.596	-4.817***	-4.703	-13.473***	-12.263*
	(0.14)	(9.35)	(0.29)	(0.09)	(0.53)	(7.05)
N	1268582	1268582	1224509	1224509	1223639	1223639
Origination Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Exposure Year FE	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 3.6
Multinomial Logistic Regressions on Countrywide as Seller and/or Servicer*Post Exposure Year 2005
This table shows the effect of Countrywide as seller or servicer on the probability of default. The sample spans from 1999 to 2014. All regressions control for origination-year-, exposure-year-, and state- fixed effects.

Dep. Var.: *Countrywide*	Prepay (1)	Default (2)	Prepay (3)	Default (4)	Prepay (5)	Default (6)
*Post Exposure Year 2005*ctrywd-Both Seller and Servicer*	0.999***	1.720**	0.993***	1.787**	0.990***	2.175***
	(0.06)	(0.77)	(0.06)	(0.77)	(0.07)	(0.67)
*Post Exposure Year 2005*ctrywd-Seller Only*	-2.189***	-2.896***	-2.161***	-2.950***	-2.156***	-1.902***
	(0.07)	(0.75)	(0.07)	(0.75)	(0.07)	(0.65)
Countrywide-Both Seller and Servicer	0.578***	0.347	0.583***	0.329	0.565***	-0.769
	(0.06)	(0.76)	(0.06)	(0.76)	(0.06)	(0.53)
Countrywide-Seller Only	-0.451***	0.145	-0.473***	0.089	-0.436***	-0.343
	(0.06)	(0.74)	(0.06)	(0.74)	(0.06)	(0.50)
Post2005	7.007***	13.678	4.261***	10.101	1.335***	26.007
	(0.11)	(2.89)	(0.21)	(3.28)	(0.36)	(7.15)
FICO Score	0.003***	-0.006***	0.003***	-0.007***	0.003***	-0.005***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Loan-to-Value Ratio	0.008***	-0.007	0.008***	-0.002	0.013***	-0.003
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
Loan-to-Value=80	-0.002	-0.023	-0.004	-0.043	-0.060**	-0.028
	(0.01)	(0.05)	(0.01)	(0.05)	(0.02)	(0.10)
Combined Loan-to-Value	0.005**	0.013**	0.003	0.014**	-0.004**	0.023***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Updated Loan-to-Value	-0.015***	0.030***	-0.012***	0.028***	-0.015***	0.017***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
# Borrowers=1	-0.192***	0.409***	-0.192***	0.427***	-0.061***	0.358***
	(0.01)	(0.05)	(0.01)	(0.05)	(0.01)	(0.07)
Debt-to-Income Ratio	-0.001	0.008***	-0.001	0.007***	-0.003***	-0.004
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
GDP Growth			1.034*	-3.697*	0.967*	3.943
			(0.54)	(2.15)	(0.54)	(2.86)
Unemployment			0.003	0.117**	-0.020*	0.130**
			(0.01)	(0.04)	(0.01)	(0.06)
HPI			0.004***	0.001	0.002***	-0.003
			(0.00)	(0.00)	(0.00)	(0.00)
30-Year Mortgage Rate			-0.399***	-0.471***	-0.078**	-1.239***
			(0.02)	(0.08)	(0.03)	(0.16)

10-Year Tbill Rate			0.057***	-0.133***	0.091***	-0.216***
			(0.01)	(0.05)	(0.01)	(0.07)
Log (Unpaid Principal Balanc)					0.638***	0.319***
					(0.02)	(0.10)
loan-age					0.021***	-0.147***
					(0.00)	(0.00)
Loan Purpose-Cash out					-0.085***	0.001
					(0.01)	(0.05)
Loan Purpose-No Cash out					-0.019	0.147**
					(0.01)	(0.06)
int-diff					-0.839***	0.446***
					(0.05)	(0.02)
Risk Premium					0.262***	0.311***
					(0.02)	(0.09)
Mortgage Insurance %					-0.003*	-0.005
					(0.00)	(0.00)
Condo					-0.133***	0.224*
					(0.03)	(0.13)
Channel-Correspondent					0.063	-0.367
					(0.04)	(0.23)
cnt-units					-0.296***	0.113
					(0.04)	(0.16)
Nonrecourse State					0.129	0.800
					(0.56)	(9.86)
# Foreclosure Process Days					0.002	-0.003
					(0.00)	(0.00)
Intercept	-9.772***	-15.795	-7.107***	-10.452	-14.556***	-16.743
	(0.16)	(3.36)	(0.38)	(3.82)	(0.57)	(7.37)
N	1268582	1268582	1224509	1224509	1223639	1223639
Origination Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Exposure Year FE	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 3.7
Multinomial Logistic Regressions on Countrywide as Seller and/or Servicer*Post Origination Year 2005
This table shows the effect of Countrywide as seller or servicer on the probability of default. The sample spans from 1999 to 2014. All regressions control for origination-year-, exposure-year-, and state- fixed effects.

Dep. Var.: *Countrywide*	Prepay (1)	Default (2)	Prepay (3)	Default (4)	Prepay (5)	Default (6)
*Post Origination Year 2005*ctrywd-Both Seller and Servicer*	0.780***	4.750	0.793***	4.811	0.764***	4.770
	(0.11)	(6.47)	(0.11)	(4.72)	(0.11)	(0.29)
*Post Origination Year 2005*ctrywd-Seller Only*	-0.702***	3.398	-0.690***	3.431	-0.598***	3.373
	(0.11)	(6.47)	(0.11)	(4.72)	(0.11)	(0.29)
Countrywide-Both Seller and Servicer	0.831***	1.065***	0.826***	1.078***	0.821***	0.285
	(0.04)	(0.38)	(0.04)	(0.38)	(0.05)	(0.39)
Countrywide-Seller Only	-1.353***	-1.854***	-1.363***	-1.933***	-1.396***	-1.549***
	(0.05)	(0.39)	(0.05)	(0.40)	(0.05)	(0.41)
Post Origination Year 2005	0.986***	-3.808	0.918***	-3.815	2.322***	-15.352
	(0.11)	(6.47)	(0.11)	(4.72)	(0.20)	(0.29)
FICO Score	0.003***	-0.006***	0.003***	-0.007***	0.003***	-0.005***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Loan-to-Value Ratio	0.009***	-0.007	0.008***	-0.002	0.014***	-0.003
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
Loan-to-Value=80	0.009	-0.020	0.007	-0.040	-0.052**	-0.025
	(0.01)	(0.05)	(0.01)	(0.05)	(0.02)	(0.10)
Combined Loan-to-Value	0.005**	0.013**	0.003	0.014**	-0.005**	0.023***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Updated Loan-to-Value	-0.016***	0.030***	-0.013***	0.028***	-0.015***	0.017***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
# Borrowers=1	-0.207***	0.403***	-0.207***	0.420***	-0.072***	0.356***
	(0.01)	(0.05)	(0.01)	(0.05)	(0.01)	(0.07)
Debt-to-Income Ratio	-0.001	0.008***	-0.002*	0.007***	-0.004***	-0.004
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
GDP Growth			0.770	-3.617*	0.714	3.905
			(0.54)	(2.14)	(0.54)	(2.86)
Unemployment			-0.024**	0.098**	-0.047***	0.128**
			(0.01)	(0.04)	(0.01)	(0.06)
HPI			0.004***	0.001	0.002***	-0.003
			(0.00)	(0.00)	(0.00)	(0.00)
30-Year Mortgage Rate			-0.416***	-0.466***	-0.180***	-1.277***

			(0.02)	(0.08)	(0.03)	(0.16)
10-Year Tbill Rate			0.063***	-0.129**	0.097***	-0.215***
			(0.01)	(0.05)	(0.01)	(0.07)
Log (Unpaid Principal Balanc)					0.640***	0.316***
					(0.02)	(0.10)
loan-age					0.019***	-0.148***
					(0.00)	(0.00)
Loan Purpose-Cash out					-0.091***	-0.004
					(0.01)	(0.05)
Loan Purpose-No Cash out					-0.011	0.153**
					(0.01)	(0.06)
int-diff					-0.845***	0.452***
					(0.05)	(0.02)
Risk Premium					0.181***	0.278***
					(0.02)	(0.09)
Mortgage Insurance %					-0.003**	-0.005
					(0.00)	(0.00)
Condo					-0.129***	0.225*
					(0.03)	(0.13)
Channel-Correspondent					0.081*	-0.364
					(0.04)	(0.23)
cnt-units					-0.290***	0.117
					(0.04)	(0.16)
Nonrecourse State					0.135	43.643**
					(0.56)	(0.02)
# Foreclosure Process Days					0.002	0.069***
					(0.00)	(0.00)
Intercept	-6.146***	-7.405	-5.049***	-4.474	-14.236***	-16.537**
	(0.14)	(5.86)	(0.29)	(6.37)	(0.56)	(7.24)
N	1268582	1268582	1224509	1224509	1223639	1223639
Origination Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Exposure Year FE	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 3.8
Countrywide as Servicer and Default Option
This table shows the effects of Countrywide as Servicer on the probability of default three months after the mortgage loan being 90-day delinquent. The dependent variable in columns (1) -(6) is a dummy variable that equals 1 if the mortgage loan is modified, and 0 otherwise. The dependent in column (7)- (9) is a factor variable that equals 0 if the mortgage loan is cured, 1 if stays delinquent, 2 if gets prepaid, 3 if is in default, and 6 if get modified. The sample spans from 1999 to 2014. All regressions in column (1) - (6) use origination-year-, exposure-year-, and state-fixed effects, while regressions in (7)-(9) only controls for exposure-year-fixed effects due to converging issues while estimating multinomial logistic regressions.

	OLS			Binomial			Multinomial		
Dep. Var.: *Default*	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Countrywide Servicer	0.096***	0.097***	0.069***	7.381***	7.209***	6.869***	7.393***	7.239***	6.915***
	(3.99)	(4.01)	(4.26)	(6.32)	(6.23)	(4.28)	(6.33)	(6.29)	(4.52)
FICO Score	0.000***	0.000***	0.000***	0.012***	0.011***	0.013***	0.012***	0.010***	0.014***
	(3.24)	(2.75)	(3.79)	(3.75)	(3.10)	(3.15)	(3.73)	(2.97)	(3.38)
Loan-to-Value Ratio	-0.001	-0.001	-0.000	-0.049	-0.047	-0.063	-0.048*	-0.048	-0.049
	(-1.54)	(-1.41)	(-0.77)	(-1.59)	(-1.39)	(-1.52)	(-1.74)	(-1.58)	(-1.17)
Loan-to-Value=80	0.003	0.003	0.003	0.319	0.350	0.431	0.373	0.370	0.585
	(0.98)	(1.02)	(0.82)	(1.17)	(1.23)	(0.85)	(1.37)	(1.30)	(1.15)
Combined Loan-to-Value	0.001*	0.001	0.000	0.065***	0.056**	-0.002	0.063***	0.056**	-0.007
	(1.84)	(1.56)	(0.41)	(2.61)	(2.14)	(-0.07)	(2.79)	(2.32)	(-0.23)
Updated Loan-to-Value	0.000	0.000	-0.000	0.007	0.005	0.025**	0.006	0.004	0.013
	(0.62)	(0.62)	(-0.48)	(1.13)	(0.64)	(2.48)	(1.05)	(0.59)	(1.39)
# Borrowers=1	0.003	0.002	-0.003	0.204	0.076	-0.048	0.226	0.103	-0.160
	(1.30)	(0.85)	(-1.25)	(0.67)	(0.24)	(-0.11)	(0.75)	(0.32)	(-0.39)
Debt-to-Income Ratio	-0.000**	-0.000**	-0.000**	-0.032**	-0.029**	-0.057***	-0.034**	-0.029**	-0.054***
	(-2.43)	(-2.09)	(-2.37)	(-2.32)	(-1.98)	(-2.87)	(-2.51)	(-2.04)	(-2.65)
GDP Growth		0.124	0.053		12.141	3.160		13.065	3.825
		(1.63)	(0.90)		(1.09)	(0.34)		(1.18)	(0.47)
Unemployment		-0.000	0.000		-0.022	-0.089		-0.006	-0.048
		(-0.55)	(0.37)		(-0.22)	(-0.79)		(-0.06)	(-0.42)
HPI index by MSA		-0.000	-0.000		-0.007	0.002		-0.007	-0.002
		(-1.44)	(-0.92)		(-1.35)	(0.36)		(-1.37)	(-0.22)
30-Year Mortgage Rate		-0.005	-0.028***		-0.599	-1.189		-0.627	-1.251
		(-1.00)	(-4.88)		(-1.10)	(-1.07)		(-1.12)	(-1.55)
10-Year Tbill Rate		0.002	-0.011***		0.114	0.144		0.132	0.151
		(0.82)	(-3.76)		(0.37)	(0.30)		(0.43)	(0.36)
Log (Unpaid Principal Balance)			-0.005			0.272			0.030
			(-1.48)			(0.48)			(0.06)
Loan Age			-0.006***			-0.133***			-0.071***
			(-9.60)			(-5.02)			(-5.67)

Loan Purpose-Cash out			0.015***			1.798***			1.854***
			(3.56)			(3.84)			(4.17)
Loan Purpose-No Cash out			0.006*			0.843			0.940*
			(1.80)			(1.39)			(1.68)
Original Rate-Current Rate			0.021***			0.321***			0.778***
			(6.98)			(3.64)			(9.85)
Original Rate - 30yr Mortgage Rate			0.000			0.265			-0.261
			(0.11)			(0.48)			(-0.65)
Mortgage Insurance %			-0.000			-0.016			-0.002
			(-0.85)			(-0.51)			(-0.09)
Condo			-0.003			0.033			0.053
			(-0.64)			(0.04)			(0.07)
Channel=Correspondent			-0.006			0.338			-0.616
			(-0.91)			(0.31)			(-0.67)
Number of Units			0.001			-3.687***			-0.958
			(0.41)			(-3.13)			(-1.30)
Nonrecourse State			-0.001			-0.090			-0.048
			(-0.32)			(-0.18)			(-0.10)
# Foreclosure Process Days			-0.000***			-0.007**			-0.011***
			(-3.90)			(-2.07)			(-2.68)
Intercept	-0.190***	-0.172***	-0.253***	-13.911***	-10.293**	2.032	-12.635***	-9.258**	1.129
	(-3.57)	(-2.76)	(-3.66)	(-4.54)	(-2.45)	(0.20)	(-4.27)	(-2.19)	(0.12)
Observations	31,225	30,625	30,491	31,011	30,442	30,316	31,225	30,625	30,491
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Orig Year FE	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
State FE	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$