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ABSTRACT

Essays on Financial Intermediation

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This dissertation contains three chapters. In Chapter 1, I study the effects of bank leverage ratio restrictions in a general equilibrium model of the macroeconomy where lenders can anticipate bank runs. This framework allows the analysis of the tradeoffs associated with bank capital requirements - while unlimited leverage allows capital to flow most freely to its most efficient users, limiting leverage through capital requirements reduces the probability of a bank run. This model enables me to study the general equilibrium effects of these tradeoffs on household welfare to understand characteristics of the optimal bank leverage ratio requirement. I find that the optimal leverage restriction will be time varying across the business cycle. When the household's marginal utility of consumption is highest, the leverage ratio requirement should be the least restrictive. Conversely, when the household's marginal utility approaches its steady state level, the optimal leverage ratio becomes more restrictive.

In Chapter 2, I explore how strengthening creditor rights on collateral used in large short-term funding markets, known as the sale and repurchase markets (the "repo" markets), both generates a credit supply shock and deteriorates the quality of the assets underlying the collateral. I study a policy change in 2005 that strengthened creditor rights on mortgage-backed repo collateral. I present evidence that these stronger creditor rights relaxed large securities dealers' cost of funding. To study how dealers passed the resulting increased supply of credit on to the mortgage companies that they funded, I hand-collect data on credit lines linking dealers to mortgage companies. Using an across dealer, within mortgage company difference-in-differences analysis, I find that in response to the policy change, dealers increased their funding to mortgage companies. I also find evidence that dealers systematically relaxed restrictions on the mortgage products that they funded.

In Chapter 3, I use a county-level difference-in-differences analysis to estimate that the expansion in credit led to a 9% increase in mortgage lending volume and increased originations of the riskiest mortgage products. I estimate that mortgages originated in response to the policy change made up 38% of mortgage defaults among all mortgages originated during 2005-2006. This chapter provides evidence that the increase in dealer funding to mortgage companies post shock amplified both the "last gasp" of the housing boom and the severity of the home price decline in the Financial Crisis.

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CHAPTER 1

The Real Effects of Capping Bank Leverage

1.1 Introduction

After the financial crisis, bank regulation was put in place to increase stability in the financial sector. In 2010 and 2011 the Basel Committee on Banking Supervision (BCBS) agreed upon the reforms, including a leverage ratio requirement for financial institutions, to be introduced in 2013 in the Third Basel Accord (Basel III).[1] Basel III scheduled a phase in of these leverage requirements, which would reach 4.5% common equity to risk weighted assets in 2015. In July 2013 the U.S. Federal Reserve, Federal Deposit Insurance Corp. (FDIC), and the Office of the Comptroller of the Currency proposed a leverage ratio cap for 8 globally systemically important banks of 6% and 5% for their insured bank holding companies, with additional surcharges to be phased in. [2,3] However the question remains what will be the effects of these leverage caps on the real economy?

In this paper, I study whether leverage ratio restrictions can balance the trade-off between increased stability in the banking sector and allocational efficiency losses in a welfare improving way. The model takes a stance on interpreting systemic risk in the economy as an economy wide run on the banking sector. I add an exogenous leverage

[1]Press Release, Basel Committee on Banking Supervision, Group of Governors and Heads of Supervision announces higher global minimum capital standards (Sept. 12, 2010), http://www.bis.org/press/p100912.pdf.

[2]Evan Weinberger, "Leverage Cap Leaves Big Banks with Unpalatable Choices," Law360, Jul. 9, 2013.

[3]Fed and FDIC agree 6% leverage ratio for US Sifis, Central Banking Newsdesk, Jul. 10, 2013.

restriction to an infinite horizon general equilibrium model of the macroeconomy with a banking sector and I study the effects generated by these leverage caps. The banks in the economy need to be highly levered following a crisis in order to buy back their efficient level of capital holdings, however the probability of a bank run is increasing in bank leverage. Bank crises occur endogenously in the model in the form of an economy wide run on the banking sector. Immediately following a crisis, returns on bank assets are high. These high returns loosen the banks' collateral constraint and allow them to take on very high leverage. The probability of a bank run occurring in the model is an increasing function of bank leverage as long as bank assets in a bank run are not sufficient to cover its liabilities. Thus it is during these high leverage periods immediately after a crisis, where the economy is most fragile and susceptible to another crisis. This model is a multiple equilibria model and I follow (25), in analyzing the equilibrium where the probability of a bank run depends on the amount of leverage in the economy. The banks in this model do not sufficiently internalize the effect of their choice of leverage on the probability of an economy wide bank run and therefore there is a role for leverage restrictions to improve welfare. It is natural to study the effects of leverage caps in a model where leverage is interpreted as the source of systemic risk in the economy.

In this multiple equilibria model, a bank run equilibrium can arise in part due to a liquidity mismatch in banking caused by the use of short-term liabilities to fund partially illiquid long-term assets, similar to (17). However, the inner workings of this model more closely resemble the technical features of the (14) model of a self-fulfilling sovereign debt crisis. This model studies a crisis like the Financial Crisis, which was a rollover crisis in the same vein as Cole and Kehoe's sovereign debt crisis. The banks in this model correspond to lightly regulated "shadow" banks or net borrowing banks in the unsecured interbank market. These banks were largely funded by short-term unsecured loans, which will correspond to deposits in this model. In the periods directly following an initial bank run, the price of capital is severely depressed and returns on capital are very high as the bankers, who are the efficient users of capital, recover their capital holdings. These high returns increase the bankers' incentive to operate honestly. The depositors understand that bankers have incentive to participate in the game and are therefore willing to increase their lending to banks. However, the probability of a bank run is very high when leverage is high.

The high probability of a bank run at the same time that depositors are eager to lend banks money seems counter intuitive, however this comes from the Cole and Kehoe rollover crisis aspect of the model. If all depositors roll over their deposits, the banks will have enough money to buy the capital, increasing the average efficiency of capital economy wide and driving up its price in the subsequent period. These returns loosen the banker's participation constraint and encourage households to lend to the bankers, since if bankers receive high returns for operating honestly, they will have little incentive to abscond with the deposits. However, if a sunspot occurs and all but one depositor fail to roll over their debt, not enough capital will be purchased by the efficient holders to raise the price to the high forecasted level that warranted the looser banker participation constraint. In this event, the bank franchise value will not be that promised under the scenario with full rollover of deposits and the bankers will prefer to runaway with any single households' deposits that may trickle in. Thus in the model, there is a probability each period that all households in the economy fail to roll over their deposits at the same time.

I add an exogenous leverage restriction to the banking sector and solve for the equilibrium recovery path following a bank run under a leverage cap regime. I then study the effects of the leverage cap on the recovery path the economy takes after a bank run, its implications for the real economy, and how relative levels of economic stability change from the laissez-faire regime with no exogenous leverage restrictions in place. I find that the optimal leverage restriction will be time varying across the business cycle. When the household's marginal utility of consumption is highest, the leverage ratio requirement should be the least restrictive, conversely, when the household's marginal utility approaches its steady state level, the leverage ratio requirement can be more restrictive. Excessively restricting bank leverage in the periods following a bank run decreases household utility relative to the laissez-faire system since banks are not able to buy back capital from the inefficient households as fast. This decreases production which decreases asset prices and tightens the banks' collateral constraint further, causing bank net worth to remain depressed relative to the laissez-faire system and a persistent decrease in the banks' ability to buy back capital. However a leverage restriction that is time varying and more lenient in the periods where households have a higher marginal utility of consumption offers a welfare improvement relative to the laissez-faire system.

Section 2 begins by outlining the model. In Section 2.4, I add a leverage ratio restriction to the model. Section 3 studies the results of the leverage restriction on the economy's recovery path following a bank run and household welfare implications. In Section 4, I discuss implications for stability of the economy when the economy is simulated for 10,000 periods. Section 5 concludes.

1.2 The Model

This is an infinite horizon model of the macroeconomy with a banking sector where I enhance the model of (25) to account for bank regulation in the form of leverage ratio restrictions. Each period, there are two possible states of the world: a bank run state and a no bank run state, and the bank runs are anticipated. There are two types of agents, households and bankers, each type of agent has a continuum of measure unity. The productive technology in the economy is $f(K_t) = ZK_t$. In the bank run state, all of the households run on the entire banking sector. I will focus on the case where if a bank run materializes, the banks do not have sufficient assets to cover their liabilities. This means that the households will receive a fraction of their original deposits and the price of capital during the bank run, Q^*, drops as banks sell their capital at fire sale prices to the inefficient households. These price changes for both deposits and capital affect the household's budget constraint.

This is a two good economy, there is capital, the durable good, and there is the consumption good which is a non-durable good. The paper abstracts from capital accumulation so here there is a fixed supply of capital each period and it does not depreciate:

$$K_t^b + K_t^h = 1$$

Both bankers and households have production functions (f^B and f^H respectively). Households require both capital and units of the consumption good inputs in order to produce more units of the consumption good. In other words, the households pay a cost in consumption goods for operating capital. I will suppose that this cost is a convex, increasing function their capital holdings:

$$f^H(K_t^h, f(K_t^h)) = ZK_t^h$$

Where I assume:

$$f(K_t^h) = \frac{\alpha}{2}(K_t^h)^2$$

K_t^h units of capital remain.

The bankers are the efficient users of capital, they only require capital good inputs in order to produce more units of the consumption good.

$$f^B(K_t^b) = ZK_t^b$$

K_t^b units of capital remain.

When households sell more capital to the banks, the amount of consumption goods in the economy increases since the banks are more efficient at producing capital. Therefore, in the absence of financial frictions, banks would intermediate all of the capital stock. However, when the banks are constrained in their ability to borrow funds to purchase the capital, the households will directly hold some of the capital. When the financial constraints tighten on the bank the households will be forced to hold an elevated supply of capital.

However lending to the bank is risky because there is a probability of an economy wide bank run each period. I study the economy in which the probability of a bank run depends on the amount of leverage that the banks have. The probability of a bank run p_t impacts the price of both capital and deposits. It also affects the banker's value function, which is calculated as the banker's return from operating honestly each period in the future given that there is no bank run. When a bank run occurs, banks are liquidated and due to borrowing constraints, once they have zero net worth, they will never be able to take deposits again.

1.2.1 Households

The households both consume and save. The households can save either by lending funds to the competitive financial institutions, the banks, or by holding the capital directly. Every period, households receive a return on their asset holdings as well as an endowment of the consumption good, ZW^h. This setup allows the household endowment to vary proportionally with the aggregate productivity Z.

Deposits held by the banks are one period bonds. In the no bank run state, these bonds yield a non-contingent rate of return R_t. However, in the bank run state, these assets receive only a fraction x_{t+1} of the promised return. Where x_{t+1} is the total liquidation value of bank asset per unit of promised deposit. So that, the household's return on deposits can be expressed as:

$$R_t = \begin{cases} \bar{R}_t & \text{if no bank run,} \\ \\ x_{t+1}\bar{R}_t & \text{if bank run occurs} \end{cases}$$

where $0 \leq x_t < 1$. In the run state, all depositors receive the same pro rata share of liquidated assets. Unlike in Diamond and Dybvig, there is no sequential service constraint on depositor contract that links payoffs in the run state to depositors place in line.

Household utility U_t is given by:

$$U_t = E_t \left(\sum_{i=0}^{\infty} \beta^i \ln C_{t+i}^h \right)$$

Where C_t^h is household consumption, $0 < \beta < 1$, and Q_t is the market price of capital. The household chooses consumption, bank deposits D_t, and direct capital holdings K_t^h to maximize expected utility subject to the budget constraint:

$$C_t^h + D_t + Q_t K_t^h + f(K_t^h) = Z_t W^h + R_t D_{t-1} + (Z_t + Q_t) K_{t-1}^h + (1 - \sigma) N_t$$

Suppose that p_t is the probability that households assign to an economy wide bank run occurring at time $t+1$. (A discussion of how p_t is determined will follow.) Since the households anticipate that a bank run will occur with positive probability, the rate of return promised on deposits, R_{t+1}, must satisfy the household's first order condition for deposits:

$$1 = R_{t+1} E_t \left[(1 - p_t)\Lambda_{t,t+1} + p_t \Lambda^*_{t,t+1} x_{t+1} \right]$$

where $\Lambda^*_{t,t+1} = \beta \frac{C^h_t}{C^{h*}_{t+1}}$ is the household's intertemporal marginal rate of substitution conditional on a bank run at $t+1$. The depositor recovery rate, x_{t+1} in the event of a run depends on the rate of return promised on deposits R_{t+1}.

$$x_{t+1} = \min \left[1, \frac{(Q^*_{t+1} + Z_{t+1})k^b_t}{R_{t+1} d_t} \right]$$

In the spirit of the global games approach developed by Morris and Shin (1998) and applied to banks by Goldstein and Panzer (2005), I postulate a reduced form that relates the probability of a bank run, p_t, to the aggregate recovery rate x_{t+1}. In this way, the probability p_t of the "sunspot" bank run outcome depends in a natural way on the fundamental x_{t+1}. In general, the probability that depositors assign to a bank run occurring in the following period is a decreasing function of the recovery rate:

$$p_t = \begin{cases} g(E_t(x_{t+1})) \quad \text{with} \quad g'(\cdot) < 0 \\ 0 \qquad\qquad\qquad \text{if } E_t(x_{t+1}) = 1 \end{cases}$$

Where g follows the simple linear form:

$$g(\cdot) = 1 - E_t(x_{t+1})$$

Higher leverage chosen by banks today will decrease the recovery rate tomorrow, which increases the probability of a bank run occurring tomorrow. This increases R_{t+1}, the rate of return households require to hold assets from today until tomorrow. Therefore when the bank is choosing leverage to maximize its value function, the cost of deposits owed at $t+1$, R_{t+1}, will affect the bank's decision on how much leverage to take on. So banks internalize the impact that their choice of leverage has on p_t only indirectly through its affect on R_{t+1}.

1.2.2 Banks

Banks in this paper correspond to lightly regulated "shadow" banks or net borrowing banks in the unsecured interbank market. These banks hold long-term securities and issue short-term debt, which makes them vulnerable to bank runs. Each banker manages a financial intermediary. Bankers fund their capital investments by issuing deposits to households as well as by investing their own net worth, n_t.

Bankers may be constrained in their ability to borrow deposits and they will attempt to save their way out of the financial constraints by accumulating their retained earnings. To limit this possibility that bankers will try to move towards one hundred percent equity financing, bankers have a finite expected lifetime and each banker has an i.i.d. probability σ of surviving until the next period and a probability $1-\sigma$ of exiting at the end of the current period. The expected lifetime of a banker is then $\frac{1}{1-\sigma}$.

Each period, new bankers enter with an endowment w^b which is received only in their first period of life. The number of entering bankers is equal to the number who exit, keeping the total number of bankers constant. Bankers are risk neutral and they will rebate their entire net worth to the households in the period that they exit so that the expected utility of a continuing banker at the end of period t is given by:

$$V_t = E_t \left[\sum_{i=1}^{\infty} \beta^i (1-\sigma)\sigma^{i-1} \Pi_{t+i} n_{t+i} \right]$$

where $(1-\sigma)\sigma^{i-1}$ is the probability of a banker exiting at date $t+i$, n_{t+i} is the banker's terminal net worth upon exiting in period $t+i$, and Π_{t+i} is the households marginal utility of consumption in period $t+i$. The bankers take the households marginal utility of consumption a given.

Conditional on the productivity Z, the net worth of the "surviving" bankers is the gross return on assets net the cost of deposits. Banks can only increase net worth using their retained earnings. This friction is a reasonable approximation of banks in reality. In this paper however, I keep Z constant across time, an area for future analysis would be to explore the effects of shocking productivity Z.

$$n_{t+1} = (Z + Q_{t+1})\, k_t^b - R_{t+1} d_t$$

Exiting bankers no longer operate their banks and they rebate their net worth to the households in the period that they exit. Each period t, new and surviving bankers finance their asset holdings $Q_t k_t^b$ with newly issued deposits and net worth:

$$Q_t k_t^b = n_t + d_t$$

There is a limit to the amount of deposits that bankers can borrow in a given period. This constraint can be motivated by assuming that a moral hazard problem exists. In time t, after accepting the deposits, but still during the same period, the banker chooses whether to operate "honestly" or to divert the assets for his personal use. Operating honestly requires the banker to invest the deposits, wait until the next period, realize the returns on deposits and meet all deposit obligations. If the banker chooses to divert the assets, he will only be able to liquidate up to the fraction θ of the assets and he will only be able to do so slowly, in order to remain undetected. Therefore the banker must decide whether to divert at time t, before the resolution of uncertainty at time $t+1$. The cost of diverting assets is that the depositors are able to force the banker into bankruptcy in the next period. Therefore at time t, the bankers decide whether or not to divert the assets by comparing the franchise value of the financial intermediaries that they operate, V_t, to the potential gains from diverting funds $\theta_t \Pi_t Q_t k_t^b$. Where V_t is calculated as the present discounted value of the future payouts from operating the bank honestly every period. Any rational depositor will not lend deposits to a banker who has an incentive to divert funds. Therefore the following incentive constraint on the banker must hold.

$$\theta_t \Pi_t Q_t k_t^b \leq V_t$$

Given that bankers consume their net worth in the period that they exit, their franchise value can be restated recursively as the expected discounted value of the sum of their net worth conditional on exiting in the following period plus their franchise value conditional on continuing in the following period.

$$V_t = E_t\left[\beta(1-\sigma)\Pi_{t+1}n_{t+1} + \beta\sigma V_{t+1}\right]$$

So that the banker's optimization problem is to choose (k_t^b, d_t) each period to maximize the franchise value subject to the incentive constraint and the balance sheet constraints. As long as the return on bank capital is greater than banks cost of deposits, banks will have incentive to take on the maximum amount of leverage available to them.

$$\phi_t = \frac{\psi_t}{\Pi_t\theta}$$

Since both the banker objective function and constraints are constant returns to scale, the optimization problem can be reduced to choosing the leverage multiple, ϕ_t to maximize the bank's "Tobin's q ratio," $\frac{V_t}{n_t} \equiv \psi_t$.

1.2.3 Aggregation

Given that the leverage multiple ϕ_t is independent of individual bank-specific factors and given a parameterization where the banker incentive constraint is binding in equilibrium, then the banks can be aggregated to yield the following relationship between total assets held by the banking system and total net worth

$$\theta_t\Pi_t Q_t K_t^b = V_t.$$

The evolution of N_t is given by the sum of surviving and entering bankers as

$$N_{t+1} = \sigma\left[(Z + Q_{t+1})K_t^b - R_{t+1}D_t\right] + W^b.$$

Where $W^b = (1-\sigma)w^b$ is the total endowment across all entering bankers and the first term is the accumulated net worth of bankers that were operating at period t and survived until period $t+1$. Conversely, exiting bankers rebate the fraction $(1-\sigma)$ of accumulated net worth back to the households:

Total output Y_t is equal to the sum of output from capital Z, household endowment ZW^h, and W^b.

$$Y_t = Z + ZW^h + W^b$$

The output is either used to pay capital management costs or for household consumption:

$$Y_t = f(K_t^h) + C_t^h.$$

The household marginal utility of consumption can be defined

$$\Pi_t = \frac{1}{C_t^h}$$

1.2.4 Adding an Exogenous Leverage Constraint to the Model

I add an exogenous leverage restriction that is more restrictive than then endogenous leverage restriction which arises due to the agency problem that bankers face. I study the effects of this exogenous leverage restriction on the evolution of the economy in the model. Introducing the exogenous leverage restriction to the model adds an additional constraint to the banker's optimization problem. Now bankers must maximize their normalized value function subject to both their endogenous participation constraint as well as the exogenous leverage restriction.

$$\psi_t = \max_{\phi_t} \mathbb{E}_t \left\{ [\beta(1-\sigma)\Pi_t + \beta\sigma\psi_{t+1}] \frac{N_{t+1}}{N_t} \right\} \quad \text{s.t.}$$

$$\begin{aligned} \theta\Pi_t\phi_t &\leq \psi_t \\ \phi_t &\leq \bar{\phi}, \quad \text{for each } t \end{aligned}$$

Taking expectations over the probability that there is no bank run each period and given that the return on bank capital holdings is greater than the cost of deposits,

$$\frac{Z + Q_{t+1}}{Q_t} - R_t \geq 0$$

bankers maximize their value function by choosing the maximum amount of leverage so that, at the optimum, their value function can the which can be written

$$\psi_t = \min\left\{1, \frac{(Z+Q^*_{t+1})K^b_t}{(\min\{\frac{\psi_t}{\theta\Pi_t},\bar{\phi}\}-1)N_tR_t}\right\}\beta\left((1-\sigma)\Pi_t+\sigma\psi_{t+1}\right)\left[\min\{\frac{\psi_t}{\theta\Pi_t},\bar{\phi}\}\frac{(Z+Q_{t+1})}{Q_t}-(\min\{\frac{\psi_t}{\theta\Pi_t},\bar{\phi}\}-1)R_t\right]$$

Which means that optimal choice of leverage is no longer equal to $\phi_t = \frac{\psi}{\theta\Pi_t}$, it is now equal to the minimum of this value and the exogenous leverage restriction. Therefore, in order to determine leverage, I must first model the banker's value function in order to know which constraint will bind. The bankers' value function is:

$$V_t = \mathbb{E}_t\left\{\sum_{i=1}^{\infty}\beta^i(1-\sigma)\sigma^{i-1}\Pi_{t+i}N_{t+i}\right\}$$

Given the law of motion of n_t

$$n_{t+1} = n_t\left[\phi_t\frac{Z+Q_{t+1}}{Q_t}-(\phi_t-1)R_t\right] \quad \text{and}$$

$$n_{t+i} = n_t\prod_{a=1}^{i}\left[\phi_{t+a-1}\frac{Z+Q_{t+a}}{Q_{t+a-1}}-(\phi_{t+a-1}-1)R_{t+a-1})\right]$$

which means that in the aggregate, the banker's normalized value function can be written as

$$\begin{aligned}
\psi_t &= \frac{V_t}{N_t} \\
\psi_t &= \mathbb{E}_t \Bigg\{ \beta(1-\sigma)\Pi_{t+1} \left[\phi_t \frac{(Z+Q_{t+1})}{Q_t} - (\phi_t - 1)R_t \right] \\
&+ \ldots + \quad \beta^{\infty}(1-\sigma)\sigma^{\infty-1}\Pi_{t+\infty} \prod_{a=1}^{\infty} \left[\phi_{t+a-1} \frac{(Z+Q_{t+a})}{Q_{t+a-1}} - (\phi_{t+a-1} - 1)R_{t+a-1} \right] \Bigg\}
\end{aligned}$$

$$\phi_t = \min \left\{ \frac{\psi_t}{\theta \Pi_t}, \bar{\phi} \right\}$$

I solve for the path that the normalized value function follows to recover from a bank run numerically. Once I have the path for the banker's value function, I can determine the path for capped leverage as a function of the normalized value function.

1.3 Recovery Following a Bank Run in Economy under Leverage Cap Regime

1.3.1 Results for Multiple Period Leverage Cap

I study the effects of an exogenous leverage requirement that restricts the maximum amount of leverage that bankers can choose for all periods where banker total assets are greater than 15 times net worth in the uncapped laissez-faire regime. The leverage restriction requires that the amount of deposits banks take on be the minimum of either 90% of the optimal leverage chosen in the laissez-faire regime, or the maximum amount of leverage allowed by their incentive constraint. For this calibration of the model, the leverage cap ceases to bind after period 67 or 16.75 years and the economy reaches the steady state in 120 periods or 30 years. I chose to cap periods with bank leverage above15 times net worth because, taking the reciprocal, this corresponds to net worth equaling 6.67% of total assets. This number is slightly more conservative than the U.S. baseline requirement, proposed in July 2013 by the Federal Reserve Board, FDIC, and Office of the Comptroller of the Currency, that the country's systemically important banks maintain equity capital worth 6% of total assets to be considered well capitalized.

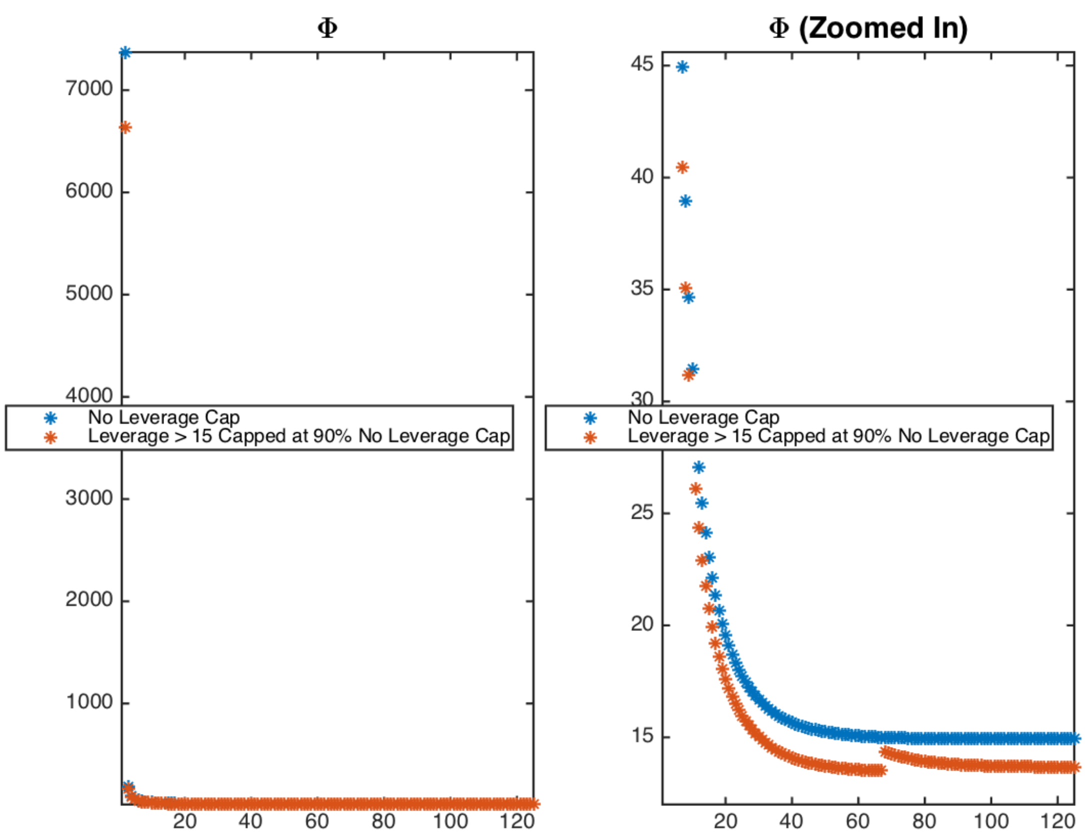

FIGURE 1.1. Leverage Φ_t with Multiple Period Leverage Cap

Figure 1 illustrates the recovery path that bank leverage in the economy, ϕ_t, follows both with and without the leverage restriction in place. The figure on the right hand side is a zoomed in version that omits the first periods directly following a bank run since these periods have enormous leverage. For all plots in this section, the x-axis denotes t or the number of periods since the last bank run. The first period, $t = 1$ is the period in which the bank run occurs and the plots illustrate the recovery path that the variable follows from the bank run period to the steady state value ($t = 125$). In the plots, I compare the path that the variables follow in the unrestricted model versus the path that they follow in the model with the same parameter values but with the leverage restriction in place. Each period, there is a probability p_t that a bank run occurs however the plots reflect the variable's trajectory in the case that no subsequent bank run occurs before the economy reaches steady state.

Figure 2 plots the path that the probability of a bank run, p_t, follows from the time of a bank run in period one to steady state. The probability of a bank run p_t decreases in the capped model relative to the uncapped model for the first 67 periods. As seen in the formula for p_t the drop in p_t relative to the unrestricted system in the first 66 periods is driven by the decrease in leverage ϕ_t.

$$p_t = 1 - \min \left\{ \frac{\overbrace{(Z_{t+1} + Q^*_{t+1})(1 - K^h_t)}^{\text{Recovery Rate, } x_{t+1}}}{(\phi_t - 1)N_t R_{t+1}}, 1 \right\}$$

There is a feedback loop at work via the recovery rate. The probability of a bank run is inversely related to the recovery rate x_{t+1}. The recovery rate depends not only on

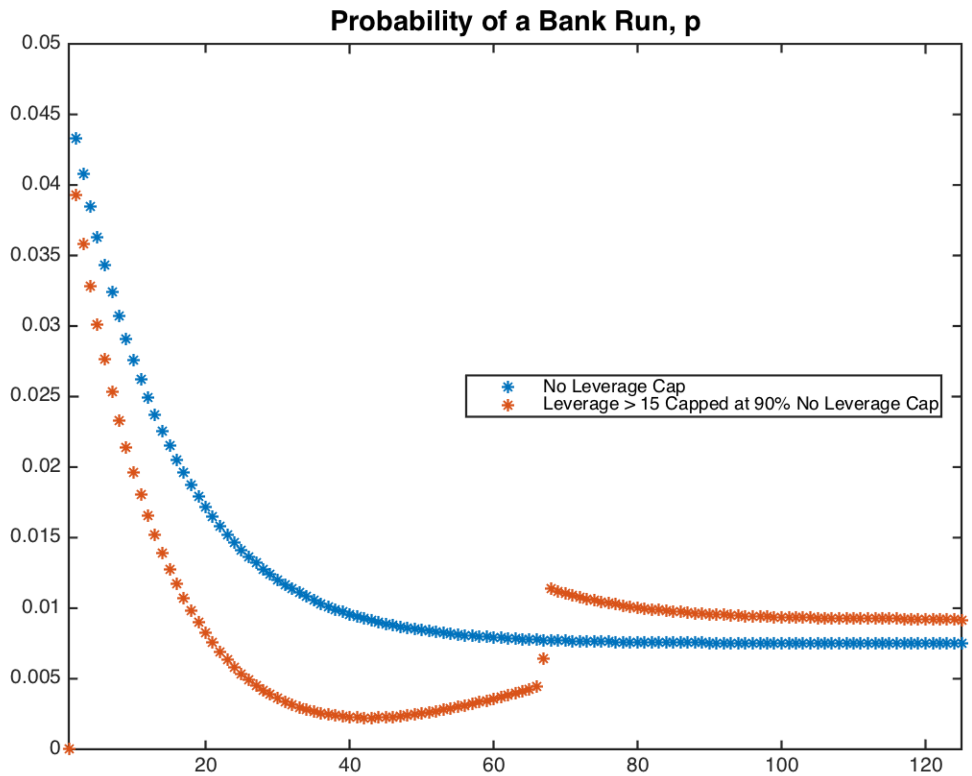

FIGURE 1.2. Probability of Bank Run p_t with Multiple Period Leverage Cap

leverage but also on the price that capital takes on in the bank run period Q^*_{t+1}. During periods of extremely high leverage following the bank run, the changes in the leverage ratio dominate the effect on p_t. However for periods where the leverage ratio is close to its steady state value, changes in the price of capital in a bank run dominate changes in p_t. However, it is by taking on more leverage that banks can purchase more capital and drive up the price of capital. Therefore forcing banks to take on lower leverage initially after a bank run can inadvertently depress the price of capital to the point that the probability of a bank run increases in the steady state.

The first term in the minimum operator is the recovery rate or the total value of bank assets in the bank run state divided by the total cost of deposits that a bank would owe in the bank run state. The recovery value is driven up as the leverage cap forces banks to take less deposits than households are willing to give them. This decreases the probability of a bank run initially, bringing it to a minimum of of 0.0022% in period 41 or about 10 years after the bank run, if the economy reaches that period without falling into another bank run. However, the probability of a bank run increases after the leverage cap stops binding because the cap causes irreparably low bank capital holdings while the cap was in place, which drive down the price of capital in the bank run state, Q_t^*, as well as the bank's current capital holdings relative to their steady state values in the lassez-faire system. Once the leverage cap ceases to bind, banks are able to increase their net worth due to relatively higher returns on capital when prices are depressed. However the depressed price of capital in the bank run state drives down the steady state probability of a bank run, p_t, tightening banker incentive constraints so that higher values of net worth do not translate into a higher franchise value. Bankers cannot restore their capital holdings to steady state levels because depositors are not willing to lend them enough in the form of deposits. The denominator of the recovery value decreases as the steady state value of leverage decreases, however banks in steady state are slightly larger which offsets the decrease in leverage. The numerator of the recovery value falls by more due to the decrease in Q_t^* and bank capital holdings than the denominator does with a simultaneous fall in ϕ_t and rise in N_t.

Return on deposits stays relatively similar between the uncapped and capped systems. For the first 6 periods after the bank run, the return on deposits in the capped system

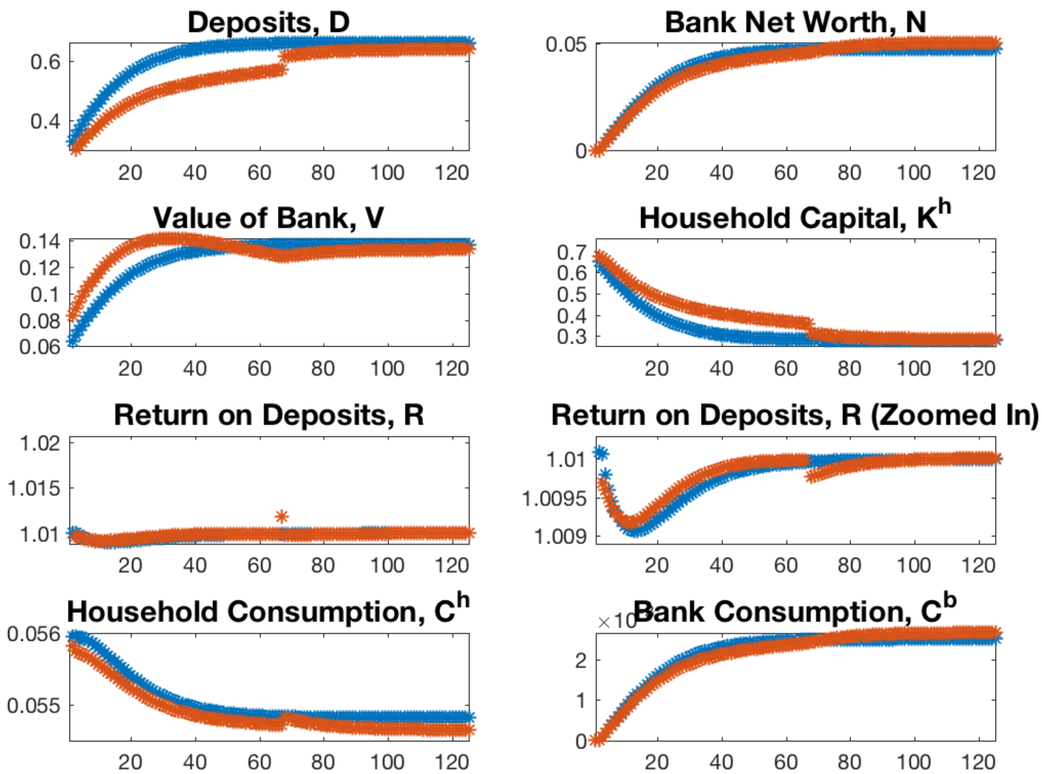

FIGURE 1.3. Recovery Path for Variables after a Bank Run with and without Multiple Period Leverage Cap (Blue stars indicate: No Leverage Cap while Red stars indicate: Leverage > 15 Capped at 90% No Leverage Cap)

is lower than in the uncapped system by maximum of 0.0013 or 0.129% in the period directly following the bank run and then by about 0.000037 or 0.004% for the next 5 periods. After that, it fluctuates between very slight increases and decreases that seem to offset each other, other than a jump in the period where the leverage cap stops binding. This jump is caused by high capital returns as well as a relative increase in the probability of a bank run as banks take on a discontinuous amount of leverage.

The banker net worth N_t is mechanically equal to zero in the period after the bank run and equal to the banker's endowment in the second period in both systems since all existing banks are liquidated in the period that the bank run occurs and banks in the period following the bank run enter with net worth equal only to their endowment. From periods 2 to 67, banks have a smaller net worth in the capped system by on average 0.0023 over this time period. Once the leverage cap stops binding, banks in the capped system begin increasing their net worth relative to the uncapped system and have a net worth that is greater than the capped system by 0.0029 in the steady state.

When the leverage is capped, bankers are not allowed to take on as many deposits as the households are willing to give to them based on their participation constraint. Since bankers are financially constrained, the households must directly hold the capital themselves. This leads to households holding more capital in the capped model than they do in the uncapped model over the entire recovery path of the economy. From periods 1 to 67 households hold on average 0.0835 units, or 22% of the average in the Laissez-faire system, more capital in the capped system than they do in the uncapped system. From periods 68 to 120, they hold on average 0.0107 more units, or 3.8% of the average, of capital and in steady state, they hold 0.0042 units or 1.5% more capital.

The household's first order condition in part helps determine the price of capital, Q_t, when the household is holding any units of capital.

$$1 = E_t \left[(1 - p_t)\beta\Lambda \frac{Z_{t+1} + Q_{t+1}}{Q_t + f'(K_t^h)} + p_t\beta\Lambda^* \frac{Z_{t+1} + Q_{t+1}^*}{Q_t + f'(K_t^h)} \right]$$

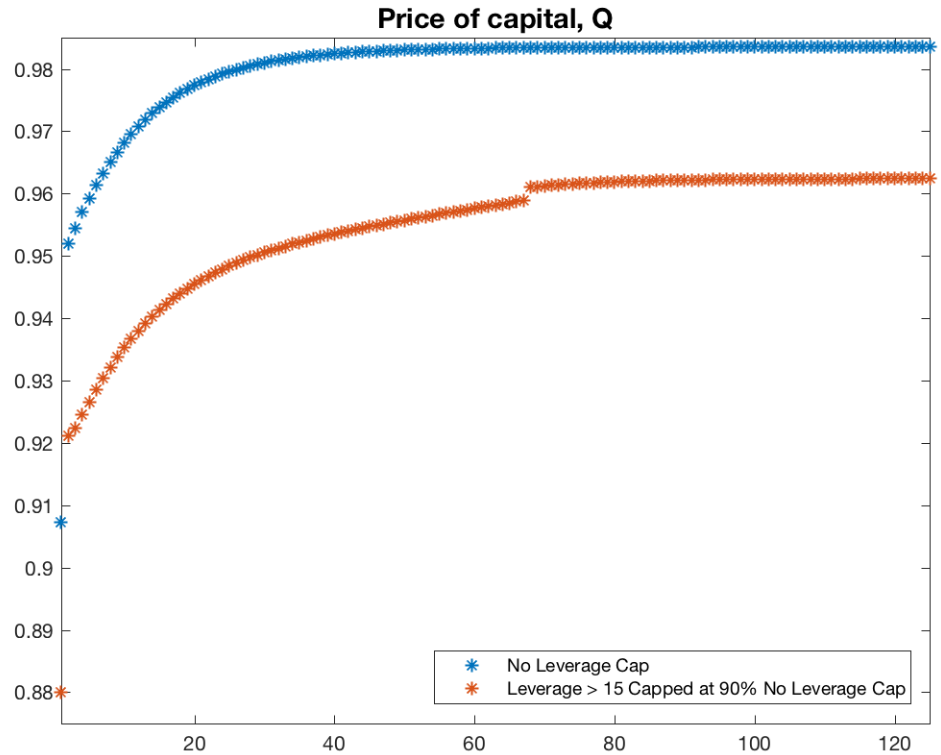

FIGURE 1.4. Price of Capital Q_t with and without Multiple Period Leverage Cap

Where $\Lambda^* = \frac{C_t^h}{C_{+1}^{h*}}$ is the household's intertemporal marginal rate of substitution conditional on a bank run occurring at time $t+1$ and $f'(K_t^h) = \alpha K_t^h$. The market price of capital tends to be decreasing in household capital, K_t^h holdings since the household's management cost for operating capital is increasing in household capital holdings.

As seen in Figure 4, relative to the system with no leverage cap, the price of capital Q_t is depressed along the economy's entire recovery path after a bank run and remains depressed in steady state. In the system with capped leverage, the price of capital during a bank run is depressed to 0.8800, a decrease of 3% from its laissez fair value of 0.9072.

While the leverage cap is in place, from periods 2 through 67, the price of capital is depressed by 3% on average. After the cap is no longer binding, the price of capital remains depressed by 2% on average and stays depressed by 2% in the steady state.

This is because in the bank run period, all banks are liquidated so that their net worth drops to zero. Once a bank has zero net worth, the assumed financial friction that banks can only increase net worth through retained earnings implies that it will never have non-zero net worth at any time in the future. Therefore, in the period following the bank run, only the bankers that enter in that period will have non-zero net worth. These banks are lucky to be born at this time. They enter the economy at a time when the households hold all of the capital in the economy, since households have a convex and increasing management cost associated with operating the capital, this means that the households' management costs are at their maximum. In the laissez-faire regime, the entering bankers are therefore able to extract the total surplus from their advantage in operational efficiency in the form of the maximum returns on bank capital possible. These high returns increase the bankers' value functions, loosening their participation constraints because the households are willing to lend them a lot of money to take advantage of these high returns. These very highly levered periods following a bank run are crucial to allow bankers to purchase as much capital as possible.

Capping leverage in one period decreases the amount of capital that banks are able to purchase from the households. Therefore the households hold relatively more capital and have higher management costs than in the uncapped system. Since households demand similar returns to the uncapped system, the current price of capital decreases as $f'(K_t^h)$ in their first order condition rises. This mechanism causes returns to fall for the first two

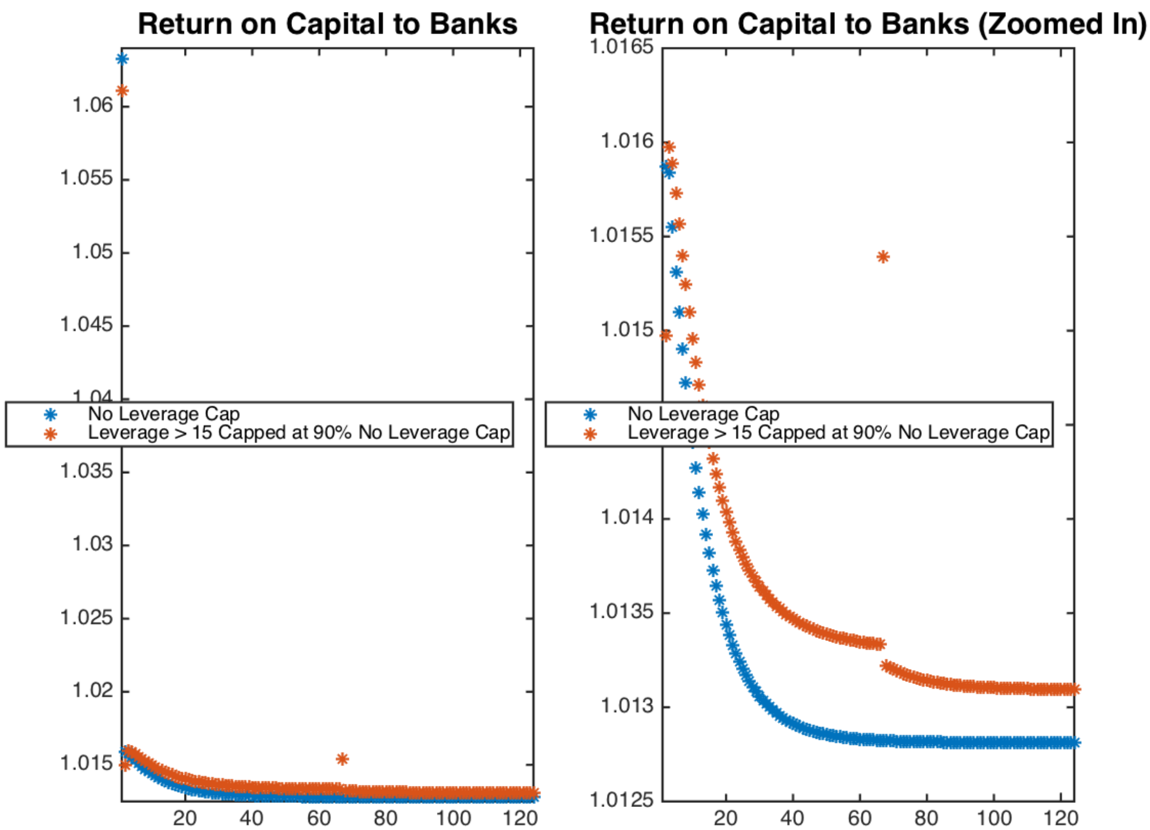

FIGURE 1.5. Return on Bank Assets after a Bank Run with and without Multiple Period Leverage Cap

periods after a bank run relative to the uncapped model since the price at which entering bankers purchase the capital in the period following the bank run is the same in both models. However beginning in the fourth period, the period returns in the capped system begin to surpass those in the uncapped system. This is because of the convex management costs that households shoulder as they operate more capital. As the leverage cap regime bears on, each period the banks are able to purchase less capital from the households, leaving households to operate incrementally more capital each period than they would in the lassez-faire system. The difference in returns between the capped and uncapped system in Figure 5 reflect the convexity of the management cost. Since the households hold more capital in the capped model than they would in the uncapped model, prices are depressed and the bankers in the capped system are able to purchase the capital at a lower price and extract rents from their advantage in operating efficiency for longer than they would be able to in the uncapped model.

Once the leverage cap ceases to bind, the banks take on the maximum amount of leverage that their participation constraint allows. As soon as the leverage cap ceases to bind, banks begin to take on the maximum leverage that the depositors are willing to give them. This causes bank returns to jump discontinuously as the banks buy capital for relatively cheap and drive the price of Q_t up discontinuously in this period. This coupled with returns, elevated from uncapped levels, drives up bank net worth. However the increase in net worth relative to the uncapped level does not translate into higher capital holdings by the banks because the higher net worth and depressed price of capital in a bank run state decrease the recovery value, increasing p_t. This increase in p_t decreases the banker value value function and tightened banker participation constraints relative to the uncapped model. Therefore, even though the banks are slightly bigger, they cannot take on enough leverage to buy as much capital from the inefficient households as in model with no leverage caps.

The banker's value function is the sum of all future consumption discounted by the banker's discount rate as well as the probability that the banker reaches a given period. Wrapped into this probability that a banker reaches a given period is the probability that there is no bank run in that given period. In steady state, the banker net worth under the leverage cap increases slightly (which increases banker consumption which is equal to the net worth of the fraction of bankers that exit the economy each period). However the probability of a bank run is increasing as the depressed Q_t^* and bank capital holdings begin to dominate the effect of decreased leverage and higher net worth in the recovery rate x_{t+1}. The increase in p_t increases the discount rate on future values of banker consumption, lowering the bankers value function, tightening the participation constraint and decreasing the amount of deposits that households will lend them. Therefore, even though banker net worth is increasing, the simultaneous decrease in leverage relative to the uncapped system makes the banks unable to purchase as much capital as they can in the uncapped system. This results in households operating elevated levels of capital which directly leads to decreased capital prices throughout the entire recovery path that the economy follows after a bank run. These results seem to imply the leverage cap introduces a wedge in the economy that allow steady state banks to be bigger and generate higher returns. However because banks in the capped system never acquire as much leverage as in the uncapped system, they cannot purchase the lassez-faire value of capital. The wedge therefore forces the inefficient households to operate elevated levels of capital and allows the efficient banks to extract higher operating rents from them each period.

1.3.2 Welfare Implications of Leverage Restrictions

In this section, I present different types of leverage restrictions and their resulting affects on household utility from the model solved numerically for illustrative purposes. Two factors drive changes in the household's lifetime expected continuation utility. The first is increased consumption which is increasing in economic productivity so that all else equal, the inefficient households will consume more when the productive bankers operate more of the capital. The second factor driving household utility is the probability of a costly bank run, since if a bank run occurs, the household will be plunged into periods of low consumption.

In the first trio of plots, I present leverage restrictions in the second period (t=2) only. This is the first period after a bank run occurs, since every time a bank run occurs, the economy restarts along its recovery path in period 1 (t=1). The first plot in the series of 3 plots represents a lenient leverage restriction. Leverage is restricted in period 2 only and it is restricted to be at a maximum, 99.99% of the value of leverage that bankers in the unrestricted system, the laissez-faire system, would choose. In a crisis period, all banks are cleared out of deposits and have a net worth equal to zero so that they can never borrow again. Therefore, in period 2 the net worth in the banking sector is very small, since the only banks in the economy with non-zero net worth are the entering banks. Concurrently at this time, the price of capital is severely depressed at its fire sale value. This implies that the return on capital will be at its largest at this time. The small net worth in the banking sector coupled with the large returns on capital allow banks to take on extreme leverage in the periods following a crisis period. This high leverage is necessary because it allows the banks to buy back capital from the inefficient households faster and improve production in the economy. In the trio of figures, the first two plots illustrate a leverage restriction of 99.99% in the second period only. Under this lenient leverage restriction, the household's lifetime expected continuation utility is higher under the leverage cap regime than it is under the no leverage cap regime at every period.

If I make the leverage cap in period 2 even slightly more restrictive and do not restrict leverage in any future period, the household lifetime expected continuation utility falls below the value in the laissez-faire system at every period. This implies that high bank leverage following a crisis is necessary in order to eliminate the largest amount of deadweight losses which are incurred when households are operating all of the capital stock. Further, the initial increase in economic productivity between periods one and two is necessary to set the economy on a higher growth path. Restricting bank leverage too much following a financial crisis can keep capital prices depressed too low for too long and lead to persistently lower household utility.

Conversely, the second plot presents the household's lifetime expected continuation utility under leverage restrictions in the long run states only, relative to the household's utility in the world with no exogenous leverage restriction in place. If I restrict bank leverage only in the long run states, the household utility increases above its Laissez-Faire value. The plot shows a leverage restriction of 99.99% of the steady state leverage value in the Laissez-Faire model in five states prior to the steady state. This implies that the benefit of decreasing the probability of a costly bank run in the long run states more than compensates for constraining the productive bank's ability to buy capital. In sum, these results provide evidence in favor of more lenient bank leverage ratio restrictions in periods during an economic downturn when household's marginal utility of consumption is highest and stricter during periods where household's marginal utility of consumption is relatively lower.

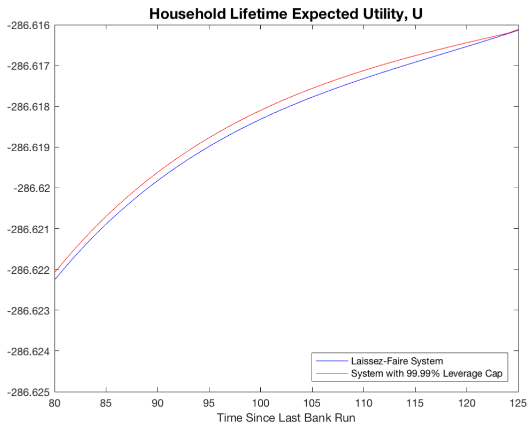

FIGURE 1.6. Household Utility with 99.99% Leverage Cap in Period 2 Only

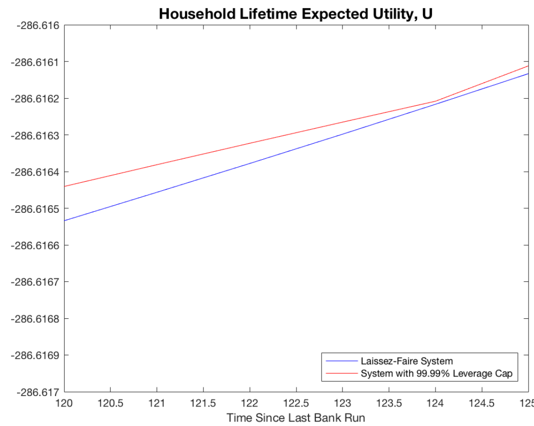

FIGURE 1.7. Household Utility with 99.99% Leverage Cap in Period 2 Only (Zoomed In)

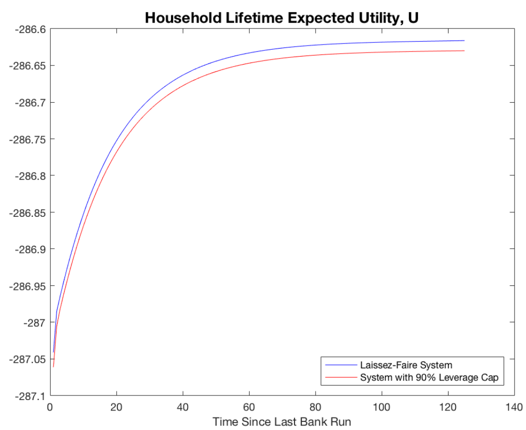

FIGURE 1.8. Household Utility with 90% Leverage Cap in Period 2 Only

1.4 Implications of Leverage Cap for Simulated Economy

I simulate the economy under both the leverage cap regime in section 3.1 and the uncapped regime for 10,000 periods. The economies both begin in the period following a bank run and are allowed to evolve according to their recovery paths solved for above.

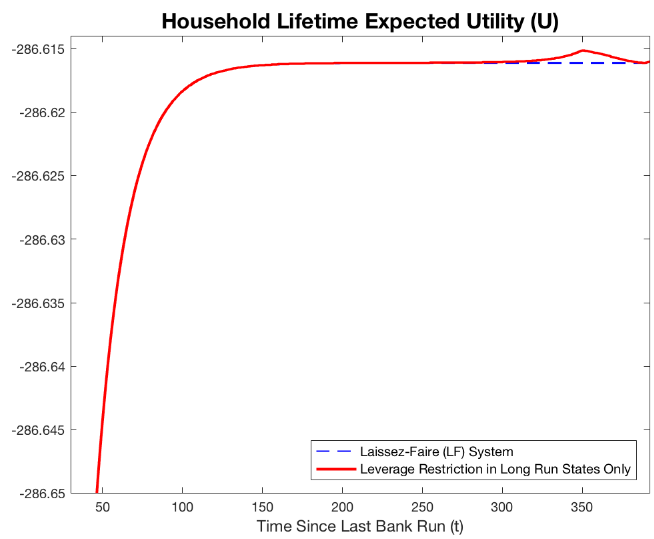

FIGURE 1.9. Household Utility with 99.99% Leverage Cap in the Long Run States Only

Each period, they are subject to a potential run on the banking sector which occurs with probability p_t. Regardless of what period the economy had reached before the bank run, if the economy falls into another bank run, it will need to start at the beginning of its recovery path and begin working sequentially toward its steady state again. Each period, I draw a random number distributed on the unit interval. The stochastic simulation begins at period 1, the period when the bank run occurs. Before the system may evolve to period 2, I first draw a random number. If the number drawn is less than p_2, then the economy is thrown back into a bank run. If not, the economy is allowed to progress to period 2 and I repeat the process, this time checking whether the random number drawn is less than p_3 before allowing the economy to advance to period 3, and so on. In the model, given the banks lose all of their net worth if a bank run occurs, their net worth in period one equals zero. Their participation constraint implies that banks in period one will not be able to take on any deposits given that their net worth is equal to zero, so the probability of a bank run occurring in period two is equal to zero. However, in period three and every future period, there is a positive probability of a bank run occurring. Intuitively, each period with probability $1 - p_t$, the economy evolves along the recovery path plotted in the figures above and with probability p_t a bank run occurs and throws the economy back into period one. p_t is decreasing as the economy moves further away from the bank run in period one. Therefore the economy is the most fragile during the periods immediately following a bank run and may suffer several bank runs that happen in rapid succession and prolong its recovery process after an initial crisis.

After simulating both the economy with a leverage cap in place and the economy with no exogenous leverage cap, I calculate the average number of periods between bank runs, the average number of periods that the economy stays in steady state once it has reached steady state, and the average number of periods that the economy takes to return to steady state after suffering a bank run. I find that on average, a bank run occurs nearly every 81.3 periods or 20.3 years in the uncapped model and nearly every 109.9 periods or 27.5 years in the capped model. The system reaches the steady state about 44.2 periods or 11 years faster when the leverage cap is in place. The longer amount of time between bank runs and the ability for the economy to reach the steady state faster under a leverage cap regime are due to the decreased probability of a bank run, p_t, while the leverage cap binds in the economy with a leverage cap in place. Conditional on reaching steady state however, the system with the leverage cap regime falls out of the steady state into a bank run on average 1.3 years or 5.2 periods earlier than it would without a leverage cap in place. This is due to the fact that p_t is driven up by the decreased price of capital in the bank run state caused by allocational efficiency losses that result from capping bank leverage in the periods directly following a bank run. These preliminary results provide evidence supporting a leverage cap's ability to stabilize the economy. However the results also imply that there could be allocational efficiency losses that increase the risk in the economy if bank leverage is too harshly restricted directly following a bank run as this can permanently slow the economy's ability to recover from a crisis.

Table 1.1. Average Recovery Times in Economy Simulated for 10,000 Periods (Multiple Period Leverage Cap)

Average Number of Periods	No Leverage Cap	Leverage Cap
Between Bank Runs	81.3	109.9
To Reach SS	318.1	273.9
In SS (Conditional on Reaching)	87.1	82.0

1.5 Conclusion

In this paper I enhance the Gertler Kiyotaki (2015) model to account for bank regulation in the form of leverage ratio restrictions. This is a macroeconomic model with a banking sector where bank runs can be anticipated. This model integrates two approaches to modeling vulnerabilities in the financial sector - a "macroeconomic" approach stressing the financial accelerator effects and a "microeconomic" approach which stresses the bank liquidity mismatch making banks vulnerable to bank runs. I provide a quantitative method for analyzing welfare effects of bank leverage ratio restrictions over the business cycle in a general equilibrium framework.

For all periods where banks take on leverage greater than fifteen times larger than their net worth in the model with no external leverage cap, I restrict the maximum amount of leverage that the banks are able to choose in the system with leverage restrictions in place. While the leverage cap binds, banks can choose leverage to be the minimum of 90% of the amount of leverage that they would optimally choose in the unrestricted system, or the maximum leverage implied by their incentive constraint. In the system with this leverage cap in place, I find that the banking sector becomes less risky, with the probability of a bank run decreasing by 49.8% at its maximum decrease relative to the economy with no exogenous leverage restriction. This point occurs about 5 years after a bank run if the economy can make it that far without falling into another bank run. The probability of a bank run under the leverage cap falls to 0.22% at its lowest point, which occurs 10 years after the bank run again if the economy can reach that point without falling into another bank run. I then simulate the economy for 10,000 periods to calculate the average differences between the systems with and without leverage restrictions in place in the amount of time an economy enjoys between bank runs, the amount of time it takes to return to steady state after a bank run, and the amount of time that the economy spends in steady state following a bank run. On average, the fall in the probability of a bank run along the recovery path while the leverage restriction holds translates into a longer amount of time between bank runs and fewer periods required to reach steady state. These results depend on my parameterization of the model. I am planning to calibrate the model to the data in order to provide economically relevant estimates.

I find that a leverage cap can be welfare improving relative to the laissez-faire system. However this depends on the way that the leverage restriction is structured. During the periods following a bank run, the economy is at a greater risk of suffering another bank run so there may be temptation to harshly restrict bank leverage. However high bank leverage during these times is necessary to increase allocational efficiency of the economy and restricting it too harshly can permanently lower production in the economy. This inhibits the banks' ability to grow their net worth which can make banks in the future riskier since they have a lower baseline net worth. However a very slight leverage restriction during these fragile periods can be welfare improving. In the steady state however, the system can sustain stricter leverage ratio restrictions. At the steady state, banks have already purchased almost all of the capital back from the households. Therefore the effects of bank leverage restrictions on increasing the deadweight loss associated with increased household capital holdings are minimal at the margin and the benefits achieved by lowering the probability of a bank run more than offset the allocational efficiency losses. This evidence indicates that the optimal leverage restriction will be time varying across the business cycle and will be looser in the states where households have a higher marginal utility of consumption.

CHAPTER 2

The Effect of Dealer Leverage on Mortgage Quality

2.1 Introduction

The 2007-2008 Global Financial Crisis is considered the most severe financial crisis since the Great Depression. Several factors contributed to the severity of the Financial Crisis, including lax mortgage lending ((35), (29), (7)); increased mortgage securitization ((38)); rating agencies' failure to evaluate the risk underlying securities ((10)); and an increased reliance on short-term debt ((21), (5), (24)). The supply of credit, or access to finance, was at the nexus of all of these factors - both during the boom and the bust ((11)). The market for repurchase agreements ("repos") - short-term loans collateralized with financial securities - played a central role in the supply of credit underlying the financial system. In this paper, I analyze an under-studied mechanism that allowed the largest securities dealers to lever themselves in the repo market. I find that this increased ability of dealers to leverage themselves increased the risk profile of the mortgage assets that they invested in - contributing to both the "last gasp" in the housing boom and its bust.

We do not have a clear understanding of the mechanism underlying the expansion of credit prior to the crisis and its link to the contraction of credit in the repo markets during the crisis. A major limitation in the literature has been the lack of data on an important segment of the repo markets. (34),(2), and(3) propose that there was a bank run in the repo market based on pricing data. However, (31) present evidence that only a small fraction of total outstanding private-label asset-backed securities was exposed to this run. My work helps to explain how a relatively small contraction in the repo market overall disproportionately affected highly-levered systemically important institutions, amplifying the contraction.

I hand collect novel micro-level data that allows me to identify transactions between dealers and mortgage companies between 2004Q3 and 2006Q3. Mortgage companies depended on the sale of mortgages to fund themselves. While they waited to sell mortgages that they had originated, they packaged the mortgages into *warehouse* facilities and posted these warehoused loans as collateral to receive funding. My data probes deeper into their funding during this warehouse phase. I collect data on the funding lines for twelve of the largest public independent mortgage companies. Prior to this paper, there has been no direct evidence of who the funders to the mortgage companies were or how they operated. I provide new evidence that mortgage companies posted their warehouse loans to receive warehouse lines of credit in the bilateral repo market and that the 27 largest dealer banks provided this funding. Although the amount of private mortgage collateral exposed to a run in the repo market was small relative to the total outstanding value of private mortgage collateral, I establish that the exposed collateral was concentrated among the most centralized dealer-banks. These dealers were crucial for the funding to independent mortgage companies, which made up close to one third of the mortgage lending market prior to the Financial Crisis. There is a literature that finds that negative shocks to bank liquidity can have general equilibrium effects throughout the economy ((30), (26)). However, how dealers transmit liquidity shocks has not been studied. I find evidence that the dealers passed on a positive liquidity shock to the mortgage companies that they funded. Isolating this credit supply channel requires simultaneously estimating both the *dealer lending channel* and the *firm borrowing channel*.

A benefit of my data is that I observe the same mortgage company receiving funding from multiple dealers. This key feature of my data allows me to study differential dealer lending within the same mortgage company. I use this setting and exploit the Bankruptcy Abuse Prevention and Consumer Protection Act of 2005 (BAPCPA) as a natural experiment to shock dealer leverage. BAPCPA exempted private-label mortgage collateral from automatic stay in repo markets, which enabled dealers holding warehoused collateral to re-use the collateral in the tri-party repo market. (28) presents a theoretical model where dealers re-use collateral to take advantage of differential haircuts required in two different repo markets in order to generate liquidity.[1] My paper is the first to use BAPCPA as a shock to dealers' ability to increase leverage by taking advantage of differential haircuts in this way. I argue that some dealers were more affected than others. Within a narrow window around BAPCPA, I exploit differences in lending, within the same mortgage company, by dealers more exposed to the shock relative to those less exposed to the shock. I use this variation to establish how differential ability to lever affected the volume and riskiness of mortgage collateral that dealers invested in leading up to the Financial Crisis.

[1]The repo market consists of two segmented markets: the tri-party market and the bilateral market. These markets differ mainly by the participants who trade in them. The tri-party repo market is the market that connects dealers with nonbank cash investors such as money market funds (MMFs) and securities lenders. It is the way in which cash funding enters the shadow banking system through repo ((31)). The bilateral repo market is a market through which funds are reallocated between dealers and between dealers and mortgage companies. Different overcollateralization or "haircuts" are charged in each market on the same collateral due to differing counterparty risk. Dealers sit in between these two markets and are able to re-use collateral received in one market for their own purposes in the other market. I will discuss the institutional background in more detail in section 2.2.

In Figure 2.2, I show new evidence, that dealers' ability to lever themselves by re-using private-label mortgage collateral in the repo market tripled following BAPCPA and crashed when the bank runs on mortgage-backed securities (MBS) began. To establish which line item captured private-label mortgage collateral prior to the Financial Crisis, I hand linked the variables in the Federal Reserve's survey data on primary dealers to the line items in the survey forms actually filled out by the dealers. I use pre-existing variation in a proxy for dealers' holding of warehoused private-label mortgage collateral prior to the shock to capture heterogeneity in dealers' ability to leverage themselves post shock. Following (30), I run a difference-in-differences analysis of the credit lines to a given mortgage company by more- versus less-exposed dealers. This setting allows me to isolate the dealer supply effect by controlling for mortgage company demand confounders. I establish that dealers who were differentially able to increase their leverage post shock increased their funding to mortgage companies by 29% relative to less-exposed dealers. I present suggestive evidence this was not a substitution from less-exposed to more-exposed dealers but an increase in total credit supply to mortgage companies. To do this, I establish that mortgage companies who were more dependent on treated dealers in the pre-period received a 13% increase in their total credit lines post shock relative to mortgage companies who were more dependent on control dealers.

Dealers' increased ability to leverage themselves in the repo market post BAPCPA led them to fund riskier mortgage products. I find that the dealers systematically loosened covenants on their credit lines to mortgage companies following the shock. Rather than increasing funding for lines collateralized by traditional mortgages, dealers increased funding for balloon, interest-only, 120-180 day delinquent mortgage collateral and for implicitly unsecured credit lines. This evidence suggests that dealers incentivized mortgage companies to originate mortgage products with low initial mortgage payments in order to make mortgages more affordable in an environment of rising home prices and interest rates. Increasing the supply of credit in this way attracted a riskier marginal homebuyer into the market - those purchasing homes as investment properties. My results complement (18), which shows that an expansion in non-bank lending offset the reduction in traditional bank lending caused by tightening of monetary policy during 2005-2006.

My paper sheds light on the open question of how relatively small losses on subprime mortgages could cripple the entire financial system. My work provides empirical evidence that a change in the ability to re-use risky collateral in the repo markets in 2005 played a roll in destabilizing the financial system prior to the Financial Crisis, both by increasing the leverage of the most critically connected dealers and by increasing the fragility of the assets that they were trading. Most previous work on dealer leverage has focused on balance sheet liabilities, which do not capture re-used, or rehypothecated, collateral ((43)). (42) shows that the re-use of collateral allowed the shadow banking system to be 50% more levered than standard estimates during 2007-2009. My paper helps us understand how the rehypothecation of mortgage collateral in the repo market caused relatively small losses on subprime mortgages to disproportionately hit the foundation of the banking system.

My paper has implications for the exemption of automatic stay granted on mortgage-backed collateral. There is a legal literature ((20), (40), (44), (19), (37)) and a theoretical literature ((12)) that debates whether risky mortgage collateral backing repo agreements should be exempt from automatic stay. (37) note that safe harbor for repurchase agreements was intended for collateral that maintains its price in a crisis. My paper is the first to show empirical evidence tying together the destabilizing effects of granting risky repo collateral safe harbor in bankruptcy. I show evidence that it incentivized large dealers to increase their use of unstable short-term financing and their investment in risky assets, which, as discussed in (33), did not retain their price in the crisis.

My work also has implications for the Federal Reserve's use of the tri-party market to conduct monetary policy. Although BAPCPA occurred relatively late in the housing boom, in late 1999 the Federal Reserve set up facilities in the tri-party market to begin purchasing mortgage pass-through securities.[2] This likely had the same effect as the mechanism that I discuss in this paper by increasing demand for these securities in the tri-party market. This would allow dealers to increase their leverage by taking advantage of the wedge between the haircuts charged on the collateral in the repo markets and may have contributed to the housing boom in the early 2000s.

There is an existing literature that uses the BAPCPA policy change as a natural experiment. (45) presents evidence that demand increased for private-label mortgage collateral in the tri-party repo market post shock. (23) uses BAPCPA to study moral hazard in the originate to distribute mortgage market. My paper provides the critical link between these two papers. I show that BAPCPA enabled dealers to increase their leverage by encouraging the re-use of risky collateral in the repo market. By linking the dealers to the mortgage companies I establish that dealers passed a liquidity shock to the

[2] I discuss this policy further in Appendix A.1.

mortgage companies that they funded and increased their financing for riskier mortgage assets.

2.2 Institutional Background

In this paper, I study a shock that affected a specific collateral class in the repo markets. This shock is interesting because of the way that it was amplified by dealers operating across segments of the repo markets and was transmitted to the mortgage companies depending on them. I study the borrowing and lending of two main groups of players: dealers and independent mortgage companies (IMCs). This section is set up as follows: describe generally how dealers operate in the repo market; describe how mortgage companies depend on credit lines from dealers; explain how a policy change affected the interactions between these two groups of players; explain what the effects of the change were.

The repo markets allow participants to make repurchase agreements (repos) - secured short-term loans in which the collateral consists of financial assets.[3] Repos are similar to collateralized loans but may qualify for different treatment in the case of bankruptcy. The repo markets are an important source of funding for dealers, and leading up to the Financial Crisis, for many independent mortgage companies. (15) estimate that during July-August 2008, the sum of all repos outstanding on a typical day was approximately \$6.1 trillion. The sum of all reverse repos outstanding was about \$4 trillion.[4]

[3]Bevill, Bresler & Schulman Asset Management Corp v. Spencer S&L Ass'n (In re Bevill, Bresler & Schulman Asset Management Corp.), the Third Circuit provide a succinct description of repos.(1) 878 F.2d 742, 743 (3d Cir. 1989).

[4]About 40% of repo activity was in tri-party repos and the remaining 60% was in bilateral repos. About 92% of reverse repos took place in the bilateral market. Due to double counting, summing the total repo and reserve repo values may overstate the total size of the market. (15) p. 2348.

There are two segmented repo markets, the bilateral repo market and the tri-party repo market. The bilateral market is where opaque, less credit-worthy agents seek short-term funding. Cash borrowers in the bilateral repo market are riskier and face larger haircuts to protect the dealers lending to them. The tri-party market has historically been where more credit-worthy agents such as large dealers and cash investors borrow and lend. The tri-party market is known as the tri-party market because it has a clearing bank which is a third party to the cash borrower and cash lender. The clearing house provides several important roles including taking custody of the collateral used in a tri-party repo transaction and settling the transaction.[5] Due to the traditionally safer participants in the tri-party market and the clearing bank facility, lower haircuts are required to borrow in this market than in the bilateral market.

The dealers operate in between the bilateral and tri-party markets. In practice, dealers could receive collateral in the bilateral market, where they lent funds to riskier players against securities at higher margins. In other words, cash borrowers in the bilateral market posted excess collateral with dealers to overcollateralize their borrowing. Dealers could borrow against this collateral in the tri-party market. By re-using the same underlying collateral, dealers could take advantage of the differential between haircuts in the bilateral and tri-party markets to generate liquidity for themselves. (28) provides a theoretical framework by which a dealer borrows and lends funds via repos, using the same underlying collateral provided by the cash borrower for both contracts. This is a process known as *rehypothecation*, or the *re-use* of collateral.

[5](15) p. 2350.

In order to operate, independent mortgage companies (IMCs) require large sums of money to originate mortgages. These mortgage companies follow a business model where they have only a small amount of equity and rely on large credit lines to originate mortgages. I observe twelve IMCs who report the lenders from whom they receive credit lines and the maximum amount of the credit lines. These were twelve of the largest public independent mortgage companies and generated approximately 15% of all mortgage originations in 2005 using HMDA origination data.[6] I establish, using my data, that they typically received a large portion of this money in the form of "*warehouse lines of credit*" or "*warehouse facility*" loans from dealers.[7] In turn, the IMC pledges mortgage loans to the warehouse lender as collateral.[8] In my data, dealer funding makes up 60% of mortgage company assets on average.

I study the Bankruptcy Abuse Prevention and Consumer Protection Act of 2005, BAPCPA. It was passed by Congress on April 14, 2005, signed into law by the president of the United States on April 20, 2005, and applied to bankruptcy cases after October 17, 2005. This shock exempted private-label mortgage collateral (PLS) from automatic stay in repo markets by expanding the definition of "repurchase agreement" to include

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[6]Based on (46)'s calculation of IMC originations plus their purchases from their correspondent lenders, the twelve IMCs account for approximately 10% of all mortgage originations in 2006.

[7]Seventeen out of the 22 primary dealers in 2005 were lending to the twelve IMCs whose data I observe. The primary dealers are a subset of broker dealers who deal directly with the government to make the market for newly issued US Treasuries. They are the most interconnected broker dealers. I observe that many of the mortgage companies were borrowing from the same large dealers, increasing the interconnectedness of the financial system.

[8]HomeBanc 2005 10-Q3 p 101 of 173 states that: the repayment of these warehouse credit lines varied by contract but they were often repayable either when the loans financed by the facility were sold or on the maturity date of the warehouse facility contract.

the following additional instruments: (1) mortgage loans; (2) mortgage-related securities;[9] (3) interests in mortgage-related securities or mortgage loans.[10]

Automatic stay is the process by which a hold is placed on a firm's assets when it enters bankruptcy proceedings. Prior to the law change, private-label mortgage collateral used in the repo markets would be subject to this hold if a mortgage company declared bankruptcy - meaning that the cash lender holding this collateral would need to return the collateral to the mortgage company while it reorganized itself in bankruptcy proceedings. The exemption from automatic stay meant that the cash lender holding the collateral would be the outright owner of the collateral even if the mortgage company declared bankruptcy.

I hypothesize that BAPCPA expanded the classes of collateral allowed in the tri-party market to include private-label mortgage collateral. Prior to BAPCPA, the dealers engaged in the re-use of collateral with liquid securities such as treasuries and agency mortgage-backed securities MBS. I present suggestive evidence that the use of private-label MBS for this kind of trade was limited before PLS was exempted from automatic stay. While PLS subject to automatic stay, if a counterparty declared bankruptcy, the collateral would need to be frozen under a temporary hold while the counterparty reorganized. Collateral in the tri-party market had to be held by a clearing house and prematurely freezing the collateral in the clearing house would create gridlock in the tri-party market. Market participants' responses to two court cases, *Lombard-Wall* and *Criimi Mae*, where the court failed to grant repo collateral preferred bankruptcy status, suggest that collateral

[9] As defined in section 3 of the Securities Exchange Act of 1934.

[10] Bankruptcy Abuse Prevention and Consumer Protection Act of 2005, Pub. L. No. 109-8, §907, 119 Stat. 23, 171-172 (codified as amended at 11 U.S.C. §101(47) (2012))

must be exempt from automatic stay in order for cash lenders to lend against it in the tri-party market.[11] [12]

After the shock, the last holder of the collateral owned it outright, making cash lenders in the repo markets senior claimants on the private-label mortgage collateral they held. Cash lenders in the tri-party market would be considered the outright owner of the collateral once they took custody of it from the dealer. They would not have to worry about the assets being frozen in the clearing house if a counterparty declared bankruptcy. I argue that this mitigated concerns about a counterparty's credit risk, making the cash lenders more willing to lend against private-label collateral. The cash lenders would need only to rely on the underlying value of the collateral, increasing demand for the it in the tri-party market.

This increased demand in the tri-party market was important because it made a riskier collateral class more liquid. The literature shows that differences in haircuts between the

[11]Lombard-Wall, a 1982 bankruptcy court decision, decided the repo collateral buyer (cash lender) would be subject to automatic stay. The following comments suggest that market participants were concerned that if collateral were subject to automatic stay in the repo market, the repo market would be scared of grid-lock in a collateral class and limit the use of that collateral class for secured borrowing. Congressman Walter Fauntroy, one of the sponsors of the repo exemption from automatic stay in 1984, reported that Lombard-Wall alarmed market participants, magnifying their uncertainty and slowing the growth of repos (statement of Del. Walter Fauntroy). An industry witness, Robert Brown, Chairman of the Board of Directors of the Public Securities Association, stated that the decision "create[d] a risk of market 'grid-lock.'" See Bankruptcy Law and Repurchase Agreements: Hearing on H.R. 2852 and H.R. 3418 Before the Subcomm. of Monopolies & Commercial Law of the H. Comm. on the Judiciary, 98th Cong. 61 (1984), at 19 and at 84.

[12] Criimi Mae was a highly levered Real Estate Investment Trust (REIT) that funded itself using repo loans from dealers in the bilateral repurchase market. Criimi Mae filed for protection from its repo lenders under Chapter 11 Bankruptcy Code. Contrary to the expectations of the market, in 2000, the court ruled that the repo collateral that Criimi Mae had posted was not an outright sale and would therefore be subject to automatic stay. This meant that the dealers did not have a senior claim on the collateral and could not seize it while Criimi Mae reorganized itself in bankruptcy. See: Kirkpatrick, David D. "Criimi Mae Seeks Bankruptcy Protection in a Blow to Commercial-Mortgage Debt." The Wall Street Journal, 6 Oct. 1998, https://www.wsj.com/articles/SB907629811575386000. (41) states that this ruling profoundly disturbed the repo industry because it set the precedent that mortgage repo collateral would not receive preferred bankruptcy status. See: (41) p. 567.

bilateral and tri-party market can be large for riskier collateral classes ((15), (28)). Due to these relatively larger differences in haircuts the liquidity generation potential for dealers re-using riskier assets was larger than it was for safer assets. The re-use of collateral to exploit differential haircuts between repo markets creates a money multiplier effect. Therefore adding a riskier asset class to the allowable collateral in the tri-party market would make a larger money multiplier possible. For example, in July 2008 the difference between median repo haircuts on private-label collateralized mortgage obligations across the bilateral and tri-party repo market was 17% - whereas the difference between median repo haircuts on agency MBS across these two markets was 2% at this time.[13] For example, if the haircut in the bilateral market was 22%, for each dollar that a dealer lent in the bilateral market, she would receive 1.22 dollars in private-label mortgage collateral. If the haircut on the same collateral in the tri-party market was 5%, she could re-use this collateral in the tri-party market to receive 1.17 dollars cash, thereby creating an extra $0.17 for each dollar with which she started.

A report from the Federal Reserve Bank of New York (FRBNY) states that, by 2008, there had been a relaxation in the asset classes used as collateral:

> [C]onditions in 2008 [became] particularly precarious [due to] the resort to less liquid collateral in repo agreements ... . Originally focused on the highest quality collateral - Treasury and Agency debt - repo transactions by 2008 were making use of below-investment-grade corporate debt and equities and even **whole loans** and trust receipts. This shift toward less liquid collateral increased the risks attending a crisis in the market

[13](15) p. 2346.

> since, in the event of a crisis, selling off these securities would likely take time and occur at a significant loss.[14]

I study the Federal Reserve Bank of New York's weekly survey of primary dealers (FR 2004) to better understand the dealers' role as intermediaries between the tri-party and bilateral repo markets. This survey data captures dealers' secured financing positions. The primary dealers report the total amount of cash received (*securities out*) and cash lent (*securities in*).[15] In Figure 2.2, I follow (28) and calculate the difference between securities out and securities in to proxy for the total amount of cash the dealer generates through their secured financing activity in the collateral class "Corporate Securities," which includes "Private-Label Mortgage Backed Securities." This proxy suggests that dealers' generation of cash using PLS more than triples following BAPCPA until the run on Northern Rock in September 2007.

At the time, accounting for repo transactions was governed by Statement of Financial Accounting Standards No. 140 ("SFAS 140"). SFAS 140 allowed repos to be accounted for as either a secured loan or as a sale of assets based on certain qualifying criteria. One of the criteria requires that in a sale of assets the transferor surrenders control over the assets. The transferor has surrendered control over transferred assets if and only if all of the following conditions are met:

(1) The transferred assets have been isolated from the transferor; put presumptively beyond the reach of the transferor and its creditors, even in bankruptcy or other receivership;

[14] (6) pp. 3-4.

[15] *Securities out* and *securities in* include repos/securities lending and reverse repos/securities borrowing, respectively. See: FR 2004.

(2) Each transferee has the right to pledge or exchange the assets it received;

(3) The transferor does not maintain effective control over the transferred assets.[16]

By granting repos backed by private-label mortgage collateral preferred bankruptcy treatment, BAPCPA enabled private-label mortgage collateral to be accounted for as a sale of the asset by fulfilling (1) above. Treating a repo as a sale would remove the assets from a dealer's balance sheet. The evidence in this paper suggests that BAPCPA allowed dealers to increase leverage in such a way that the underlying risk was not apparent on dealers' balance sheets. Figure 2.1 constructs an example of Dealer A lending to an IMC via a secured loan, while dealer B lends to the IMC via a warehouse repurchase facility. Dealer A's leverage increases to 2.5 after it lends to the IMC, while Dealer B's leverage remains at 2.25 both before and after lending to the mortgage company.

The repos are short-term, typically 30-60 days at the peak of the housing boom, and are rolled over if necessary. Since they happen over the quarter of a year, the repurchase agreements will not show up on the dealer's balance sheet. They would go into a cash account. For a dealers like Goldman Sachs, they would not even show up as cash flow from investing or financing activities, all of the repo transactions would be part of cash flow from operations, and would therefore get netted out. The balance sheet is a stark document, at a given point in time it is a snapshot picture. Over the course or the year the dealer may average $100 billion repo transactions using private-label mortgage collateral outstanding and it is very possible that none of it or only $10 million of it might show

[16]Lloyd, Terry and Prateek V. Shah. The State of New York vs. Ernst & Young: Putting Lehman's Accounting for "Repo 105" Transactions on Trial. 2013. Available at: https://www.fsgexperts.com/wp-content/uploads/2013/01/Lehman-and-Repo-105-Final-_2_.pdf

FIGURE 2.1. DEALER BALANCE SHEET

Accounting Treatment of Secured Loan vs Repo as an Outright Sale

0% interest rates for simplicity. Dealer funds loan to Independent Mortgage Company (IMC) with bank debt.

No Relationship with IMC

Balance Sheet of Bank A at Day 0 with Vanilla Secured Loan	
Assets	**Liabilities and Equity**
Other Assets 900	**Total Liabilities 500**
	Equity 400
Total Assets $900	**Total Liabilities & Equity $900**

Dealer lends to IMC in form of a Vanilla Secured Loan

Balance Sheet of Bank A at Day 1 with Vanilla Secured Loan	
Assets	**Liabilities and Equity**
Secured Loan to IMC $ 100	**Total Liabilities 600**
Other Assets 900	**Equity 400**
Total Assets $1,000	**Total Liabilities & Equity $1,000**

IMC pays off loan

Balance Sheet of Bank A at Day 2 with Vanilla Secured Loan	
Assets	**Liabilities and Equity**
Other Assets 900	**Total Liabilities 500**
	Equity 400
Total Assets $900	**Total Liabilities & Equity $900**

0% interest rates for simplicity. Dealer funds loan to IMC with repo debt from tri-party repo market.

No Relationship with IMC

Balance Sheet of Bank B at Day 0 with Reverse-Repo treated as Outrigt Sale	
Assets	**Liabilities and Equity**
Other Assets 900	**Total Liabilities 500**
	Equity 400
Total Assets $900	**Total Liabilities & Equity $900**

Dealer purchases securities from IMC as a Reverse-Repo

Balance Sheet of Bank B at Day 1 with Reverse-Repo treated as Outrigt Sale	
Assets	**Liabilities and Equity**
Other Assets 900	**Total Liabilities 500**
	Equity 400
Total Assets $900	**Total Liabilities & Equity $900**

Dealer sells securities back to IMC

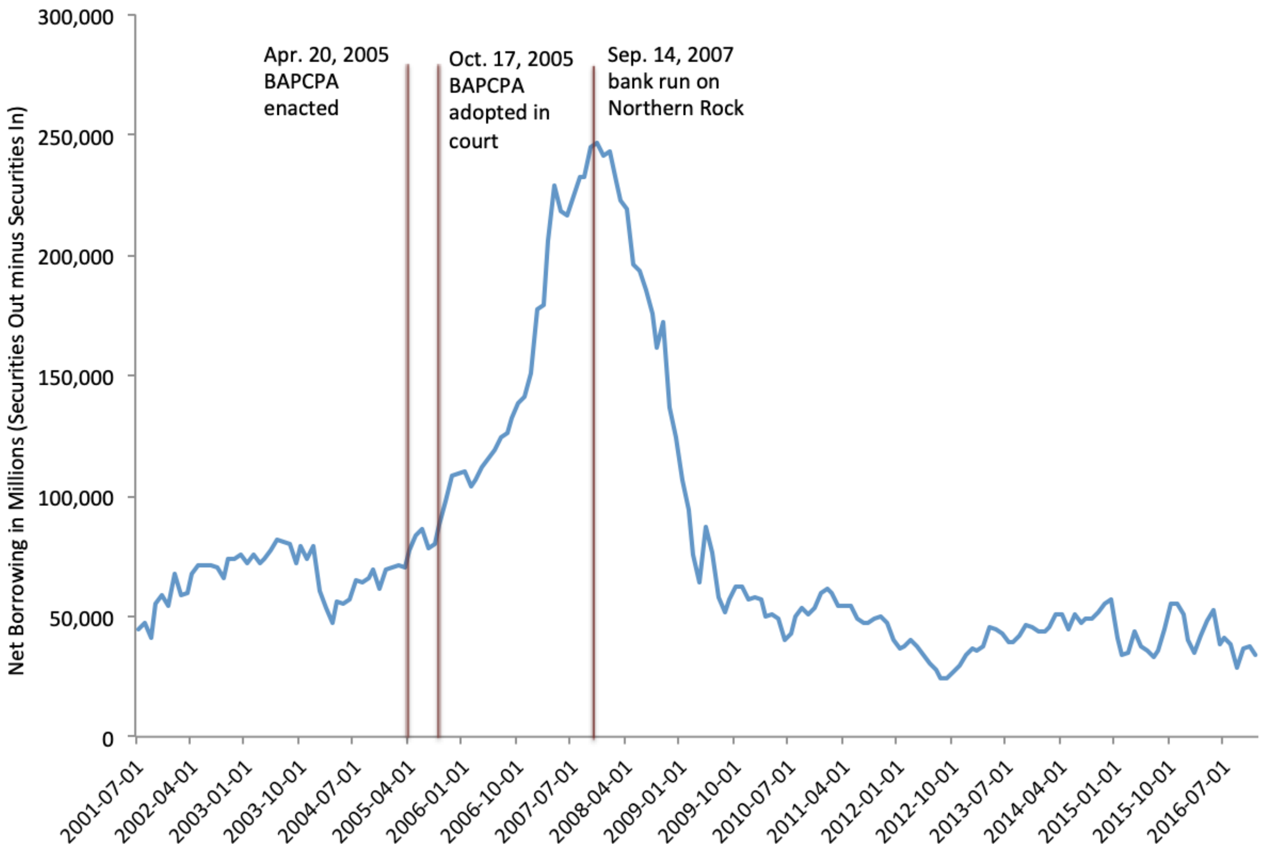
Balance Sheet of Bank B at Day 2 with Reverse-Repo loan treated as Outrigt Sale	
Assets	**Liabilities and Equity**
Other Assets 900	**Total Liabilities 500**
	Equity 400
Total Assets $900	**Total Liabilities & Equity $900**

Dealer Leverage Ratio (Assets/Equity)

	Day 0	Day 1	Day 2
Secured Loan (A)	2.25	2.5	2.25
Reverse-Repo (B)	2.25	2.25	2.25

up in cash flow from operations, without discussion of where the cash came from, at the financial year end.

Figure 2.2. Proxy for Dealer Net Borrowing Using Private-Label Mortgage Collateral (Securities Out - Securities In)



Notes: Figure plots the weekly time series of dealer secured borrowing (securities out) minus dealer secured lending (securities in) in the collateral class corporate securities reported in the FR 2004. I calculate a lower bound estimate of the fraction that private-label mortgage collateral comprised of corporate securities to be 14% using 2018 data, due to data availability I cannot estimate the value for 2005. This is likely to be an underestimate as the use of private-label mortgage collateral was at an all time high in 2005. See Appendix section A.2 for details on the calculation. Securities out includes all dealer repo transactions and securities lending transactions. Securities in include all reverse repo transactions and securities borrowing transactions. Dealer net borrowing is calculated by securities out minus securities in.

Prior to the law change, dealers had been financing IMCs via secured loans called warehouse lines of credit. (37) states that "indeed, the predecessor to the mortgage repo was the warehouse secured loan." [17] Post BAPCPA, in order to take advantage of the protected bankruptcy status granted to mortgage collateral under repurchase agreements, the data suggests that dealers began changing the format of their funding lines to repurchase agreements. Post shock, I observe the language in the quarterly filings of the IMCs that I study change from "*warehouse lines of credit*" to "*warehouse repurchase facilities*." This language change happens for the same credit line, from the same dealer, for the same amount of credit. In its 2005 annual report, American Home Mortgage Investment Trust, an independent mortgage company, added the following statement which was not in its 2004 annual report:

> "Our borrowings under repurchase agreements may qualify for special treatment under the bankruptcy code, giving our lenders the ability to avoid the automatic stay provisions of the bankruptcy code and to take possession of and liquidate our collateral under the repurchase agreements without delay in the event that we file for bankruptcy."[18]

The independent mortgage companies operated in the bilateral repo market in order to receive this funding.[19]

Figure 2.3 (a) Depicts a dealer's lending to a mortgage company prior to BAPCPA. The dealer would receive repo collateral from the IMC but the collateral was not very

[17](37) pp. 10, 22 note 68., (44) pp. 173-80.

[18]American Home Mortgage Investment Corp. 2005 Annual Report p. 14.

[19]Almost all of the IMCs that I observe classify as Real Estate Investment Trusts (REITs). Using a snapshot of data from early 2015, (8) finds that REITs enter into the bilateral repo market to secure funding.

liquid prior to the policy change, so the dealer would hold the collateral. Post BAPCPA is shown in (b). For example, in the bilateral market a dealer would pay \$100 to buy mortgage collateral valued at \$136, about a 36% haircut, from the mortgage company with an agreement to sell it back in 60 days at \$101. The extra \$36 was overcollateralization or a haircut to protect dealers from the risk of the mortgage company. Post BAPCPA, the collateral became more liquid, allowing dealers to turn around and re-sell the same collateral in the tri-party repo market for a much lower haircut. Since dealers were considered more credit worthy borrowers, they could re-sell the same collateral, valued at \$136 for \$130, about 5% haircut. This allowed dealers to generate 30 extra dollars by re-selling the overcollateralization portion posted by the mortgage companies. They could then use this extra \$30 to lend for even more mortgages.

The following simple example captures this.

Dealer Return Before BAPCPA

$$\frac{InterestRate_{IMC} \times AmountBorrowed_{IMC}}{\underbrace{AmountBorrowed_{IMC}}_{\text{Amount funded by dealer}}} \tag{2.1}$$

Dealer Return After BAPCPA

$$\frac{InterestRate_{IMC} \times AmountBorrowed_{IMC}}{\underbrace{x \times AmountBorrowed_{IMC}}_{\text{Amount funded by dealer}}} \tag{2.2}$$

where $0 < x < 1$.

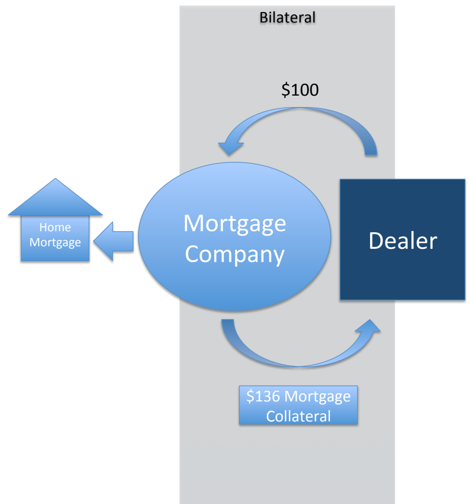
Post BAPCPA, dealers were able to re-use the collateral that they received to borrow for their own accounts. For simplicity, assume that the interest rate that dealers were required to pay on their borrowing backed by the re-used collateral was 0%. Then the dealers could immediately promise out a fraction $1 - x$ of the collateral and receive the funding from outside sources to fund the loan to the mortgage company. This would amplify the return the dealer received on the loan to a mortgage company. In the limit, if $x = 0$ the dealer's return on this trade is infinite. Therefore receiving this repledgeable collateral from the IMC becomes very profitable to the dealer. The dealer has incentive to encourage the IMC to make as much of the collateral as possible. In a time when demand for housing was plateauing and housing was increasingly expensive, the dealers would be incentivized to accept lower quality collateral to generate this return.

According to my hypothesis, post shock, the dealer's effective leverage constraint would have been loosened because she had an additional collateral class that she could re-use. By reinvesting her new liquidity back into mortgage collateral, the dealer could take advantage of a feedback loop. For each dollar that she reinvested in PLS, she could generate more than a dollar by taking advantage of the wedge between haircuts in the bilateral and tri-party repo markets. In the sections that follow, I discuss empirical evidence for the propagation of the shock to the mortgage market through each step of the lending chain depicted in Figure 2.3.

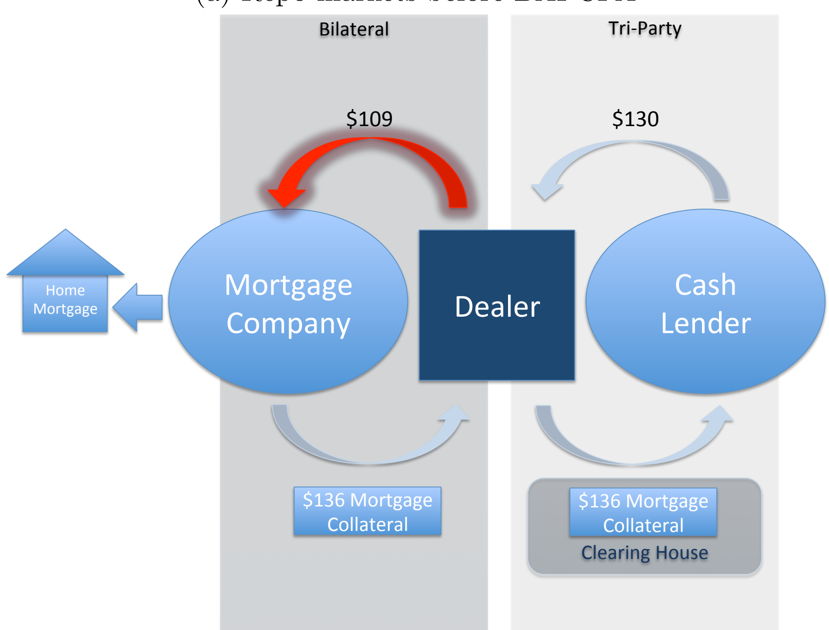
2.3 Data

In this paper I study the amplification of a credit supply shock through a chain of lending involving participants in the repo markets including cash lenders such as money market funds (MMFs), dealers, and independent mortgage companies (IMCs). In order to study how the shocked was passed through a chain of lending in the repo markets, I study

FIGURE 2.3. REPO MARKETS BEFORE AND AFTER BAPCPA 2005



(a) Repo markets before BAPCPA



(b) Repo markets after BAPCPA

Notes: Figures depict the process by which a dealer can borrow and lend funds via the tri-party and bilateral repurchase market respectively, using the same underlying private-label mortgage collateral provided by the cash borrower for both contracts. Figure (a) depicts the intermediation chain before BAPCPA and Figure (b) depicts the proposed intermediation chain after BAPCPA.

micro-level data at various steps of the intermediation process. I study dealer trading data, hand collected data on dealer credit lines to mortgage companies, and mortgage company lending data. Below I describe the structure of this data, the construction of key variables and the representativeness of the data.

2.3.1 Dealer Data

2.3.1.1 Dealer Borrowing Data

To study the funding of the dealers, I use the Federal Reserve Bank of New York Statistical Release (FR 2004). There are limited data sources that track dealer activity prior to 2007. (15) report statistics from the tri-party repurchase market as early as 2008. (9) states that there is limited data available for the repo markets prior to the Financial Crisis. I use the FR 2004 data to measure primary dealers' aggregate trading activity by collateral class. The primary dealers are the largest and most interconnected dealers in the repo market and their trading activity is likely to be representative of trading activity in the repo markets as a whole. (15) states that primary dealers made up 79% of all dealer activity in the tri-party repo market in July and August 2008 and the authors assume that this percentage holds across the total repo markets.

To my knowledge, mine is the first paper to study the primary dealers' use of private-label mortgage collateral (PLS) to fund themselves using this data. One reason that I do not believe this data has been used previously to study dealers' trading in private-label MBS is because this collateral class is included in the line item "corporate securities" prior to 2013. [20] In Appendix section A.2, for reference, I decompose corporate securities

[20] See FR 2004 Government Securities Dealers Reports Instructions for January 2013 and earlier. Available at: https://www.federalreserve.gov/apps/reportforms/reporthistory.aspx?sOoYJ+5BzDZq2f74T6b1cw==.

into the collateral classes that it is comprised of using more recent data. Furthermore, there is no external data dictionary for this data outside the Federal Reserve. Therefore, I hand match the FR 2004 time series to the survey instructions given to the FR 2004 survey respondents in order to create a time series of total dealer holdings and financing aggregated across primary dealers. This data contains primary dealer financing activity within a given collateral class in a given week. I study the variable "*securities out*." Securities out represents the value of primary dealer secured borrowing.[21] I study the primary dealers' securities out reported for both agency MBS and corporate securities relative to total securities out. This allows me to understand how dealers changed their use of private-label MBS collateral to raise secured funding in response to BAPCPA.

2.3.1.2 Dealer Treatment Assignment Data

I utilize heterogeneity in dealer exposure to BAPCPA in order to causally identify the effect of the shock on dealer lending to mortgage companies. To assign dealers to the treatment and control groups, I proxy for dealers' holdings of private-label MBS prior to BAPCPA using data from CoreLogic ABS database and Inside Mortgage Finance's Mortgage Market Statistical Annual. This data is used to compute the total value of subprime residential mortgage-backed securitization deals underwritten by financial institution. I scale the total value of deals by total assets for each underwriter (dealer).[22] I

[21](28) p. 46.
[22]This measure was taken from (38) p. 457 and updated with information from the CoreLogic ABS database and Inside Mortgage Finance's Mortgage Market Statistical Annual to compute the value of subprime deals underwritten by a dealer. I am very grateful to Shane Sherlund for his help calculating this measure. I scaled the value of subprime deals underwritten by each dealer by total assets of either the holding company of the dealer or the total assets of the dealer itself when a dealer was not part of a larger holding company.

assign dealers in the top quartile of the scaled value of deals underwritten to the treatment group.

2.3.2 Data Linking Dealers to Mortgage Companies

I hand collect data on the warehouse lines of credit of twelve of the largest public independent mortgage companies (IMCs) in 2005. I collect this data from their quarterly and annual filings between 2004Q3 to 2006Q3. These IMCs make up about 15% of total IMC mortgage originations in the HMDA data by number of originations in 2005. This data reports the lender on each credit line as well as the maximum credit line available at the quarterly level. I use this data to link independent mortgage companies to the dealers who were lending to them. My data allows me to probe deeper into independent mortgage company funding than has thus far been possible. I find that the mortgage company warehouse lines of credit were all funded by dealers largely via *warehouse repurchase facilities* in the bilateral repo market. These credit lines make up 61% of mortgage company assets on average. This data allows me to study whether dealers passed a credit supply shock on to the mortgage companies that they funded by conducting a within mortgage company, across dealer analysis of dealers' changes in funding in response to BAPCPA. This setting enables me to analyze whether treated dealers increase their lending to a mortgage company relative to control dealers lending to *the same* mortgage company.

2.4 Credit Supply Shock Transmission

In this section, I document how BAPCPA changed each of the connections in the rehypothecation chain depicted in Figure 2.3. I provide empirical evidence that these changes resulted in a credit supply shock to the mortgage market.

2.4.1 Dealer Liquidity Shock (Tri-party Market)

I hypothesize that BAPCPA increased dealers' ability to leverage themselves by enabling them to re-use collateral posted by the mortgage companies in the bilateral market in order to raise funding for themselves in the tri-party market. Figure 2.3 illustrates the change pre and post policy change in a dealer's ability to re-use capital received in the bilateral market to raise funding for herself in the tri-party market. I propose that prior to the policy change, private-label mortgage collateral was not widely accepted as collateral in the tri-party market because it was subject to *automatic stay*. As discussed above, [23] automatic stay on the collateral made the clearing house reluctant to hold the collateral since if a counterparty defaulted, the clearing house would not own the collateral outright and would need to wait for the bankruptcy court to decide who received ownership of the collateral. I argue that BAPCPA increased demand for private-label mortgage collateral in the tri-party market by exempting the collateral from automatic stay - making the clearing house willing to hold the collateral since they would own it outright if a counterparty defaulted. Increasing demand for this collateral in the tri-party market would increase dealers' ability to re-use collateral that they received in the bilateral market in order to borrow funds in the tri-party market.

[23] Supra footnote 12.

Data for the primary dealers support the assumption that dealers were more able to use private-label mortgage collateral to borrow secured funding in the tri-party market post shock.[24] The primary dealers make the market for newly issued government securities and are among the largest and most connected dealers. They also make up the majority of lenders to the twelve mortgage companies in my sample.

To study these dealers, I use the FR 2004 weekly data aggregated across all primary dealers at the collateral-class level. I use the corporate securities collateral class, which includes private-label mortgage backed collateral, as a proxy for dealers' use of private-label mortgage collateral. The use of private-label mortgage collateral in the repo markets was at an all time high between 2002 and 2007 so private-label mortgage collateral is likely to account for a large portion of the corporate securities line item. In Appendix section A.2, for reference, I decompose corporate securities into the collateral classes that it is comprised of using more recent data. There were no significant changes that affected the other collateral classes that comprised corporate securities around the time of BAPCPA. The FR 2004 data reports the primary dealers' aggregate activity in both the tri-party and bilateral repo markets.

In order to study the link between dealers and large cash lenders such as money market funds in Figure 2.3, I study the *securities out* line item, which represents securities lent (cash borrowed), for both agency MBS collateral and private-label mortgage collateral pre and post shock. Securities out proxies for the total amount of secured funding that primary dealers receive by collateral class. In Figure 2.4, I plot the line items Agency

[24]Due to data limitations, I am only able to show this evidence for a subset of dealers - the primary dealers, for whom the Federal Reserve collects transaction data.

MBS[25] and private-label MBS[26] in the FR 2004 data each as a fraction of total securities out. Agency MBS was exempted from automatic stay in 1984 so it was not affected by BAPCPA. Figure 2.4 examines the fraction of total borrowing that dealers borrowed against agency mortgage collateral relative to private-label mortgage collateral. Prior to the shock the fraction of total securities out that dealers pledged as agency MBS and as private-label MBS moved in parallel and remained stable. Figure 2.4 shows that prior to the shock, private-label mortgage collateral consisted of only about 6% of primary dealers' secured borrowing. This suggests that prior to the shock, a constant fraction of the total funding that dealers raised in the tri-party market was backed by agency and private-label collateral.

After the shock however, in April and then October 2005, the primary dealers began increasing their use of private-label mortgage collateral as a fraction of total securities out relative to their use of agency MBS. The fraction of total securities out comprised of private-label mortgage collateral increased steeply until mid 2007 - suggesting that dealers were increasing their use of this collateral post shock to secure their borrowing in the tri-party market. Over this time, private-label mortgage collateral as a fraction of total securities sent out nearly doubled from about 6% to close to 12% and its value almost doubled from $247 billion in March 2005 to $466 billion in July 2007. This evidence is

[25]Agency MBS is comprised of Federal Agency and GSE MBS in the FR 2004 data.

[26]Private-label MBS is comprised of Corporate Securities Total from 7/4/2001 to 3/27/2013. From 4/3/2013 to 6/6/2018 it is comprised of: (1) Non-Agency Residential MBS, (2) Other CMBS, (3) Corporate Securities Commercial Paper, (4) Corporate Securities Investment grade bonds, notes, and debentures of various maturities, (5) Corporate Securities Below investment grade bonds, notes, and debentures of various maturities, (6) State and Municipal Government Obligations of various maturities, (7) Credit card-backed, Student loan-backed, Automobile loan-backed, Other Asset Backed Securities.

consistent with the idea that granting private-label mortgage collateral preferred bankruptcy treatment increased demand for it in the tri-party market,[27] making it easier for dealers to pledge as collateral to raise funding. I propose that this policy change therefore increased the dealers' ability to finance themselves with this form of collateral.

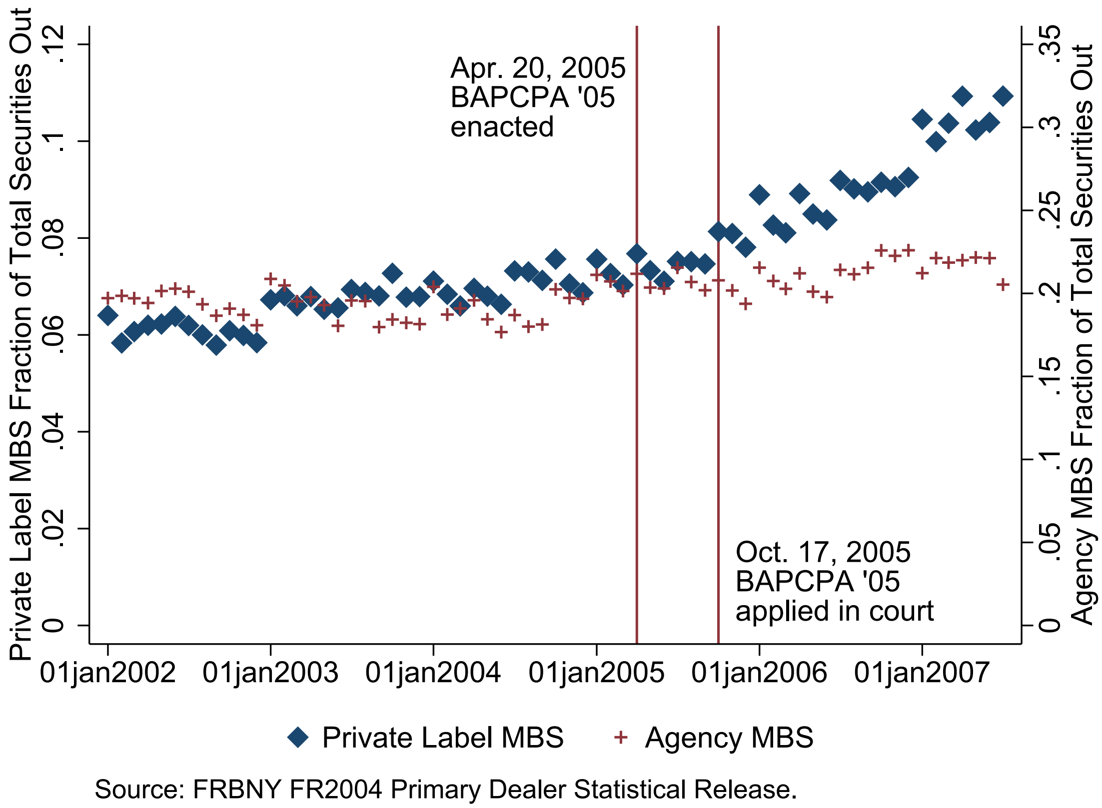
$$\log(SecuritiesOut_{i,t}) \quad = \quad \beta_1 Post_t + \beta_2 PLSIndicator_i + \beta_3 Post_t \times PLSIndicator_i + \epsilon_{i,t} \tag{2.3}$$

In Table 2.1, I run a regression to test the statistical significance of dealers' increased use of private-label MBS to borrow. I present the results of the difference-in-differences regression specified in Equation 2.3 over the period January 1, 2001 through July 31, 2007 on weekly data. $\log(SecuritiesOut_{i,t})$ is the log of the value of aggregate securities out for collateral class i at time t. $Post_t$ is an indicator variable that is equal to zero prior to April 15, 2005 and equal to one on this date and later. $PLSIndicator_i$ is an indicator term that is equal to one for private-label MBS collateral and zero for agency MBS collateral. The coefficient on the interaction term predicts a statistically significant 18.6% increase in private-label MBS securities out relative to agency MBS securities out in the post period.

In Figure 2.3, I depict the change in dealers' ability to re-use the collateral posted by a mortgage company prior to BAPCPA in (a) versus after BAPCPA in (b). Prior to the shock, I argue that the mortgage collateral that dealers held, against their credit lines to fund mortgage companies, was not able to be re-used in the tri-party market. It was simply held as illiquid collateral, with limited re-investment capability, to protect dealers from the credit risk of the mortgage companies. After the policy change, I propose that dealers now had the ability to

[27](28) p. 44 states that the dealers are likely to be cash borrowers (securities lenders), in the tri-party market.

Figure 2.4. Private Label vs. Agency Mortgage Backed Securities as a Fraction Total Collateral Posted by Dealers



Notes: Figure plots the fraction of total primary dealer securities out made up of Private-Label MBS versus Agency MBS pre and post BAPCPA. I use the line item Corporate Securities as a proxy for Private-Label MBS. Directly after BAPCPA, Private-Label MBS as a fraction of securities began to increase significantly relative to Agency MBS. Agency MBS is comprised of Federal Agency and GSE MBS in the FR 2004 data. Private-Label MBS is comprised of Corporate Securities Total matching data from pre March 2013 indicates that Corporate Securities is comprised of: (1) Non-Agency Residential MBS, (2) Other CMBS, (3) Corporate Securities Commercial Paper, (4) Corporate Securities Investment grade bonds, notes, and debentures of various maturities, (5) Corporate Securities Below investment grade bonds, notes, and debentures of various maturities, (6) State and Municipal Government Obligations of various maturities, (7) Credit card-backed, Student loan-backed, Automobile loan-backed, Other Asset Backed Securities.

re-use the collateral in the tri-party market. In Figure 2.3 (b), I depict dealers' ability to re-use collateral that they received from mortgage companies to raise funding after the policy

Table 2.1. Increase in Dealer Secured Borrowing using Private-Label Mortgage Collateral

	(1) Fraction of Total Securities Out	(2) log(Securities Out)
Post	0.018***	0.423***
	(0.001)	(0.014)
PLSIndicator	-0.126***	-1.063***
	(0.001)	(0.020)
Post × PLSIndicator	0.004**	0.186***
	(0.002)	(0.027)
r2	0.9788	0.9172
N	582	582

Notes: Table reports the increase in use of private-label mortgage collateral in the rep market post BAPCPA. Regression run from January 1, 2002 through July 31, 2007. Where April 15, 2005 and after is considered the post period.

change. I propose that post shock, the dealers could generate liquidity by taking advantage of the differential between the haircuts that they charged to the mortgage companies in the bilateral market and the haircuts that they were charged in the tri-party market.

Prior to the shock, I observe the dealers in my data requiring the mortgage companies to overcollateralize credit lines with 136% (a 36% haircut) of a line's value in mortgage collateral. Post shock, the overcollateralization required on the same credit lines fell to around 125% (a 25% haircut). I hypothesize that prior to the shock, use of the collateral in the tri-party market was limited - corresponding to near infinite haircuts. Post shock, the haircuts required in tri-party market were much lower since the dealers were considered more credit worthy market participants and since the collateral would be held by a clearing house. The earliest data that I can find on the haircuts charged in the tri-party market are from (15). The authors report that the tri-party market required 105% overcollateralization on borrowing against mortgage collateral in July of 2008 (a 5% haircut) - I expect haircuts post BAPCPA until July 2008 to be close to 5% or lower. This created a 20% differential in haircuts that the dealer could capture post shock.

I argue that prior to the policy change, the dealer starts with \$100 of cash that she lends to a mortgage company and receives \$136 of *illiquid* collateral that she holds to protect herself from the mortgage company's credit risk and opacity of operations. Post shock, I hypothesize that the dealer is now able to re-use the \$136 of mortgage collateral that she received from the mortgage company by posting it in the tri-party market to borrow \$130. In this way, post shock, I propose that the dealer is able to start with \$100 of liquid cash and end with \$130 of *liquid* cash. The extra \$30 of cash would lower dealers' cost of financing inventory and could be used for additional investment opportunities. I propose that the dealer would increase its investment in private-label mortgage collateral to capture the multiplier effect created by the differential haircuts. This would increase a dealer's leverage, since she could increase her use of debt in the tri-party repo market to increase investment.[28]

There are several ways in which dealers could increase investment in PLS collateral, for example: (a) by decreasing haircuts that they required on mortgage collateral in the bilateral market; (b) by walking down the quality curve on the types of mortgage collateral that they funded; and (c) by lowering the interest rate on their credit lines to mortgage companies. These would all translate into increased funding to mortgage companies so I will focus on an increased value of credit lines that dealers sent to mortgage companies in this section. I also find preliminary evidence that dealers decreased the haircuts that they required on the mortgage collateral

[28]Consider the stylized example of a dealer with \$100 in capital. This dealer can use its capital to buy \$136 of mortgage collateral by lending \$100 to a mortgage company via repurchase agreements in the bilateral repo market. The dealer can then re-sell this collateral as repos out in the tri-party market to obtain cash. If the margin on the repo in the tri-party market is 4.6%, the dealer can receive \$130 in cash. The dealer can invest this cash in more mortgage collateral by lending to mortgage companies via repurchase agreements, and resell the collateral in the tri-party repo market. Assuming the same margin, the dealer now receives \$169 in cash in this way. Continuing this process, the dealer can support total lending to mortgage companies many times its initial \$100 of capital. The formula to find the value of the total lending is $1 + 1.3 + 1.3^2 + ... = \sum_{i=0}^{\infty} 1.3^i$, which diverges to infinity.

that they funded from 36% pre shock to 25% post shock as I depict in Figure 2.3 (b). In Figure 2.8, I present anecdotal evidence that dealers decreased interest rates on their credit lines to mortgage companies. Consistent with dealers walking down the quality curve on the types of mortgage collateral that they funded, I will show suggestive evidence that dealers loosened the covenants that they required on their credit lines. In section 3.2, I will also conduct a county level analysis where I analyze the characteristics of originations by the mortgage companies affected by the shock. I find evidence that post shock, there is a statistically significant increase in riskier originations among mortgage companies exposed to dealer funding.

In order to empirically study whether dealers passed this increased liquidity on to the mortgage companies that they were lending to, I utilize heterogeneity among dealers' exposure to private-label mortgage collateral at the time of the shock. Although the shock affected the entire repo market, I assume that dealers who were holding more private-label mortgage collateral at the time of the shock would experience a greater liquidity shock. A larger previously illiquid fraction of their assets would become liquid - allowing them to differentially increase their leverage. I argue that dealers who underwrote more private-label MBS deals in 2004 would have had a disproportionately higher holding of PLS at the time of the policy change. Due to their greater liquidity, I expect these dealers to differentially increase their investment in the mortgage companies that they fund.

To calculate which dealers would be the most exposed to the shock, I study the value of subprime MBS deals underwritten by dealers in 2004. (4) provides a description of the kinds of mortgages that make up the private-label market. Generally this market was comprised of "near prime" and "subprime" mortgages. Therefore I assume that dealers who underwrote a larger value of subprime MBS in 2004 had a larger exposure to private-label MBS collateral, I will define these dealers as *treated*. These dealers were likely to experience a greater relaxation of their leverage constraint at the time of the policy change since they would have more private-label mortgage collateral available to re-pledge in order to receive secured financing. I define these treated dealers to be those who were in the top quartile of value of subprime MBS underwritten in 2004 scaled by total assets of the dealer holding company in 2004.[29] The control dealers are the dealers in the bottom three quartiles of subprime MBS underwritten in 2004. In Table 2.2, I present descriptive statistics showing that the treated and control dealers had similar total assets, equity, and liabilities during the pre-period.

TABLE 2.2. DEALER DESCRIPTIVE STATISTICS (2004)

	Mean (Control)	Mean (Treated)	Difference	P-value
log(Total Assets)	20.03	20.00	.03	.951
log(Originations)	6.24	6.17	.07	.955
Number of Counties	1795	1705	90	.890
N	15	7		

Notes: Table presents dealer descriptive statistics. Dealers in the top quartile of value of 2004 private-label MBS deals underwritten, scaled by total assets, are defined as treated dealers (scaled value of 2004 underwritten deals ≥ 0.023). Value of 2004 underwritten deals represents the total value of subprime residential mortgage-backed securitization deals underwritten by a financial institution in 2004, scaled by total assets of the financial institution. Data from the CoreLogic ABS database and Inside Mortgage Finance's Mortgage Market Statistical Annual were-used to compute the value of deals underwritten by a dealer.[a] Total assets reports the total value of book assets in 2004Q4 for each financial institution or holding company of the financial institution when applicable. There are 27 dealers in my dataset, five dealers' assets, liabilities, and equity I am not able to observe. These five dealers all underwrote $0 of subprime residential mortgage-backed securitization deals in 2004. Origination and county statistics are generated using HMDA data.

[a]This measure was inspired by (38) p. 457. I am very grateful to Shane Sherlund for his help calculating this measure.

[29]This measure was taken from (38) p. 457 and updated with information from the CoreLogic ABS database and Inside Mortgage Finance's Mortgage Market Statistical Annual to compute the value of subprime deals underwritten by a dealer. I am very grateful to Shane Sherlund for his help calculating this measure. I scaled the value of subprime deals underwritten by each dealer by total assets of either the holding company of the dealer or the total assets of the dealer itself when a dealer was not part of a larger holding company.

2.4.2 Dealer Lending to Mortgage Companies (Bilateral Market)

2.4.2.1 Dealer Lending to Mortgage Companies - Causal Evidence

In order to causally identify the extent to which dealers passed their liquidity supply shock on to mortgage companies, I utilize a within mortgage company, across dealer empirical strategy similar to (30). I exploit the fact that the mortgage companies in my data borrow from multiple dealers simultaneously.[30] I estimate how much a treated dealer increases her lending to a mortgage company post shock relative to an untreated dealer lending to the same company within a tight window around the shock. The shock occurred on April 2005 and October 2005, I estimate the change in lending by treated dealers relative to untreated dealers from 2004Q3 to 2006Q3.[31] All dealers will eventually be affected by the shock since BAPCPA affected repo at the national level, however the identifying assumption that I make is that dealers who have a larger fraction of their balance sheet exposed to private label mortgage collateral will be differentially affected immediately following the shock.

The dealer lending channel (supply channel) is typically difficult to estimate because supply shocks are often correlated with demand shocks. Both supply and demand shocks will affect the dealer lending volumes that I want to measure. In order to identify the supply effect, it is important that I control for changes in mortgage company demand for credit. If the dealers who receive a positive credit supply shock due to BAPCPA lend more to IMCs, a concern for identification is that the IMCs to whom they lend are more productive and thus demand more credit. In order to control for this, I collect a panel dataset of the warehouse credit lines

[30] I find that the dealers lending to the Independent Mortgage Companies between 2004Q3 to 2006Q3 are largely primary dealers. For example 17 out of 22 of the primary dealers in 2005 were lending to the IMCs in my sample.

[31] Most IMCs in the sample become public in mid 2004 thus I am only able to observe data for the IMCs via their public filings beginning in third quarter of 2004.

received by twelve of the largest public IMCs from 2004Q3 to 2006Q3. Each of these IMCs receives warehouse funding from three or more dealers.

Following (30), I run the difference-in-differences regression in Equation 2.4 where I regress the log dollar value of the credit line from a dealer to an IMC on an indicator for post BAPCPA, an indicator for whether the line was funded by a shocked dealer, and their interaction term. The unit of observation is a credit line extended by a given dealer to a given IMC. The post period is 2005Q2 - 2006Q3. In my regression, I include $IMC \times Quarter$ fixed effects (FE) so that I compare the lending volumes of a treated dealer to that of an untreated dealer both lending to the same IMC pre and post BAPCPA. Including IMC fixed effects enables me to examine changes in the credit lines offered by shocked dealers versus those offered by unshocked dealers immediately following the policy change. The FE approach tests whether the same IMC borrowing from two different dealers experiences a larger increase in lending from a dealer who is more exposed to the credit supply shock.

My regression specification allows me to estimate how the dealers passed their liquidity shock on to the IMCs post BAPCPA. By studying the increase in value of credit lines offered by shocked dealers relative to unshocked dealers within an IMC, I tease out the increase in credit supplied to an IMC that is caused by the shock to dealer collateral. In addition to $IMC \times QuarterFE$ to control for IMC demand confounders, I include $DealerFE$ to control for unobserved dealer heterogeneity that may be constant overtime. This setting allows me to isolate the increase in credit supply that was caused by BAPCPA. I run the following regression specification:

$$\log(CreditLine_{i,j,t}) = \gamma_{i,t} + \eta_j + \beta Post_t \times Treated\ Dealer_j + \epsilon_{i,j,t} \tag{2.4}$$

Where $\log(CreditLine_{i,j,t})$ is the log of the credit line extended to IMC i by dealer j at quarter t. $Treated\ Dealer_j$ is an indicator variable that equals one for treated dealers - those who were in the top quartile of underwriters for Subprime Residential Mortgage-Backed Securitized deals in 2004 as defined in the previous section. I argue that these dealers were more active in private-label MBS securitization pre-shock and held more of this collateral as a fraction of total assets. I assume that this made dealers differentially advantaged after the shock since a larger fraction of their total assets would have become liquid post shock. $Post_t$ is an indicator variable that equals one for the second quarter of 2005 and later - since BAPCPA was passed in April 2005 - and zero otherwise. β is the coefficient of interest. It is the coefficient on the interaction term that equals one for treated dealers in the post period. The coefficient on $Post_t \times Treated\ Dealer_j$ measures the difference in lending between treated and untreated dealers after the shock less the difference between the two before the shock. Since the liquidity shock occurs at the dealer level, changes in credit lines from the same dealer may be correlated. I observe 27 dealers lending to the IMCs in my sample. I cluster my standard errors at the dealer level. $\gamma_{i,t}$ contains fixed effects for $IMC_i \times Quarter_t$ and η_j contains fixed effects for each $Dealer_j$. These fixed effects allow me to control for demand shocks to the IMCs by holding the IMC constant and studying changes to IMC credit lines offered by shocked and unshocked dealers within a given IMC pre and post shock. Table 2.3 presents the FE specification with a total of twelve IMCs and 539 credit lines extended to the IMCs from the dealers between 2004Q3 and 2006Q3. The results indicate a large dealer lending channel effect. Being a treated dealer is associated with a 28.9% increase in lending relative to untreated dealers post shock. The $IMC_i \times Quarter_t$ fixed effects absorb time-varying firm-specific factors, including firm specific credit demand shocks. The results suggest that immediately after BAPCPA passed, dealers who were more exposed to private-label mortgage collateral prior to the shock differentially increased their lending to IMCs.[32]

[32]The credit lines are measured as warehouse lines of credit and warehouse repurchase facilities reported in the IMCs' annual and quarterly reports.

Table 2.3. Within Mortgage Company Across Dealer Analysis

	log(Credit Line)
Post × Treated Dealer	0.289**
	(0.127)
IMCxQuarterFE	Yes
DealerFE	Yes
r2	0.7061
N	539

Notes: Table reports the response of treated dealer funding relative to untreated dealer funding within a given IMC post BAPCPA. I run the regression

$$\log(Credit\ Line_{i,j,t}) = \gamma_{i,t} + \eta_j + \beta Post_t \times Treated\ Dealer_j + \epsilon_{i,j,t}$$

$\log(Credit\ Line_{i,j,t})$ is the log of the credit line extended to IMC i by dealer j at quarter t. $Treated\ Dealer_j$ is an indicator variable that equals one for treated dealers - those who were in the top quartile of underwriters for Subprime Residential Mortgage-Backed Securitized deals in 2004. $Post_t$ is an indicator variable that equals one for the second quarter of 2005 and later - since BAPCPA was passed by Congress on April 20, 2005 - and zero otherwise. β is the coefficient of interest. It is the coefficient on the interaction term that equals one for treated dealers in the post period. The coefficient on $Post_t \times Treated\ Dealer_j$ measures the difference in lending between treated and untreated dealers after the shock less the difference between the two before the shock. Since the liquidity shock occurs at the dealer level, changes in credit lines from the same dealer may be correlated, I observe 27 dealers lending to the IMCs in my sample, I calculate the standard errors clustered at the dealer level. $\gamma_{i,t}$ contains fixed effects for $IMC_i \times Quarter_t$ and η_j contains fixed effects for each $Dealer_j$.

In Figure 2.5, I trace out the response of dealer volume of lending to IMCs overtime. In Equation 2.5, I run the dynamic version of Equation 2.4. I plot the coefficient on an indicator variable that interacts dealer treatment with an indicator for each quarter pre and post the shock. The indicator variable is set to zero in 2005Q1, the quarter before BAPCPA was passed. This figure shows that prior to BAPCPA, treated and untreated dealers' lending volume to IMCs is similar. Post BAPCPA, however, the shocked dealers begin to lend differentially more than untreated dealers within a given IMC. In the following section, I will present suggestive evidence that mortgage companies were not substituting their borrowing away from untreated dealers and toward treated dealers post shock but rather supply of credit overall was increasing.

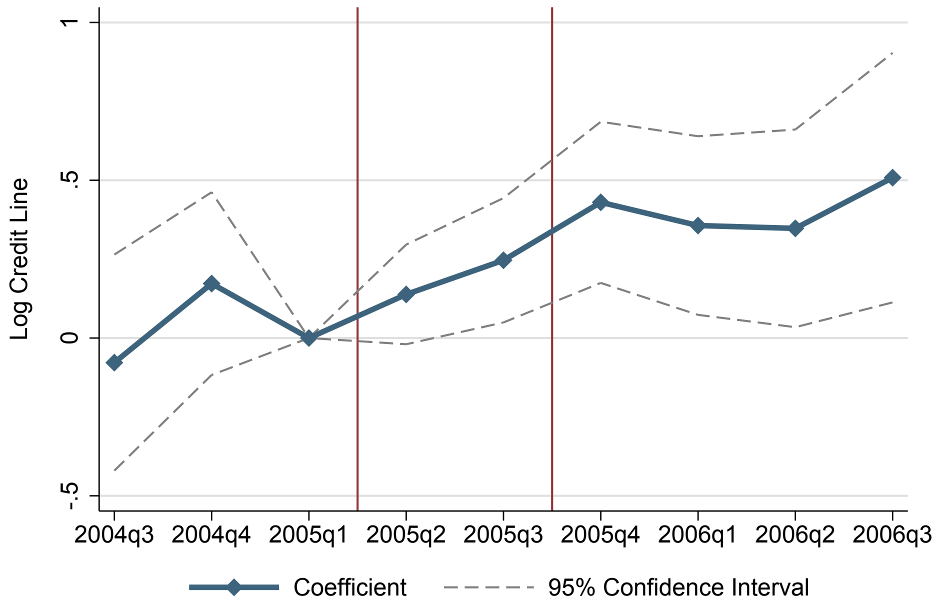
$$\log(CreditLine_{i,j,t}) = \gamma_{i,t} + \eta_j + \sum_T \beta_T \; Treated\ Dealer_j \times \mathbb{1}_{t=T} + \epsilon_{i,j,t} \tag{2.5}$$

The fixed effects strategy that I use does not require that dealer liquidity supply shocks and IMC demand shocks are uncorrelated since the mortgage company fixed effects will absorb any mortgage company demand shocks. One potential concern however is that the BAPCPA shock to dealer liquidity was anticipated so that dealers could adjust their lending to IMCs prior to the law change. If there was an adjustment due to anticipation, this would bias my results downward since treated dealers should increase their lending relative to untreated dealers in the pre-period, not only in the post-period. That said, there does not appear to be any anticipation in the pre-trends plotted in Figure 2.5. If the shock was anticipated, I would expect to see the treated dealers increase their lending to IMCs prior to 2005Q2, however Figure 2.5 represents the coefficient on $\log(Credit\ Line_{i,j,t})$ extended to the IMCs and it does not seem to be trending up in the pre-period.

2.4.2.2 Dealer Lending to Mortgage Companies - Suggestive Evidence

In the previous section, I established that following BAPCPA, mortgage companies' borrowing from treated dealers increased relative to their borrowing from untreated dealers. I present evidence that the effect is not that mortgage companies substitute away from untreated dealers toward treated dealers, but that there is an overall credit supply expansion following BAPCPA. To establish this, I break these twelve IMCs into two groups, "treated IMCs" - the six mortgage companies that receive an above median fraction of their warehouse credit lines from shocked dealers and "untreated IMCs" - the six that receive a below median fraction of their warehouse

Figure 2.5. Effect of Dealer Treatment Effect on Credit Lines to Independent Mortgage Companies (IMC)



Source: Quarterly Filings.

Notes: Figure plots the dynamic response of treated dealer funding relative to untreated dealer funding within a given IMC pre and post BAPCPA. I run the regression

$$\log(CreditLine_{i,j,t}) = \gamma_{i,t} + \eta_j + \sum_T \beta_T \; Treated \; Dealer_j \times \mathbb{1}_{t=T} + \epsilon_{i,j,t}$$

Where $\log(CreditLine_{i,j,t})$ is the log of the credit line extended to IMC i by dealer j at quarter t. $Treated \; Dealer_j$ is an indicator variable that equals one for treated dealers - those who were in the top quartile of underwriters for Subprime Residential Mortgage-Backed Securitized deals in 2004. $Post_t$ is an indicator variable that equals one for the second quarter of 2005 and later - since BAPCPA was passed by Congress on April 20, 2005 - and zero otherwise. β_T is the coefficient of interest. It is the coefficient on the indicator variable that interacts dealer treatment with an indicator for each quarter pre and post shock. The indicator variable is set to zero in 2005Q1, the quarter before BAPCPA was passed. Since the liquidity shock occurs at the dealer level, changes in credit lines from the same dealer may be correlated. I calculate the standard errors clustered at the dealer level. $\gamma_{i,t}$ contains fixed effects for $IMC_i \times Quarter_t$ and η_j contains fixed effects for each $dealer_j$.

I plot the coefficient β_T. This figure shows that prior to BAPCPA, treated and untreated dealers lending volume to IMCs is similar. Post BAPCPA, however, the treated dealers begin to lend differentially more to IMCs.

credit lines from shocked dealers during the pre-treatment period. I present descriptive statistics of the treated versus control IMCs in Table 2.4. I find that there is no significant difference between treated and control mortgage companies pre-treatment.

Table 2.4. Independent Mortgage Company (IMC) Descriptive Statistics (2004)

	Mean (Control)	Mean (Treated)	Difference	P-value
log(Total Assets)	14.3	14.9	-.6	.593
log(Originations)	6.4	7.4	-1.1	.430
Number of Counties	1708	1976	-268	.660
N	6	6		

Notes: Independent Mortgage Companies (IMCs) descriptive statistics collected from quarterly filings and HMDA data.

$$\log(CreditLine_{i,t}) = \beta \ Post \times Treated \ IMC_i + \gamma_i + \alpha_t + \epsilon_{i,t} \tag{2.6}$$

In Equation 2.6, I regress $\log(CreditLine_{i,t})$ for a given mortgage company i in quarter t on an interaction term between an indicator variable equal to one in the post period and an indicator equal to one for $Treated\ IMC_i$. $CreditLine_{i,t}$ is defined as the sum of maximum value of credit lines that a mortgage company receives from eah dealer, j, that it is linked to in a given quarter: $CreditLine_{i,t} = \sum_j CreditLine_{i,j,t}$. I include mortgage company fixed effects γ_i and quarter fixed effects α_t. There are twelve mortgage companies so I calculate my standard errors using bias-adjusted cluster version of heteroskedasticity consistent standard errors. I follow the advice of Imbens and Kolesar (2016) and apply the "LZ2" correction to the standard errors and compute confidence intervals using a t-distribution with degrees of freedom suggested by (32). Imbens and Kolesar present Monte Carlo evidence that the resulting confidence intervals have good coverage even with as few as five clusters or unbalanced cluster size ((27)).[33] The results presented in Table 2.5, suggest that a treated mortgage company increases its total value of maximum credit lines by 13.8% in the post period relative to untreated mortgage companies. This evidence is consistent with a total increase in lending to mortgage companies with an above median fraction of their credit lines from treated dealers post BAPCPA rather than a substitution of lending from untreated to treated dealers within a mortgage company.

Table 2.5. Treated IMC Credit Lines

	log(Credit Line)
Post × Treated IMC	0.138*
	(0.059)
IMCFE	Yes
QuarterFE	Yes
r2	0.9427
N	102

Notes: Table reports the response of the $\log(CreditLine_{i,t})$ for a given mortgage company i in quarter t as function of whether or not the mortgage company was treated.

$$\log(Credit\ Line_{i,t}) = \beta\ Post \times Treated\ IMC_i + \gamma_i + \alpha_t + \epsilon_{i,t}$$

I define a treated mortgage company to be a mortgage company who received an above median fraction of its credit lines from treated dealers in the pre-period. I include mortgage company fixed effects γ_i and quarter fixed effects α_t. There are 12 mortgage companies so I calculate my standard errors using bias-adjusted cluster version of heteroskedasticity consistent standard errors as in Imbens and Kolesar (RESTAT 2016) using the Bell-McCaffrey degrees of freedom adjustment as in Imbens and Kolesar (RESTAT 2016). I follow code provided by Gabriel Chodorow-Reich: https://scholar.harvard.edu/chodorow-reich/data-programs ((13)).

In Figure 2.6, I plot the average number of dealers that an IMC was borrowing from pre and post BAPCPA. Prior to the shock an average of five dealers were lending to IMCs, directly following 2005Q2, when BAPCPA was passed, the average number of dealers lending to an IMC began to increase. By 2006Q1, the average number of dealers lending to an IMC increased to

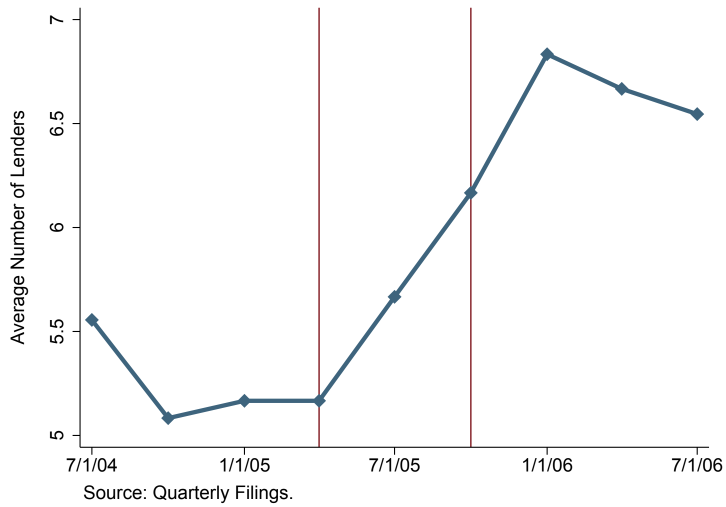
[33] I follow code provided by Gabriel Chodorow-Reich: https://scholar.harvard.edu/chodorow-reich/data-programs ((13)).

seven. This implies that more dealers were moving into funding arrangements with mortgage companies post shock, suggesting that funding mortgage collateral became more profitable post BAPCPA. In Figure 2.6, I plot the average total value of warehouse credit lines extended to an IMC pre and post the shock. To calculate the average total value of warehouse lines of credit received by each IMC, I aggregate the maximum value of warehouse lines of credit plus repurchase agreements received by an IMC. I average the total value across all of the twelve IMCs in the sample. I find that prior to the shock the total average value of IMC warehouse credit lines had remained stable around \$3 billion dollars, however post shock the average total value of warehouse credit lines extended to IMCs increased sharply to close to \$5 billion dollars.

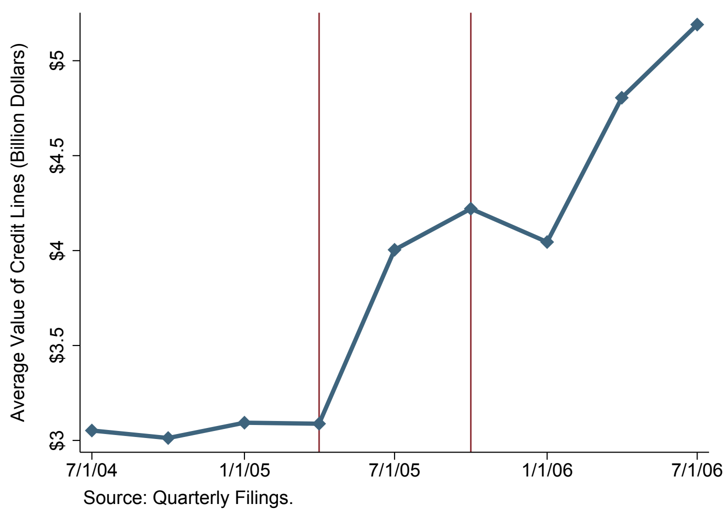
In addition to dealers increasing their credit lines to mortgage companies, I find evidence that post BAPCPA, the dealers loosened the covenants that they imposed on the credit lines. Dealers imposed covenants on the credit lines in the form of sublimits of funding available for certain types of mortgage loans. Post shock, I present evidence that dealers increased the sublimits of funding allowed to finance risky mortgage products. For example, in Figure 2.7, I show that the maximum amount of funding provided for interest only, second-lien, jumbo, non-owner occupied, and 120-180 day past due loans all doubled post BAPCPA. This loosening of covenants that dealers imposed on their credit lines to mortgage companies suggests that dealers incentivized the mortgage companies to originate riskier mortgage products. I provide a more detailed examination of lender-mortgage company pair funding lines in Appendix section A.3 which has additional interesting ramifications that support my claim that the credit lines increased in size and risk post shock.

Combined with Appendix section A.3, evidence suggests that not only did dealers increase the value of implicitly unsecured funding, but they also lowered the cost of funding this form of collateral. Dealers extended credit to IMCs via both "*dry*" funding and "*wet*" funding. Dry funding is when the mortgage company posts collateral that has already been created, and

Figure 2.6. Average Credit Lines to Mortgage Companies



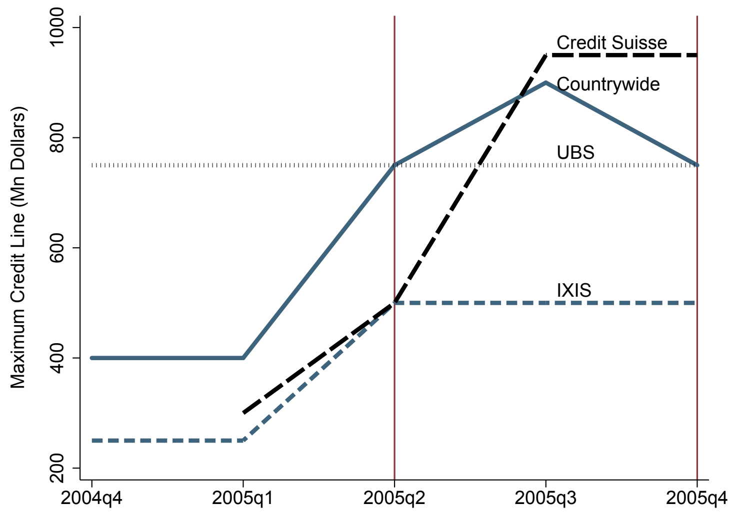
(a) Average Number of Credit Lenders per Mortgage Company



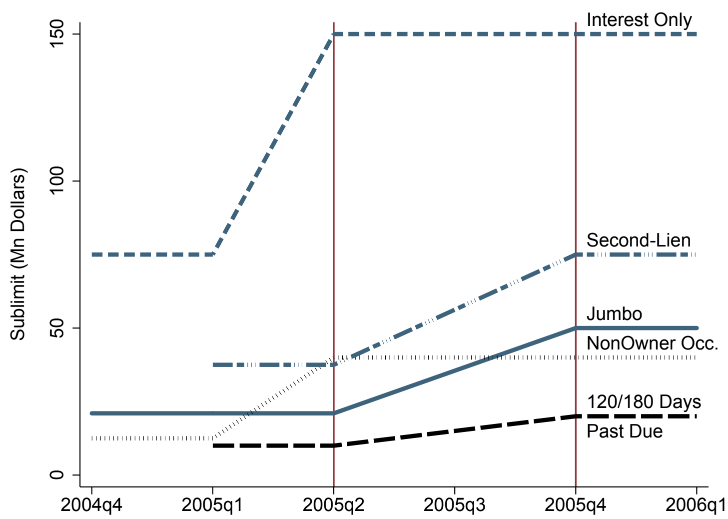
(b) Average Total Value of Credit Lines Available per Mortgage Company

Notes: Figures plot the average number of dealers lending to the Independent Mortgage Companies (IMCs) in my sample pre and post BAPCPA and average total value of credit lines available to an IMC. Post BAPCPA, the average number of dealers lending to an IMC and the average total credit extended to an IMC began to increase. This data is taken from IMC quarterly filings. Both figures include all twelve IMCs in my regression analysis. The second figure also includes GMAC which only reports aggregate data on the warehouse credit lines that it receives.

Figure 2.7. Credit Lines to an Example Mortgage Company



(a) Maximum Credit Line

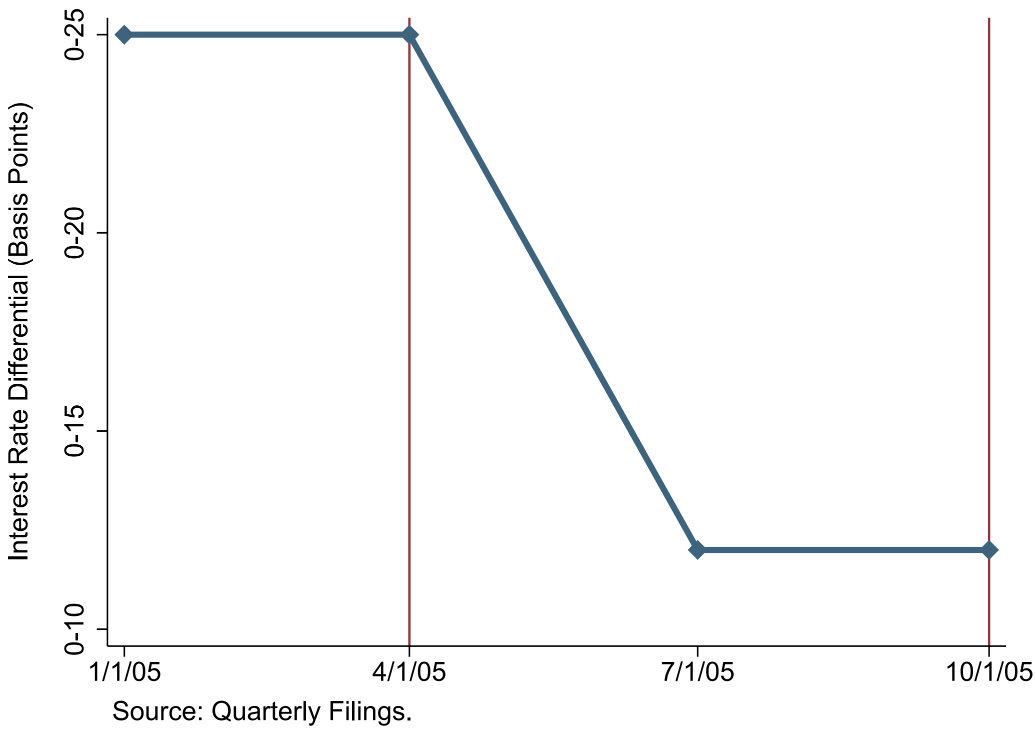


(b) Sublimits by Collateral Type

Notes: The first figure plots the maximum credit line values extended to an example mortgage company by dealers pre and post shock. The second figure plots the sublimit of funding available to fund certain mortgage products. In other words, the dealers would offer a maximum credit line value with covenants that specified the maximum amount of funding per credit line that could be applied to fund certain mortgage products.

transfers the loan documents, in order to receive a warehouse line of credit. Wet funding on the other hand is when the IMC posts collateral that has not yet been created, and therefore transfers no loan documents, in order to receive a warehouse line of credit. Since wet funding was implicitly unsecured, the interest rate differential charged on wet funding was greater than that charged on dry funding. In Figure 2.8, I plot the interest rate differential that a mortgage company in my sample reports on wet funding relative to dry funding. It fell from 0 to 25 basis points to 0 to 12 basis points post shock.

Figure 2.8. Interest Rate Differential between Secured and Implicitly Unsecured Credit



Notes: Figure plots the interest rate differential between credit lines backed by "wet" vs. "dry" collateral for an example mortgage company. Dry funding is secured by collateral that has already been created by the IMC, and requires that the loan documents be transferred to the dealer. Conversely, wet funding is implicitly unsecured. It is when the IMC posts collateral that has not yet been created, and therefore transfers no loan documents. This data is collected from IMC quarterly filings.

2.5 Conclusion

I present a mechanism by which a credit supply shock operates in the repo markets. Dealers are able to generate liquidity by intermediating between two segments of the repo markets. To do this, they receive collateral in one segment and re-use the same collateral in another segment. This re-use of collateral creates a money multiplier effect and increases dealer leverage. Expanding the classes of collateral that dealers can re-use in this way enhances the ability of dealers to generate liquidity. When the collateral classes added are riskier, they require larger differences in overcollateralization between the two repo markets - increasing the potential for dealers to leverage themselves. This can lead to a large expansion of credit and the desire to invest in the risky asset.

I present empirical evidence that this mechanism contributed to both the credit boom and bust in the second half of the 2000s. I hand collect novel data on dealer to mortgage company credit lines. This data allows me to conduct an across dealer, within firm, analysis to causally estimate the extent to which dealers pass a credit supply shock on to the firms that depend on them. In the context of the mortgage market in the second half of 2000s, I find that in response to a liquidity shock, dealers increased their lending to mortgage companies and loosened covenant restrictions on their credit lines incentivizing mortgage companies to originate more and riskier mortgages.

My paper contributes to the debate on exemptions from automatic stay in the repo markets. (37) states that the main argument supporting automatic stay is that it reduces systemic risk in the repo markets by reducing frictions on the collateral in bankruptcy. However in this paper, I provide evidence that contradicts this claim and sheds light on an important mechanism through which changes in regulatory changes create liquidity shocks that originate in the repo market and cascade to the firms linked to the repo market. This evidence suggests that BAPCPA contributed to the overall systemic risk of the repo markets and amplified the effects of the financial crisis by incentivizing dealers to increase funding for riskier mortgage assets.

CHAPTER 3

Quantifying a Credit Supply Shock Outside the Regulated Banking Sector

3.1 Introduction

The Bankruptcy Abuse Prevention and Consumer Protection Act (BAPCPA), passed by Congress in April 2005, created a credit supply expansion to mortgage companies. It incentivized them to originate non-traditional mortgages in order to generate enough volume to meet demand in the repo market. (36) attribute the boom and bust in home prices to housing speculation by "flippers," or homebuyers purchasing investment properties. This chapter explores who was funding these speculators during 2005 through early 2007.

To understand how the policy change affected mortgage originations, I conduct a county-level analysis. I exploit variation in a county's pre-period exposure to the mortgage companies that receive an above-median fraction of their funding from dealer banks who were most affected by the policy change. I conduct a difference-in-differences analysis where I utilize variation in the county level market share of the treated mortgage companies in 2004, the year before the shock. Prior to the shock, I observe no statistical difference in mortgage characteristics between counties with low mortgage company market share versus counties with high market share. Post shock, I find that counties with higher treated mortgage company exposure increased their mortgage originations and originated riskier mortgages in response to the shock. I find that a 10% increase in treated mortgage company market share leads to an 8.7% increase in mortgage originations. Not only did the number of originations increase but the distribution of these originations significantly shifted toward balloon, adjustable-rate with artificially low introductory "teaser" rates, interest-only, negative amortizing, and non-owner-occupied mortgages. Shifting the composition of the mortgage market toward these mortgage products increased the risk in the market since these mortgages were more sensitive to interest rate resets and home prices ((22)).

I find that these risky mortgage originations contributed to the "last gasp" in the increase in originations, driving up home prices in the short run. However, these mortgage products were the most vulnerable to default in the crisis. Within a five-month window around the shock, a loan originated one month post shock in a county with a higher mortgage company market share was twice as likely to default relative to a loan originated in that county one month prior to the shock. Consistently, I find that a 10% increase in treated mortgage company market share led to a statistically significant increase in home prices of 9.5% during 2005-2006 and to a significant 19% decrease in home prices during 2007-2008.

My results suggest that the increase in home prices masked the increased risk of these new mortgages. Once home prices stopped rising, these mortgages were at a greater risk of negative equity and were very sensitive to interest rates. This increased likelihood of negative home equity created an environment where borrowers were more likely to default if home prices fell. I estimate the total increase in mortgage originations in response to BAPCPA and the total fraction of mortgage defaults that they comprised. I find that mortgage originations in response to BAPCPA were a relatively small fraction of total originations, between 2%-9% depending on assumptions. However, these mortgages comprised a large fraction of total defaults in the crisis. Among all mortgages originated during 2005-2006, I estimate that mortgages originated in response to BAPCPA account for 14%-38% of defaults depending on assumptions. This evidence sheds light on the puzzle of why 2006 and 2007 vintage mortgage loans were of worse quality than 2001-2005 mortgage loans even after controlling for borrower characteristics ((16), (39)).

My results are consistent with BAPCPA causing an amplification effect by incentivizing both the substitution away from traditional forms of financing toward unstable short-term repo financing as well as the increased investment in risky mortgage products. As the mortgage companies originating the risky mortgages began to falter, they faced margin calls on their repo warehouse credit lines which forced them into bankruptcy. By early 2007, I observe the majority of mortgage companies in my sample fail and either get acquired by one of their dealer-lenders or declare bankruptcy. The bankruptcy filings in all cases were triggered by the mortgage company's inability to meet margin calls or other requirements stipulated on their repo credit lines. I argue that these mortgage company failures decreased the amount of credit available to fund potential homebuyers, lowering demand for housing and exacerbating home price declines - precisely in the areas with heavy use of the mortgage products likely to default in the event of home price declines. The significant 19% decline in home prices that I estimate in counties more exposed to treated mortgage companies during 2007-2008 is consistent with this amplification effect. My work provides evidence that the 27 most central dealer-banks were disproportionately exposed to these mortgage defaults and mortgage company failures due to their role as warehouse lenders.

3.1.1 Data

3.1.2 Mortgage Market Data

I conduct a county level analysis where I study the effect of independent mortgage company market share in a given county on mortgage characteristics in that county pre and post BAPCPA.

I rely on the HMDA data definition of originators as independent mortgage companies if they underwrite and fund a loan in their own name.

3.1.2.1 HMDA Data

The HMDA data are loan application-level data constructed from disclosure reports submitted by mortgage lenders.[1] These data include various characteristics of the loan and applicant including the originator of the loan. However, the public version of the data only reports the year that a loan is created. I use these data to construct the county level market share of independent mortgage companies in 2004, the year prior to the shock. This exposure measure allows me to study how county level mortgage characteristics vary pre and post the policy change as a function of the county's exposure to mortgage companies affected by the shock. I calculate the IMC market share as the number of mortgage originations originated by IMCs in a county relative to the total number of mortgages originated in that county in 2004. I calculate the market share variable both for all IMCs as well as for a subset of the IMCs who I will designated as "treated IMCs" and I will use these measures to conduct two parallel analyses.

To calculate IMC market share, I use the crosswalk maintained by Robert Avery to match subsidiaries belonging to the same parent company[2] to identify the originator of a given mortgage loan. This allows me to aggregate all mortgages originated by subsidiaries of the same parent company. I use the HMDA data to identify which originators were IMCs.[3] I then aggregate the total number of mortgage originations originated by IMCs in a given county and divide it by the total number of all mortgage originations in that county. I also construct the IMC county level market share in 2004 based on value of mortgage originations and the results are similar.

[1]https://www.ffiec.gov/hmda/hmdaproducts.htm

[2]Available upon request at Robert.Avery@fhfa.gov.

[3]I merge the public HMDA data with the subset of confidential HMDA data that I have in order to identify IMCs using the TYPE variable in the confidential data. I merge the TYPE variable onto the public HMDA data using the mortgage originator identifiers (HM5RID and CODE).

To study total mortgage originations as well as purchase and refinance mortgages at the county month level, I merge IMC county market share onto the HMDA data reported at the county month level.[4]

3.1.2.2 CoreLogic Data

I use the CoreLogic Loan Level Market Analytics (LLMA) data to study county level mortgage characteristics of the mortgages originated by IMCs pre and post BAPCPA. The LLMA contain detailed information on mortgage characteristics at origination as well as monthly performance data for a large sample of anonymized borrowers. CoreLogic collects this data from 25 of the largest mortgage servicers in the United States. The LLMA data track approximately 5.7 million mortgages each year and in a typical year include 45% of mortgages originated in the US over the sample period (2003-2008). I use variables captured in the LLMA origination data that record a loan's initial interest rate and occupancy status as well as whether a loan is a balloon mortgage, a negative amortization mortgage, or an adjustable rate mortgage (ARM). I aggregate these statistics up to the county level and merge the IMC county market share. This allows me to analyze the effect of 2004 IMC county market share on changes in loan characteristics in response to BAPCPA 2005.

I use the mortgage monthly performance data over the life of a loan in order to study whether a loan enters default at some point in its lifetime. I use the variable "mba_delinquency_status" which records the status of the borrower's payments on the loan in accordance with the Mortgage Bankers' Association (MBA) standards including indicators for foreclosure, bankruptcy, and REO. REO stands for Real Estate Owned properties, which are home properties that have been seized by banks or other lenders from borrowers who are unable to pay their mortgages.

[4] Neil Bhutta publishes the HMDA data reported at the county month level on his personal website: https://sites.google.com/site/neilbhutta/data.

3.1.3 Home Price Data

In order to study the effect of BAPCPA on home prices at the county level, I use the county level Zillow Home Value Index (ZHVI). ZVHI is a time series tracking the monthly median home value in a particular county across the sample period.

3.2 Mortgage Company Lending

I have shown above that a positive shock to dealer liquidity translates into dealers sending increased credit lines to the mortgage companies that they fund. However, this increased lending to mortgage companies need not have any effect on real outcomes if the mortgage companies do not lend the money out to homebuyers. In this section, I study the final step of the chain - how do the independent mortgage companies (IMCs) pass the credit supply shock on to households? I first study the effect on mortgages originated by the six treated mortgage companies in my sample - the companies which received an above median fraction of their credit lines from treated dealers prior to the shock. I hypothesize that mortgage companies that receive more of their funding from shocked dealers will increase the volume of their originations in response to an influx of funding from their funders post shock. Due to data limitations, I do not observe the mortgage originator in the loan level data that I use. Therefore I conduct a county level analysis where I create a variable that captures the exposure of a county to the treated mortgage companies in 2004, the year prior to the shock. I call this variable $TreatedIMCMarketShare_{c,2004}$. I calculate this variable as

$$TreatedIMCMarketShare_{c,2004} = \frac{Number\ of\ originations\ by\ \textbf{treated}\ IMCs\ in\ a\ county\ in\ 2004}{Total\ number\ of\ all\ originations\ in\ a\ county\ in\ 2004}$$

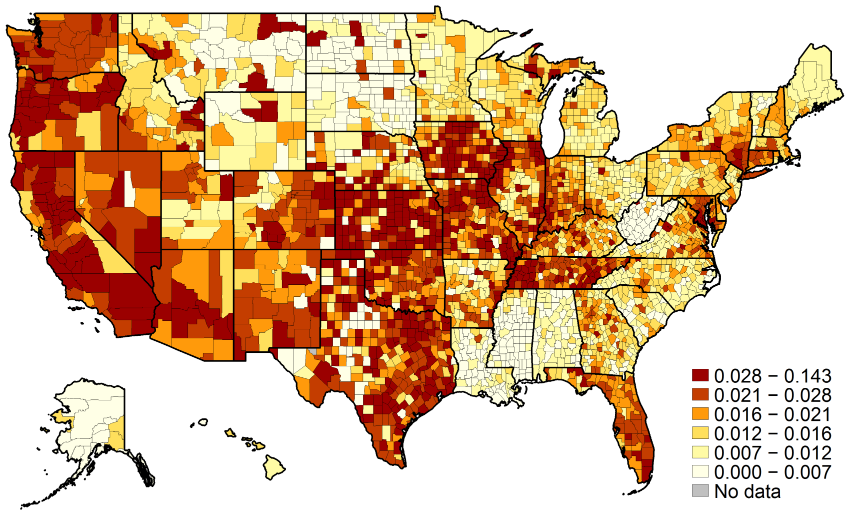
In order to understand the aggregate extent to which mortgage companies passed their credit supply shock on to the public, I conduct a county level analysis where I study how $TreatedIMCMarketShare_{c,2004}$ affects mortgage originations in a given county. The heterogeneity comes from the variation in the market share of treated mortgage companies in a given county prior to the passing of BAPCPA. Figure 3.1 depicts the county level market share of treated independent mortgage companies in the United States in 2004. The states with the highest county level market shares are California, Nevada, Florida, parts of Texas and parts of Colorado. Many of these areas faced large expansions in home prices leading up to the Financial Crisis and large contractions in home prices directly following the crisis. I will argue that BAPCPA amplified the housing boom and bust in these areas by creating a credit supply expansion to the independent mortgage companies lending in these counties, leading mortgage companies to originate non-traditional mortgages in order to generate mortgage volume to meet the demand in the repo market.

I run the following dynamic regression.

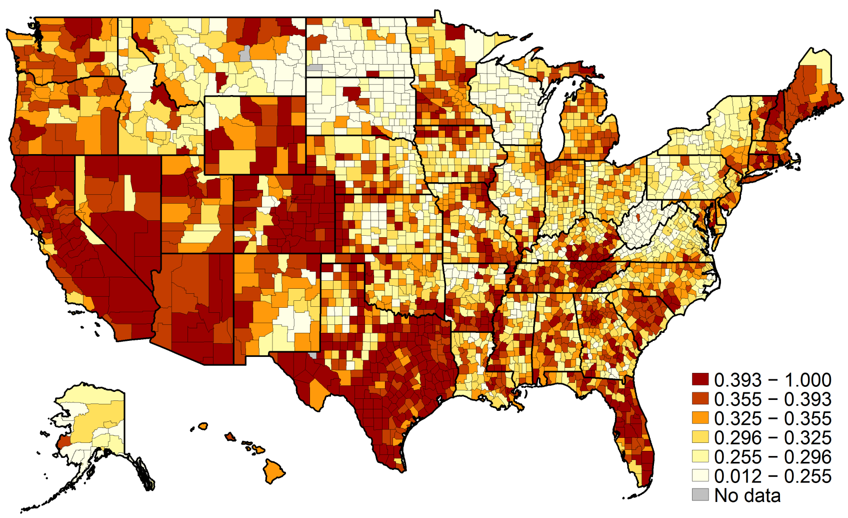
$$Y_{c,t} = \gamma_c + \eta_{s,t} + \sum_{T} \beta_T TreatedIMCMarketShare_{c,2004} \times \mathbb{1}_{t=T} + \epsilon_{c,t} \tag{3.1}$$

Where $Y_{c,t}$ is the variable of interest in county, c at time t. γ_c represents county level fixed effects, $\eta_{s,t}$ represents $state \times month$ fixed effects, $TreatedIMCMarketShare_{c,2004}$ is the IMC county level market share in a given county in 2004, the year before the shock occurs. I set the reference month to March 2005, the month prior to the passage of BAPCPA. In Equation 3.2, I run the equivalent regression to Equation 3.1, however with a single pre-period and a single post-period in order to estimate the cumulative effect of the shock in the post period. For each regression specification, I include both the dynamic response plots as well as the pooled pre- and post-period regression coefficients. Standard errors are clustered at the county level.

FIGURE 3.1. INDEPENDENT MORTGAGE COMPANY (IMC) MARKET SHARE



(a) Six Treated IMCs



(b) All IMCs

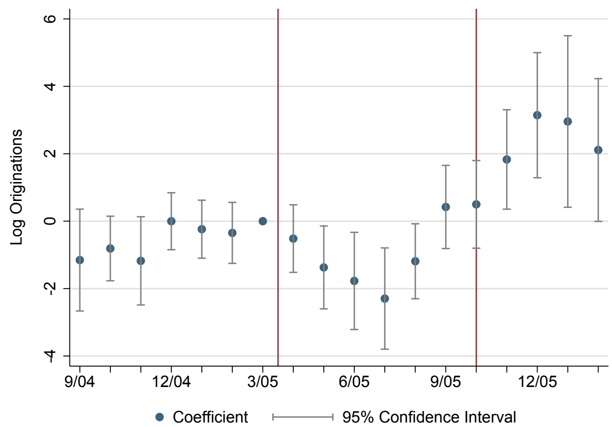
Notes: The first figure depicts the county level market share of the six treated independent mortgage companies (IMCs) reported in 2004. The second figure depicts the county level market share of all IMCs reported in 2004. Data source: public HMDA data.

$$Y_{c,t} = \gamma_c + \eta_{s,t} + \beta \; Post_t \times TreatedIMCMarketShare_{c,2004} + \epsilon_{c,t} \tag{3.2}$$

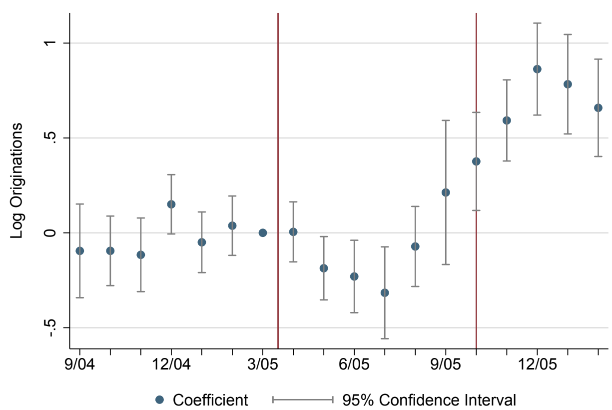
The first right hand side variable of interest that I study is $\log(Originations)$ at the county month level. Originations is total mortgage originations. It includes both refinance mortgages, which are originated in order to refinance an existing mortgage loan, as well as purchase mortgages, which are mortgage loans originated for the purpose of purchasing a home. I study the HMDA mortgage origination data aggregated at the county month level. I include additional results for $\log(Refinance\ Originations)$, and $\log(Purchase\ Originations)$ in Appendix section B.1. I find that total mortgage originations increase disproportionately in counties where there was a higher IMC market share in 2004. I plot the evolution of the coefficient of interest from September 2004 to February 2006 in Figure 3.2. This plot shows that originations in counties that had a higher IMC market share in 2004 were not statistically different from other counties prior to the policy change. Post BAPCPA however, counties with a higher market share of treated mortgage companies increased their total number of mortgage originations relative to counties with lower mortgage company market shares after BAPCPA was passed. In Table 3.1, I present the results from Equation 3.2, the regression with a single pre and post period. I find that if a county increases its mortgage company market share by 10%, the number of mortgage originations in a county would increases by 8.7% on average in the post period. This suggests that mortgage companies passed the increased funding that they received in response to BAPCPA on to homebuyers.

I now study whether the additional mortgages originated because of the shock were fundamentally riskier than mortgages originated prior to the shock. The evidence, in the previous section, that dealers loosened covenants on credit lines funding mortgage companies post shock suggests that the mortgages originated post shock would be fundamentally riskier mortgage products such as interest only, non-owner occupied, balloon mortgages and that mortgage companies servicing loans may try less rigorously to keep mortgage borrowers out of default now

Figure 3.2. IMC County Market Share Effect on Total Mortgage Originations



(a) Six Treated IMCs



(b) All IMCs

Notes: Figure plots the dynamic response of total mortgage originations in a given county to the 2004 market share of independent mortgage companies (IMCs) in that county. I run the regression

$$Y_{c,t} = \gamma_c + \eta_{s,t} + \sum_T \beta_T \ (Treated)IMCMarketShare_{c,2004} \times \mathbb{1}_{t=T} + \epsilon_{c,t}$$

$Y_{c,t}$ is $\log(Originations_{c,t})$ in county, c at time t. γ_c represents county level fixed effects, $\eta_{s,t}$ represents $state \times month$ fixed effects, $(Treated)IMCMarketShare_{c,2004}$ is the IMC county level market share in a given county in 2004, the year before the shock occurs. β_T is the coefficient of interest. It is the coefficient on the indicator variable that interacts $(Treated)IMCMarketShare_{c,2004}$ with an indicator for each month pre and post the shock. I set the reference month to March 2005, the month prior to the passage of BAPCPA. I use the public HMDA data to compute the 2004 county level IMC market share and the county month HMDA data to study originations.

TABLE 3.1. IMC COUNTY MARKET SHARE EFFECT ON TOTAL ORIGINATIONS

(a) Treated IMC County Market Share Effect

	(1) log(Originations)	(2) log(Originations)
Post $\times$ TreatedIMCMarketShare$_{c,2004}$	5.533***	0.870
	(0.291)	(0.694)
CountyFE	Yes	Yes
StatexMonthFE	No	Yes
r2	0.9635	0.9946
N	8728	8572

(b) All IMC County Market Share Effect

	(1) log(Originations)	(2) log(Originations)
Post $\times$ IMCMarketShare$_{c,2004}$	0.375***	0.268***
	(0.013)	(0.080)
CountyFE	Yes	Yes
StatexMonthFE	No	Yes
r2	0.9642	0.9947
N	8728	8572

Notes: Tables report the response of total mortgage originations in a given county to the 2004 market share of independent mortgage companies (IMCs) in that county. I run the regression

$$Y_{c,t} = \gamma_c + \eta_{s,t} + \beta \ Post_t \times (Treated)IMCMarketShare_{c,2004} + \epsilon_{c,t}$$

$Y_{c,t}$ is log($Originations_{c,t}$) in county, c at time t. γ_c represents county level fixed effects, $\eta_{s,t}$ represents $state \times month$ fixed effects, $(Treated)IMCMarketShare_{c,2004}$ is the IMC county level market share in a given county in 2004, the year before the shock occurs. β is the coefficient of interest. It is the coefficient on the interaction between $(Treated)IMCMarketShare_{c,2004}$ and the post period. This coefficient measures the change in the dependent variable if $(Treated)IMCMarketShare_{c,2004}$ increased from 0% to 100%. I use the Public HMDA data to compute the 2004 county level IMC market share and the county month HMDA data to study originations. [a]

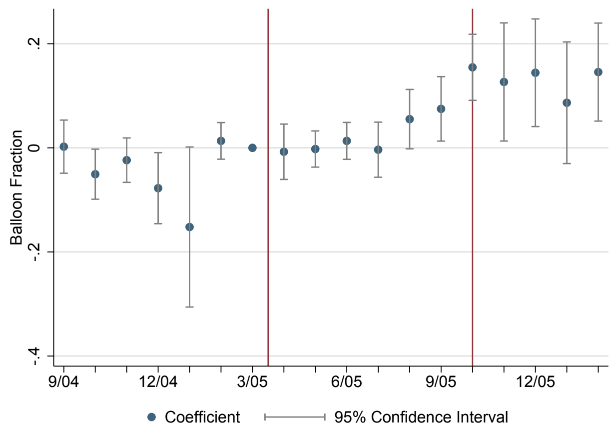
[a]Neil Bhutta publishes the HMDA data reported at the county month level on his personal website: https://sites.google.com/site/neilbhutta/data.

that dealers were willing to accept more 120-180 day past due loans as collateral for their credit lines.

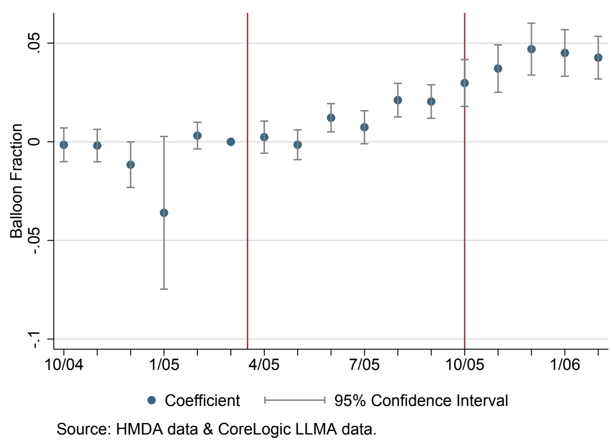
In order to study the effect of BAPCPA on the distribution of mortgage characteristics post shock, I use the CoreLogic database of mortgage originations in the United States. I study the effect of $TreatedIMCMarketShare_{c,2004}$ on the county level origination of balloon mortgages as well as on the introductory interest rates on mortgage originations. I aggregate all variables of interest in the CoreLogic data to the county level and merge on $TreatedIMCMarketShare_{c,2004}$ for each county. I keep the top 5,000 counties that Neil Bhutta uses in his county month HMDA dataset to remain consistent with the above analyses on mortgage originations. I run the regression in Equation 3.1 to study the dynamic effect of $TreatedIMCMarketShare_{c,2004}$ on the fraction of mortgage originations by product type. I find that not only did an increase in $TreatedIMCMarketShare_{c,2004}$ increase mortgage originations in a county but that it shifted the composition of these mortgage originations toward riskier mortgage products.

Balloon mortgages are mortgages that do not fully amortize over the term of the loan, therefore leaving a large balance or balloon payment due at maturity. Borrowers of these mortgages are more likely to experience negative equity when home prices stop rising. They are therefore more likely to default as the borrower may not have the resources to pay off the balance at the end of the loan even if she sells the home and negative equity makes it difficult to refinance. I calculate the fraction of balloon mortgages as the number of balloon mortgages originated in a given county divided by the total number of mortgages originated in that county in a given month. I run the dynamic regression in Equation 3.1, where the dependent variable is fraction of balloon mortgages. In Figure 3.3, I plot the fraction of balloon mortgages each month pre and post BAPCPA from September 2004 to February 2006. I find that prior to BAPCPA, the fraction of balloon mortgages originated in counties with higher IMC market share was not statistically different from other counties. Post shock, not only was there a statically significant

FIGURE 3.3. IMC COUNTY MARKET SHARE EFFECT ON FRACTION OF BALLOON ORIGINATIONS



(a) Six Treated IMCs



(b) All IMCs

Notes: Figure plots the dynamic response of the fraction of balloon mortgage originations in a given county to the 2004 market share of independent mortgage companies (IMCs) in that county. I run the regression

$$Y_{c,t} = \gamma_c + \eta_{s,t} + \sum_T \beta_T \; (Treated)IMCMarketShare_{c,2004} \times \mathbb{1}_{t=T} + \epsilon_{c,t}$$

$Y_{c,t}$ is $Fraction\ Balloon\ Originations_{c,t}$ in county, c at time t. γ_c represents county level fixed effects, $\eta_{s,t}$ represents $state \times month$ fixed effects, $(Treated)IMCMarketShare_{c,2004}$ is the IMC county level market share in a given county in 2004, the year before the shock occurs. β_T is the coefficient of interest. It is the coefficient on the indicator variable that interacts $(Treated)IMCMarketShare_{c,2004}$ with an indicator for each month pre and post the shock. I set the reference month to March 2005, the month prior to the passage of BAPCPA. I use the Public HMDA data to compute the 2004 county level IMC market share CoreLogic origination data.

Table 3.2. IMC County Market Share Effect on Fraction of Balloon Originations

(a) Treated IMC County Market Share Effect

	(1) Balloon Fraction	(2) Balloon Fraction
Post × TreatedIMCMarketShare$_{c,2004}$	0.095***	0.113***
	(0.009)	(0.027)
CountyFE	Yes	Yes
StatexMonthFE	No	Yes
r2	0.1555	0.5191
N	9000	8874

(b) All IMC County Market Share Effect

	(1) Balloon Fraction	(2) Balloon Fraction
Post × IMCMarketShare$_{c,2004}$	0.005***	0.030***
	(0.001)	(0.004)
CountyFE	Yes	Yes
StatexMonthFE	No	Yes
r2	0.1507	0.5239
N	9000	8874

Notes: Tables report the response of fraction of balloon mortgages originated in a given county to the 2004 market share of independent mortgage companies (IMCs) in that county. I run the regression

$$Y_{c,t} = \gamma_c + \eta_{s,t} + \beta\ Post_t \times (Treated)IMCMarketShare_{c,2004} + \epsilon_{c,t}$$

$Y_{c,t}$ is $Fraction\ Balloon\ Originations_{c,t}$ in county, c at time t. γ_c represents county level fixed effects, $\eta_{s,t}$ represents $state \times month$ fixed effects, $(Treated)IMCMarketShare_{c,2004}$ is the IMC county level market share in a given county in 2004, the year before the shock occurs. β is the coefficient of interest. It is the coefficient on the interaction between $(Treated)IMCMarketShare_{c,2004}$ and the post period. This coefficient measures the change in the dependent variable if $(Treated)IMCMarketShare_{c,2004}$ increased from 0% to 100%. I use the Public HMDA data to compute the 2004 county level IMC market share CoreLogic origination data.

increase in the number of balloon mortgages, but there was a statistically significant increase in the fraction of originations that were balloon mortgages post BAPCPA. In Table 3.2, I present the results from Equation 3.2, the regression with a single pre- and post-period. I find that a 10% increase in treated mortgage company market share results in a statistically significant increase in the fraction of balloon mortgages originated in that county by 1.13 percentage points.

I limit the sample to only adjustable rate mortgage (ARM) originations and study the average initial interest rates charged on these mortgages in a county pre and post shock as a function of the market share of treated independent mortgage companies. In Figure 3.4 (a), I plot the response of the $\log(Initial\ Interest\ Rate_{c,t})$ in a given county in response to the 2004 market share of the treated IMCs. I find that prior to the shock, there was no statistical difference in the average initial interest rate charged on mortgages between counties with high and low market share of treated IMCs. However, counties with a higher market share of treated mortgage companies experienced a significant decline in their average initial interest rates post shock. In Table 3.3 (a), I report the results from Equation 3.2, the regression with a single pre- and post-period. I find that a 10% increase in treated mortgage company market share results in a statistically significant decrease in the average interest rate on ARMs in the county by 6.98% after controlling for $state \times month$ fixed effects. The filings of the mortgage companies that I observe report that their adjustable rate mortgages were pegged to the twelve-month treasury rate. In Figure 3.4 (c), I show that the twelve-month treasury rate over this period was increasing monotonically. This evidence is consistent with mortgage companies creating mortgages with low initial "teaser" interest rates. These interest rates would not reflect the true interest payment required to fully amortize the loan but rather an artificially low interest rate advertised to attract potential borrowers. The interest rates would reset to the actual interest rate after a specified point in time, potentially causing the risk of "payment shock" to the borrower.

The evidence that I have presented above is consistent with treated IMCs shifting their composition of mortgage originations toward riskier mortgage products in response to BAPCPA. This

Table 3.3. IMC County Market Share Effect on Initial Interest Rate

(a) Treated IMC County Market Share Effect

	(1) Log Average Initial Interest Rate	(2) Log Average Initial Interest Rate
Post × TreatedIMCMarketShare$_{c,2004}$	2.497***	-0.698***
	(0.154)	(0.268)
CountyFE	Yes	Yes
StatexMonthFE	No	Yes
r2	0.8456	0.9473
N	9000	8874

(b) All IMC County Market Share Effect

	(1) Log Average Initial Interest Rate	(2) Log Average Initial Interest Rate
Post × IMCMarketShare$_{c,2004}$	0.175***	-0.239***
	(0.006)	(0.033)
CountyFE	Yes	Yes
StatexMonthFE	No	Yes
r2	0.8543	0.9482
N	9000	8874

Notes: Tables report the response of initial interest rates on adjustable rate mortgages in a given county to the 2004 market share of independent mortgage companies (IMCs) in that county. I run the regression

$$Y_{c,t} = \gamma_c + \eta_{s,t} + \beta \ Post_t \times (Treated)IMCMarketShare_{c,2004} + \epsilon_{c,t}$$

$Y_{c,t}$ is $\log(Initial\ Interest\ Rate_{c,t})$ in county, c at time t. γ_c represents county level fixed effects, $\eta_{s,t}$ represents $state \times month$ fixed effects, $(Treated)IMCMarketShare_{c,2004}$ is the IMC county level market share in a given county in 2004, the year before the shock occurs. β is the coefficient of interest. It is the coefficient on the interaction between $(Treated)IMCMarketShare_{c,2004}$ and the post period. This coefficient measures the change in the dependent variable if $(Treated)IMCMarketShare_{c,2004}$ increased from 0% to 100%. I use the Public HMDA data to compute the 2004 county level IMC market share CoreLogic origination data.

evidence supports the view that BAPCPA increased the value of private-label mortgage backed collateral in the repo markets, generating more demand for this collateral. In order to generate more of the collateral, dealers increased their credit lines to mortgage companies and loosened the restrictions on these credit lines. The excess funding and relaxed restrictions on acceptable collateral incentivized the IMCs to originate new and different kinds of mortgages that were inherently riskier in their structure, particularly in a rising interest rate environment, regardless of borrower characteristics. The use of balloon mortgages was increasing and introductory "teaser" interest rates were falling in areas with increased IMC market share post BAPCPA.

I find that post BAPCPA, the increased supply of credit to homebuyers increased the volume mortgage originations in counties where there was a higher market share of mortgage companies in 2004. In order to understand whether increased mortgage originations increased the demand for homes and drove up home prices differentially in these counties, I study the effect of $TreatedIMCMarketShare_{c,2004}$ on home prices. I run the regression in Equation 3.1 where the dependent variable is $\log(HomePrice_{c,t})$. Figure 3.5 (a), plots the coefficient on the term that interacts $TreatedIMCMarketShare_{c,2004}$ with an indicator for each month pre and post the shock. Prior to BAPCPA, $TreatedIMCMarketShare_{c,2004}$ was not associated with a differential change in home prices. Post shock however, the figure shows a clear increase in home prices in counties with higher $TreatedIMCMarketShare_{c,2004}$ between April 2005 and early 2007. I run the regression in Equation 3.2 with a single pre and post period where $Y_{c,t} = \log(Home\ Price_{c,t})$ over the sample from June 2003 to November 2006. The post period is equal to April 2005 and later. Table 3.4 (a) reports the results of the regression. My preferred specification includes both $County$ fixed effects and $State \times Month$ fixed effects, reported in the second column. I find that a 10% increase in treated mortgage company market share is associated with a 9.5% increase in home prices between April 2005 and November 2006, following BAPCPA. This increase in home prices was followed by a steep and significant decline in home prices from mid-2007 to 2008.

This evidence is consistent with an increase in dealer liquidity amplifying the 'last gasp' of the housing boom and its bust. The expansion of credit enabled by BAPCPA facilitated the increased use of balloon mortgages with low introductory interest rates, in a rising interest rate environment. In this way mortgage companies were able to make mortgages more affordable to a new kind of marginal borrower who was investing in investment properties. This drove up the price of homes in these counties, which masked the fragility of the mortgages. Once home prices stopped increasing, these mortgages were at higher risk of negative equity, which would leave the borrower more likely to default. Combined with increased use of adjustable rate mortgages in a rising interest rate environment, these counties experienced higher rates of default. This increased likelihood of default depressed home prices and also caused the mortgage companies to declare bankruptcy. I see almost all of the six treated mortgage companies exit my sample by 2007. I conjecture that the mortgage company failures resulted in a sudden decrease in the amount of credit available to fund mortgages in these counties, lowering demand for homes, and further depressing home prices.

In order to test whether the loans originated by treated IMCs post shock were riskier loans, I study the CoreLogic LLMA performance data. I limit the dataset to loans that were originated within a five-month window around the shock from November 2004 to September 2005. I create an indicator variable $Defaulted\ Loan$ that is set equal to one if the loan ever enters 90 day delinquency, foreclosure, or becomes an REO property in its lifetime and set equal to zero if the loan remains active. If the loans originated post shock by treated IMCs are of riskier quality, I expect the fraction of loans that default at some point in their life to increase in counties with higher IMC market share in 2004 within a narrow window around the shock. I find that in counties with a higher market share of treated IMCs, the fraction of mortgage loans originated in a given month that ever default increased just post shock.

I run the following regression:

$$Defaulted\ Loan_l = \gamma_c + \eta_{s,t} + \sum_T \beta_T\ TreatedIMCMarketShare_{c,2004} \times \mathbb{1}_{t=T} + \epsilon_l \tag{3.3}$$

Table 3.4. IMC County Market Share Effect on Home Price

(a) Treated IMC County Market Share Effect

	(1) log(Home Price)	(2) log(Home Price)
Post × TreatedIMCMarketShare$_{c,2004}$	3.591***	0.953**
	(0.527)	(0.478)
CountyFE	Yes	Yes
StatexMonthFE	No	Yes
r2	0.9771	0.9956
N	19232	18929

(b) All IMC County Market Share Effect

	(1) log(Home Price)	(2) log(Home Price)
Post × IMCMarketShare$_{c,2004}$	0.443***	0.209**
	(0.094)	(0.082)
CountyFE	Yes	Yes
StatexMonthFE	No	Yes
r2	0.9768	0.9957
N	19232	18929

Notes: Tables report the response of log($Home\ Price_{c,t}$) in a given county to the 2004 market share of independent mortgage companies (IMCs) in that county. I run the following regression on data from June 2003 to November 2006.

$$Y_{c,t} = \gamma_c + \eta_{s,t} + \beta\ Post_t \times (Treated)IMCMarketShare_{c,2004} + \epsilon_{c,t}$$

$Y_{c,t}$ is log($Home\ Price_{c,t}$) in county, c at time t. γ_c represents county level fixed effects, $\eta_{s,t}$ represents $state \times month$ fixed effects, $(Treated)IMCMarketShare_{c,2004}$ is the IMC county level market share in a given county in 2004, the year before the shock occurs. β is the coefficient of interest. It is the coefficient on the interaction between $(Treated)IMCMarketShare_{c,2004}$ and the post period. This coefficient measures the change in the dependent variable if $(Treated)IMCMarketShare_{c,2004}$ increased from 0% to 100%. I use the Public HMDA data to compute the 2004 county level IMC market share and the Zillow county level home price index to study home prices.

With this regression, I study the default hazard rate of a loan by month of origination as a function of $TreatedIMCMarketShare_{c,2004}$. γ_c represents county level fixed effects. $\eta_{s,t}$

represents $state \times month$ level fixed effects. $TreatedIMCMarketShare_{c,2004} \times \mathbb{1}_{t=T}$ is the interaction term between the county level market share of treated IMCs in a given county in 2004, the year before the shock occurs, and an indicator variable for the month in which the mortgage was originated. In Figure 3.6, I plot β, the coefficient on the interaction term and I find a statistically significant increase in the default hazard rate of mortgages originated in the months just post shock relative to the months prior to the shock in counties with a higher treated IMC market share. This indicates that the treated mortgage companies began originating riskier loans immediately following the shock.

$$Defaulted\ Loan_l = \gamma_c + \eta_{s,t} + \beta\ Post_t \times TreatedIMCMarketShare_{c,2004} + \epsilon_l \tag{3.4}$$

When I run the regression with a single pre- and post-period in Table 3.5 (a), I find that a 10% increase in IMC market share raises the default hazard rate on mortgages originated in the five months post shock by 11.1 percentage points. This evidence is consistent with treated mortgage companies originating riskier loans post shock.

In the above analyses, I focus on the effects of only the six treated independent mortgage companies - in my sample of twelve mortgage companies - that receive an above median fraction of funding from treated dealers. It is my most conservative analysis. However, all mortgage companies in the United States were likely to be affected by this policy change. (46) notes that independent mortgage companies fund mortgages primarily using funds of warehouse lenders.[5] From my data, I identify dealers as the main funders of independent mortgage companies (IMCs) via warehouse lines of credit. Of the twelve IMCs that I study, I find that on average the total warehouse credit lines provided by dealers equaled 61% of mortgage company total assets. In the analysis that examines dealer lending to mortgage companies in subsubsection 2.4.2.1, I exploit

[5](46) p. 267.

Table 3.5. IMC County Market Share Effect on Default Hazard Rate

(a) Treated IMC County Market Share Effect

	(1) Default Hazard Rate	(2) Default Hazard Rate
Post × TreatedIMCMarketShare$_{c,2004}$	1.887***	1.117***
	(0.383)	(0.275)
CountyFE	Yes	Yes
StatexOrigMonthFE	No	Yes
r2	0.0401	0.0448
N	355154	355134

(b) All IMC County Market Share Effect

	(1) Default Hazard Rate	(2) Default Hazard Rate
Post × IMCMarketShare$_{c,2004}$	0.331***	0.141***
	(0.058)	(0.044)
CountyFE	Yes	Yes
StatexOrigMonthFE	No	Yes
r2	0.0402	0.0447
N	355154	355134

Notes: Tables report the fraction of loans originated in a given county between November 2004 and September 2005 that ever default. I calculate the fraction of loans originated in a given county just prior to April 2005 that ever defaulted and compare it to the fraction of loans originated just post April 2005 in that county that defaulted as a function of the 2004 market share of treated independent mortgage companies (IMCs). I run the regression

$$Defaulted\ Loan_l = \gamma_c + \eta_{s,t} + \beta\ Post_t \times (Treated)IMCMarketShare_{c,2004} + \epsilon_l$$

$Defaulted\ Loan_l$ is an indicator variable set equal to a loan if the loan defaults at any point in its lifetime in county, c at time t. γ_c represents county level fixed effects, $\eta_{s,t}$ represents $state \times month$ level fixed effects, $(Treated)IMCMarketShare_{c,2004}$ is the county level market share in 2004 of a treated IMC in a given county in 2004. β is the coefficient of interest. It is the coefficient on the interaction between $(Treated)IMCMarketShare_{c,2004}$ and the post period. This coefficient measures the change in the dependent variable if $(Treated)IMCMarketShare_{c,2004}$ increased from 0% to 100%. I use the Public HMDA data to compute the 2004 county level IMC market share and the CoreLogic LLMA loan performance data to calculate whether a loan ever defaults.

heterogeneity among dealers' ability to increase their leverage immediately following the policy change. However, I expect that eventually all dealers would have experienced an increase in liquidity due to the policy change. They would have found it profitable to invest in private-label mortgage collateral due to their ability borrow in the tri-party repo market against collateral that they received in the bilateral market. Therefore I expect all independent mortgage companies (IMCs) to be affected by the policy change. I expect to see the volume of mortgage originations increase and mortgage loan characteristics become more lax in counties with higher total IMC market share.

I rerun all of the county level analyses above but now define the dependent variable as the total IMC market share in a given county in 2004, rather than the treated IMC market share in a given county.

$$IMCMarketShare_{c,2004} = \frac{Number\ of\ originations\ by\ \textbf{all}\ IMCs\ in\ a\ county\ in\ 2004}{Total\ number\ of\ all\ originations\ in\ a\ county\ in\ 2004}$$

I report my results in panel (b) of Figure 3.1 - Figure 3.6 and of Table 3.1 - Table 3.5 and in Appendix section B.1. I find that post shock, a 10% increase in IMC market share leads to a 2.7% increase in total mortgage originations in a given county. The riskiness of these mortgages also increased. The dynamic plots show that there were no statistically significant differences in counties with higher mortgage company market share prior to the policy change in April 2005. Post shock, there was a statistically significant increase in the fraction of mortgages that were balloon mortgages, negative amortization mortgages, and second home mortgages in counties with higher IMC market share. I also find that there is a statistically significant decrease in the fraction of mortgages that were owner-occupied and that there was a statistically significant decline in the introductory interest rate for adjustable rate mortgages in counties with higher all IMC market share. Consistent with the analysis using the treated IMC market share as the dependent variable, I find a statistically significant increase in the mortgage default hazard rates for mortgages originated five months post shock relative to five months prior to the shock in counties with higher all IMC market share. I also find that there was a statistically significant increase in home prices from April 2005 through the beginning of 2007 in counties with higher IMC market share, and that home prices in these counties fell disproportionately more between 2007 to 2008.

In Appendix section B.2, I discuss my results using an alternative measure of mortgage default rates. Here the fraction of default is calculated as the number of loans that default in the month that they default relative to all active loans in that month. I find that there is also a statistically significant increase in default in counties with a higher all IMC market share post shock using this alternative measure.

In light of the previous sections, these results provide sobering evidence that BAPCPA encouraged the use and re-use of private-label mortgage collateral in repo markets. This incentivized increased interconnectedness of financial intermediaries at the same time as the assets underlying the collateral that they were trading were becoming riskier. Balloon mortgages and negative amortization mortgages both had the potential for the borrower to owe a large balance at the end of the loan term. In the event of falling home prices, borrowers with these mortgage products would have a higher risk of experiencing negative equity - increasing the likelihood of default. The decreasing fraction of owner occupied mortgages implies that there was a higher fraction of investment properties mortgages which were typically riskier than owner occupied mortgages. In states of the world with falling home prices, these mortgages would have higher default rates, contributing to the fragility of the housing market leading up to the Financial Crisis.

3.2.1 Housing Market Implications of BAPCPA

To understand the overall effect of BAPCPA on the housing market, I calculate the total increase in mortgage originations in response to the shock and the amount that these mortgages contributed to the total defaults that we saw among all mortgages originated during 2005 and 2006. To calculate how many additional originations occurred as a result of BAPCPA, I use my county level originations analysis. The county level analysis directly estimates the increase in mortgages originated by IMCs in response to BAPCPA. One key feature of the Financial Crisis was an unexpected level of mortgage defaults. My analysis allows me to study whether BAPCPA played a role in amplifying the number of mortgage defaults in the economy. My analysis on the the default hazard rates directly before and after the shock allows me to calculate the marginal increase in probability of default on loans originated in response to BAPCPA. Combining these two analyses allows me to estimate the total number of mortgages originated in response to BAPCPA and their marginal probability of default. Once I know the total amount of estimated defaults resulting from the policy change, I calculate what fraction they account for relative to all defaults on loans originated between 2005 and 2006.

I calculate the effect of BAPCPA under three different levels of treatment assumptions in order to estimate bounds on the effect of the policy change. My most conservative treatment group assumes that only the six treated IMCs in my dataset who receive an above median fraction of their credit lines from treated dealers experienced an increase in funding in response to the policy change. My next most conservative treatment group assumes that all IMCs operating in the US in 2005 experienced an increase in funding in response to the policy change. My most expansive treatment group assumes that all IMCs operating in the US in 2005 as well as all dealers who had their own mortgage origination arms received an increase in funding in response to the shock.

Under the most minimal treatment assumption, where only the six treated IMCs experience an increase in their funding in response to the policy change, I report in Table 3.1 (a), that when treated IMC market share increases from 0% to 100%, originations increase by 87% (this marginal effect is large because the market shares of treated IMCs is small). Multiplying 87% by the total market share of treated IMCs in the pre-period, which was 2.7%, implies that in response to the policy change 2.3% additional mortgages were created. To calculate how much defaults on these mortgages contributed to all defaults on mortgages originated during 2005-2006, I use my estimate on the default hazard rate of mortgages originated in the five months post shock, reported in Table 3.5 (a). This estimate allows me to calculate the implied marginal hazard rate on the mortgages originated in response to BAPCPA. Note that the mortgage hazard rate is calculated over the five months following the shock. I use this short time frame to pick up the marginal increase in the mortgage default hazard rate attributable to BAPCPA. I carry this forward for all loans originated between 2005 and 2006 when I combine this marginal hazard rate analysis with my origination analysis.

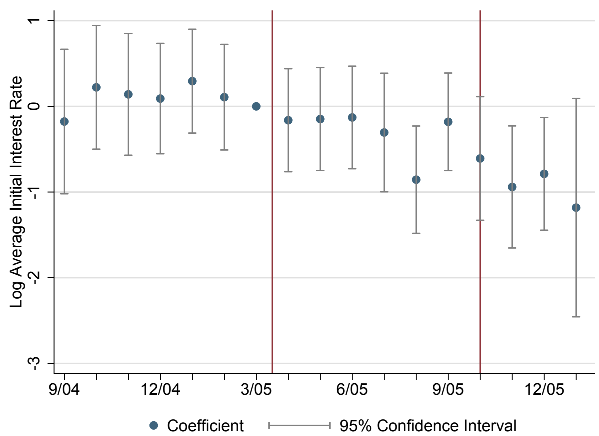
This analysis implies that each additional loan originated by treated IMCs in response to BAPCPA defaulted. Applying this marginal default rate to the increase in mortgage originations attributable to the shock, approximately 2.3% more loans go into default, than otherwise would have, as a result of the shock. To calculate how much this contributed to total defaults, I divide 2.3% by the actual average default rate of loans originated in 2005 and 2006, which was 16.8%. My analysis calculates that loans that were originated due to BAPCPA accounted for 14% of defaults among all loans originated during 2005 and 2006.

Under my next most conservative treatment assumption, I assume that all of the IMCs experienced a positive shock to their funding in response the policy change. The total market share of all IMCs was 34% of mortgage originations in the pre-period according to the HMDA data. In Table 3.1 (b), I find that when all IMC market share increases from 0% to 100%, originations increase by 26.8%. Therefore, I calculate that BAPCPA was responsible for a 9% increase in mortgage originations in the post period. In Table 3.5 (b), I find that when all IMC market share increases from 0% to 100%, the default hazard rate in that county increases by 21 percentage points. By combining my results on the number of mortgage originations created in response to BAPCPA with the increase in mortgage default hazard rates post shock, I am able to calculate the implied marginal default hazard rate on mortgages originated in response to BAPCPA. I calculate this implied marginal default rate to be 71%. Therefore, 71% of loans originated in response to BAPCPA default, accounting for 38% of defaults among all loans originated between 2005 and 2006. I describe this calculation in detail in Appendix section B.3.

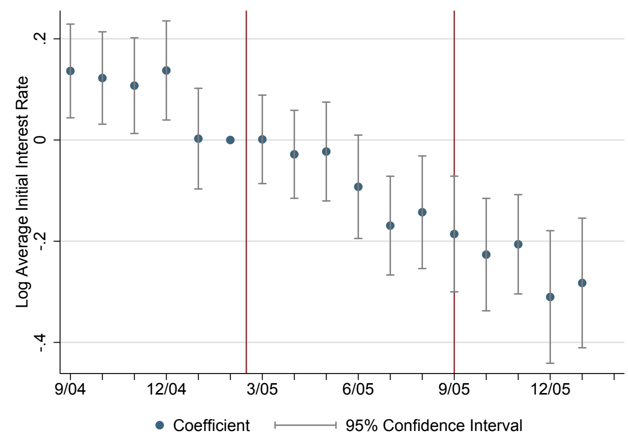
Under the most expansive treatment group assumption, I assume that all IMCs and all dealers' experience a positive shock to their funding in response to BAPCPA. In total, dealers' and all IMCs' combined market shares accounted for 57% of mortgage originations in the pre-period according to the HMDA data. To calculate the total effect of BAPCPA on originations and defaults if all dealers and IMCs were treated, I use the same coefficients estimated in Table 3.1 (b) and Table 3.5 (b). These results estimate the response of mortgage originations and defaults to the IMC market share. I believe that $IMCMarketShare_{c,2004}$ is a cleaner measure of exposure to the shock than dealer market share, which may be correlated with other factors since dealers were large financial institutions. I apply these coefficients to the dealer plus IMC market share. Under this treatment assumption, BAPCPA is responsible for a 15% increase in mortgage originations in the post period and these mortgages account for 66% of defaults among all loans originated between 2005 and 2006.

3.3 Conclusion

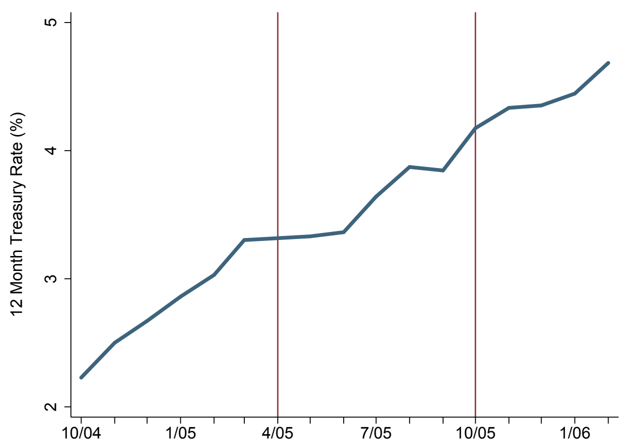
I present empirical evidence that a policy change in the sale and repurchase market, (the "repo" market), created a credit supply shock to the mortgage market. I show that independent mortgage companies increased the amount mortgages that they originated and shifted the distribution of originations toward non-owner occupied mortgages with low introductory monthly payments, large balloon payments at the end. This change in mortgage products brought new marginal homebuyers into the housing market. I show that this drove up home prices initially following the policy change. When home prices stopped rising, the areas more affected by the policy change suffered the worst fall in home prices. I estimate the total effect of the policy change to be an increase in mortgage originations by 2%-9%. I present evidence that these additional mortgages were inherently riskier in nature, making up 14-38% of all defaults on mortgages originated during 2005-2006.



(a) Treated IMC Market Share Effect



(b) All IMC Market Share Effect



(c) 12 Month Treasury Rate

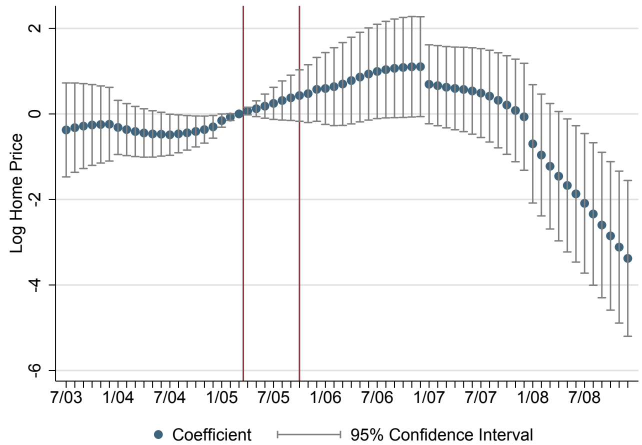
Figure 3.4. Response of Initial Interest Rates on Adjustable Rate Mortgages

Notes: Figures plot the dynamic response of county level average initial interest rates on adjustable rate mortgages as a function of county level market share of independent mortgage companies (IMCs) in 2004. I run the regression

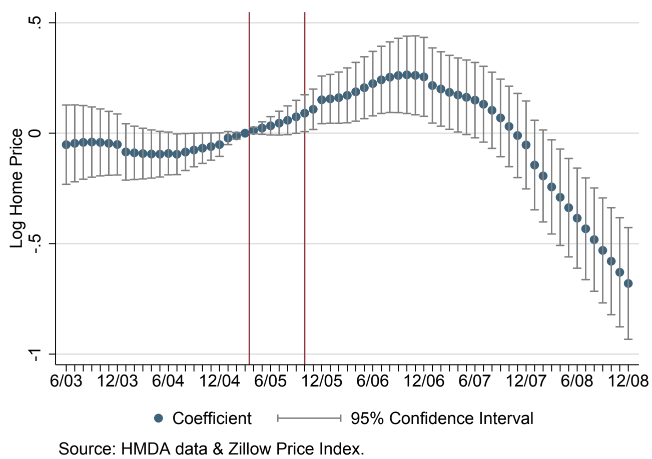
$$Y_{c,t} = \gamma_c + \eta_{s,t} + \sum_T \beta_T (Treated) IMCMarketShare_{c,2004} \times \mathbb{1}_{t=T} + \epsilon_{c,t}$$

where $Y_{c,t} = \log(Initial\ Interest\ Rate_c, t)$ in county, c at time t. γ_c represents county level fixed effects, $\eta_{s,t}$ represents $state \times month$ fixed effects, $(Treated)IMCMarketShare_{c,2004}$ is the IMC county level market share in a given county in 2004, the year before the shock occurs. β_T is the coefficient of interest. My standard errors are clustered at the county level. Adjustable rate mortgages (ARMs) were pegged to the 12 month treasury rate which was increasing over this time.

Figure 3.5. IMC County Market Share Effect on Home Prices



(a) Six Treated IMCs



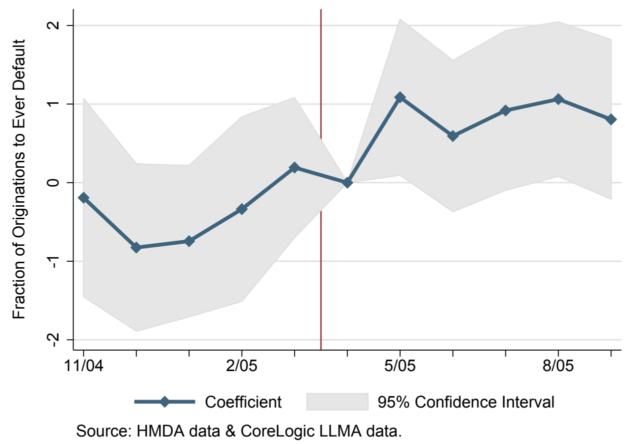
(b) All IMCs

Notes: Figures plot the dynamic response of home prices. I run the regression

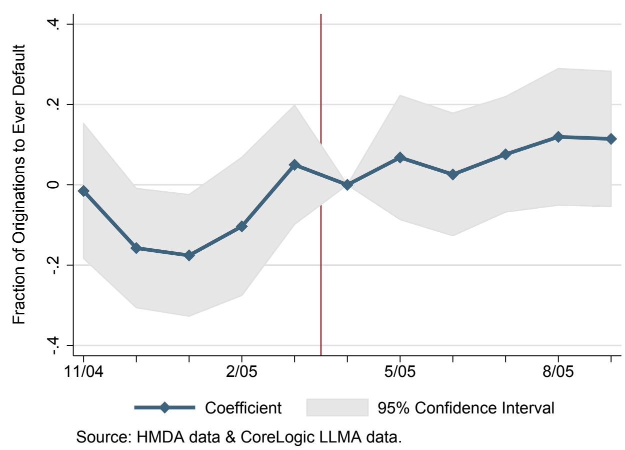
$$Y_{c,t} = \gamma_c + \eta_{s,t} + \sum_T \beta_T (Treated) IMCMarketShare_{c,2004} \times \mathbb{1}_{t=T} + \epsilon_{c,t}$$

$Y_{c,t}$ is log($Home\ Price_{c,t}$) in county, c at time t. γ_c represents county level fixed effects, $\eta_{s,t}$ represents $state \times month$ fixed effects, $(Treated)IMCMarketShare_{c,2004}$ is the IMC county level market share in a given county in 2004, the year before the shock occurs. β_T is the coefficient of interest. It is the coefficient on the indicator variable that interacts $(Treated)IMCMarketShare_{c,2004}$ with an indicator for each month pre and post the shock. I set the reference month to March 2005, the month prior to the passage of BAPCPA. My standard errors are clustered at the county level. I use the Zillow Home Price data for this analysis.

Figure 3.6. IMC County Market Share in 2004 Effect on Loan Default Hazard Rate



(a) Six Treated IMCs



(b) All IMCs

Notes: Figures plot the dynamic response of Default Rate on loans originated five months prior to the shock and five months post the shock in a given county as a function of the 2004 market share of independent mortgage companies (IMCs) in that county. I run the regression

$$Defaulted\ Loan_l = \gamma_c + \eta_{s,t} + \sum_T \beta_T\ (Treated)IMCMarketShare_{c,2004} \times \mathbb{1}_{t=T} + \epsilon_l$$

Where $Defaulted\ Loan_l$ is an indicator that is equal to one if a loan ever defaults in its lifetime, and zero otherwise. γ_c represents county level fixed effects. $\eta_{s,t}$ represents $state \times month$ level fixed effects. $(Treated)IMCMarketShare_{c,2004} \times \mathbb{1}_{t=T}$ is the interaction term between the county level market share of (Treated) IMCs in a given county in 2004, the year before the shock occurs and an indicator variable for the month in which the mortgage was originated. I cluster my standard errors at the county level.

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APPENDIX A

Appendix to Chapter 2

A.1 Federal Reserve's Decision to Purchase Mortgage Pass-Throughs in the Tri-Party Repo Market

The FOMC voted, at its August 24 meeting, "to approve a temporary expansion of the securities eligible as collateral in the repurchase transactions undertaken by the FRBNY in the management of banking system reserves. The principal effect of this expansion will be the inclusion of pass-through mortgage securities of GNMA, FHLMC and FNMA, STRIP securities of the U.S. Treasury and "stripped" securities of other government agencies. In order to gain access to this larger pool of securities, the FRBNY will be establishing custody arrangements with commercial banks to manage the clearing and settlement of collateral on a "tri-party" basis. The tri-party arrangements are expected to be in place in early October, permitting the introduction of the broader pool of collateral at that time." See FRBNY September 8, 1999 Press Release, "Expansion of Collateral Accepted by FRBNY in Repurchase Transactions" available at: https://www.newyorkfed.org/newsevents/news/markets/1999/an990908.html

A.2 FR 2004 Corporate Securities

Using the definition for Corporate Securities from the FR 2004 March 2013 Instructions, Corporate Securities contains three categories from 7/4/2001 to 3/27/2013: Corporate Debt including commercial paper, Equities, and All other dollar denominated debt instruments used as collateral. All other dollar denominated debt instruments includes non-Agency or GSE-issued

MBS, CMOs, REMICS, State and Municipal securities, and Asset-Backed securities, excluding financing arrangements where the underlying collateral consists of international securities, whole loans, or money market instruments such as negotiable CDs and bankers acceptances. This line item is likely to understate value of private-label MBS instruments used if it does not include whole loans since BAPCPA exempted whole loans from automatic stay. Exempting whole loans from automatic stay likely increased demand for them in the repo markets, making dealers likely to use for their own secured borrowing. After 3/27/13, the line item previously reported as Corporate Securities contains four categories: Corporate Debt, Asset-backed Securities, Equities, and Other. Other includes All Other dollar denominated debt instruments used as collateral including non-Agency or GSE-issued MBS, CMOs, REMICS, and State and Municipal securities, excluding financing arrangements where the underlying collateral consists of international securities, whole loans, or money market instruments such as negotiable CDs and bankers' acceptances. See FR 2004 March 2013 Instructions "Securities Financing" reported on p. 23 and June 2001 Instructions "Types of financing" and pp. 5-6 available at: https://www.federalreserve.gov/apps/reportforms/reporthistory.aspx?sOoYJ+5BzDZq2f74T6b1cw== . On June 13, 2018 Other comprised 14% of the total of the 4 categories (Corporate Debt, Asset-backed Securities, Equities, and Other). This is a proxy for the fraction of that private-label mortgage collateral comprises of the Corporate Securities variable in 2005. See June 21, 2018 FR 2004 Form C "Financing by Primary U.S. Government Securities Dealers." This estimate is likely to be a lower bound of the fraction that private-label mortgage collateral comprises of the Corporate Securities variable in 2005, as the use of private-label mortgage collateral in repo markets was at an all-time high leading up to the Financial Crisis.

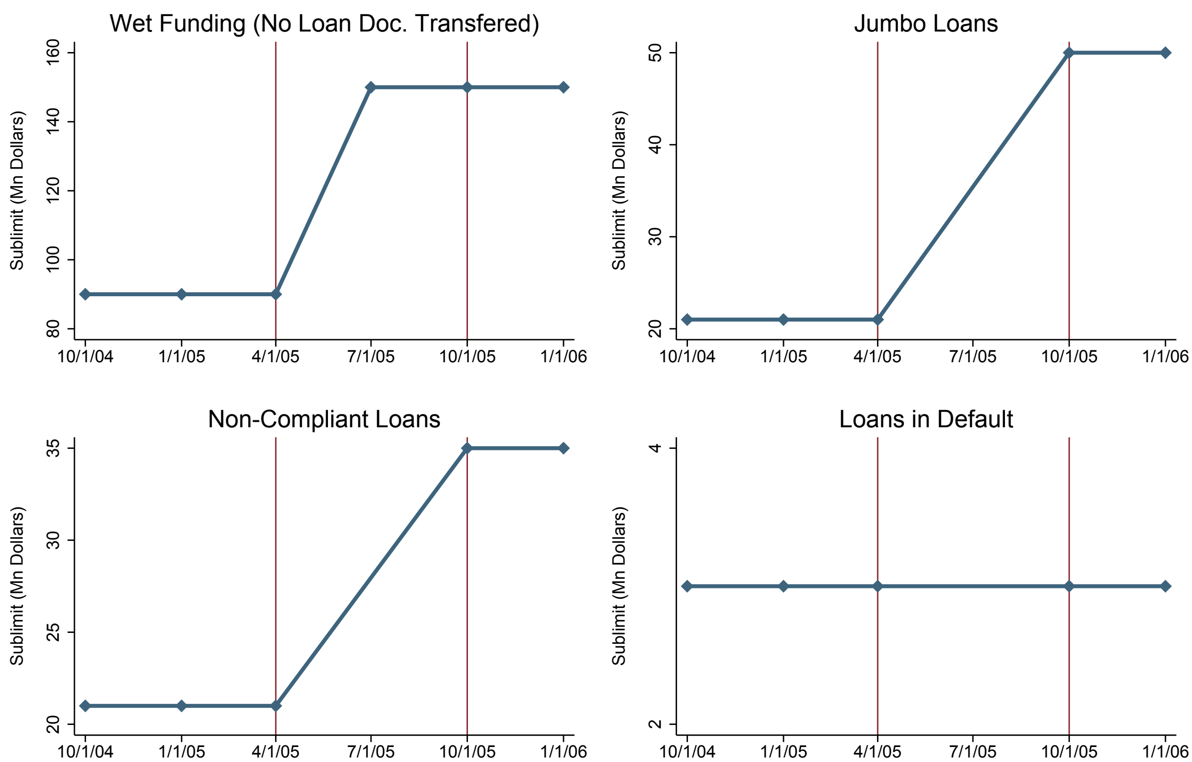
A.3 Examination of Dealer - Mortgage Company Credit Line Covenants

In Figure A.1 through Figure A.4, I find that all of the dealers extending credit to an example mortgage company in my sample increased their sublimits on wet funding - funding with no loan documents transferred. Since the collateral backing wet funding has not been created yet, this form of collateral was exposed to more risk and was traditionally more expensive for a mortgage company than dry funding. I also find that credit lines for the riskiest mortgage products increased. For example Figure A.1, post shock, the dealer increases the sublimit for 120-180 day past due loans however, not the sublimit for 30-60 day past due loans. Similarly in Figure A.4, the dealer increases the sublimit for non-conforming subordinate mortgages however, not the sublimit for Alt-A subordinate mortgages, which are typically less risky than the former.

Figure A.1. Dealer 1 Covenants on Credit Line to Example Mortgage Company

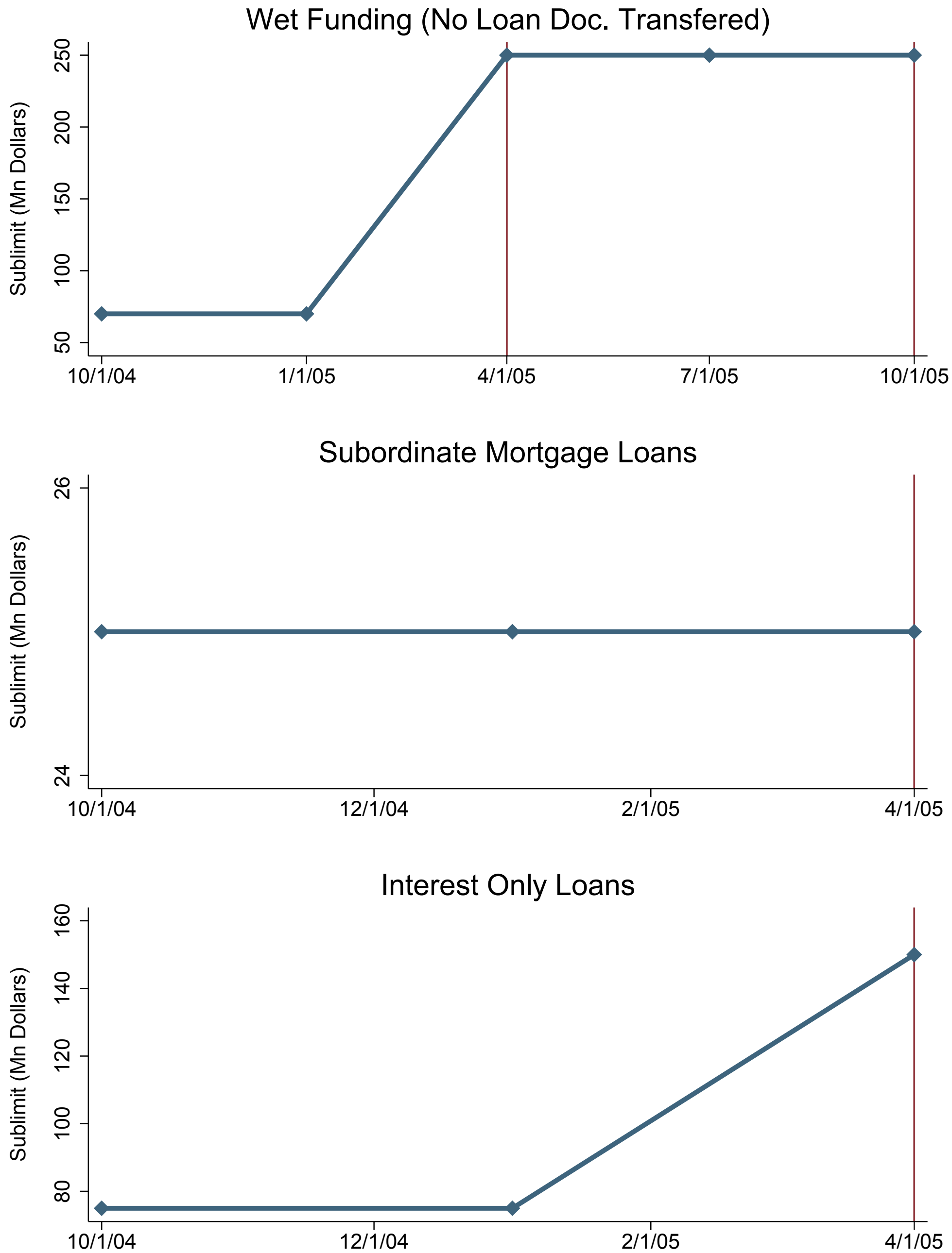
Notes: Figure provides suggestive evidence that the covenants were loosened post BAPCPA.

Figure A.2. Dealer 2 Covenants on Credit Line to Example Mortgage Company



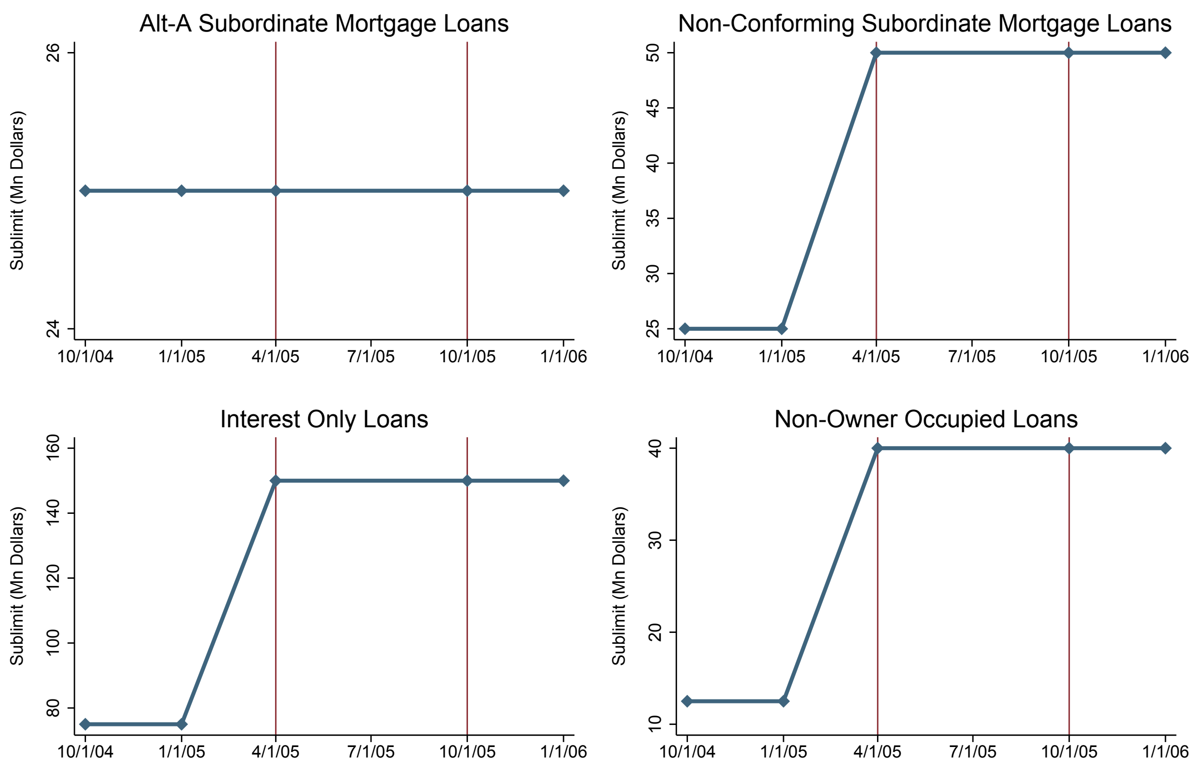
Notes: Figure provides suggestive evidence that the covenants were loosened post BAPCPA.

Figure A.3. Dealer 3 Covenants on Credit Line to Example Mortgage Company



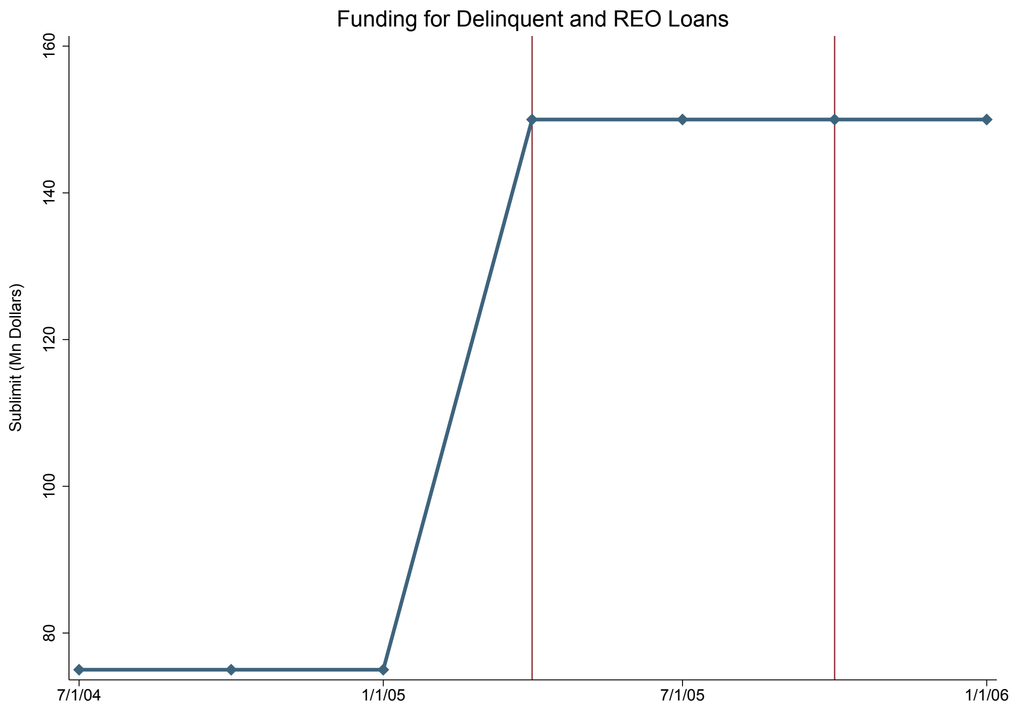
Notes: Figure provides suggestive evidence that the covenants were loosened post BAPCPA.

Figure A.4. Dealer 4 Covenants on Credit Line to Example Mortgage Company



Notes: Figure provides suggestive evidence that the covenants were loosened post BAPCPA.

Figure A.5. Dealer 5 Covenants on Credit Line to Example Mortgage Company



Notes: Figure provides suggestive evidence that the covenants were loosened post BAPCPA. REO stands for Real Estate Owned, which indicates that a property has been seized by the lender from borrowers who are unable to pay their mortgages.

APPENDIX B

Appendix to Chapter 3

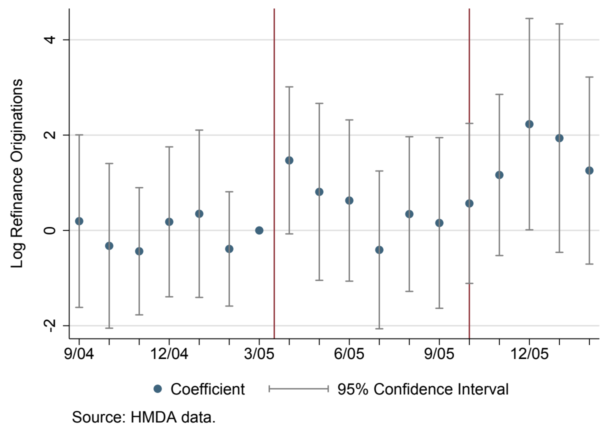
B.1 Examination of Additional Mortgage Characteristics

I study whether refinance and purchase mortgage originations were affected differently by this shock. To do this, I run the same regression in Equation 3.1 except I change the dependent variable to log(Refinance Originations) where Refinance Originations are the monthly refinance originations reported in the county month HMDA data. Figure B.1 shows the dynamic response of refinance mortgages to the shock.

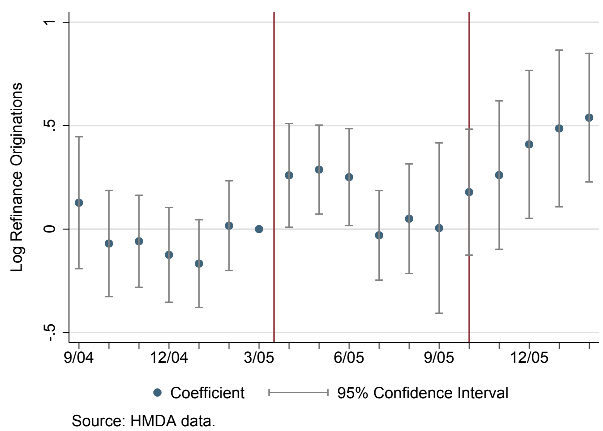
When I run the regression with a single pre- and post-period in Equation 3.2, I find that increasing the market share of treated IMCs in a county by 10% leads to a statistically significant 6.93% increase in purchase mortgage originations post shock. Figure B.2 shows the dynamic response of purchase mortgages to the shock. From September 2005 on, purchase mortgages mortgages increase differentially for areas where treated IMCs had a larger market share in 2004.

Negative amortization occurs whenever a mortgage payment does not cover the incurred interest over that period. The result is that rather than being paid down over the life of the loan, the loan balance grows by the amount of the unpaid interest each period. This leaves a large payment due at the end of the mortgage term. Negative amortization loans allow the introductory payments to be lower than almost any other type of mortgage. For example, the mortgage may accrue interest at a 5% interest rate but have an introductory payment period at a 1% payment rate. This payment rate is not the interest rate, it simply represents the amount of interest that the borrower is required to pay during the introductory period which could be

Figure B.1. IMC County Market Share Effect on Refinance Mortgage Originations



(a) Six Treated IMCs



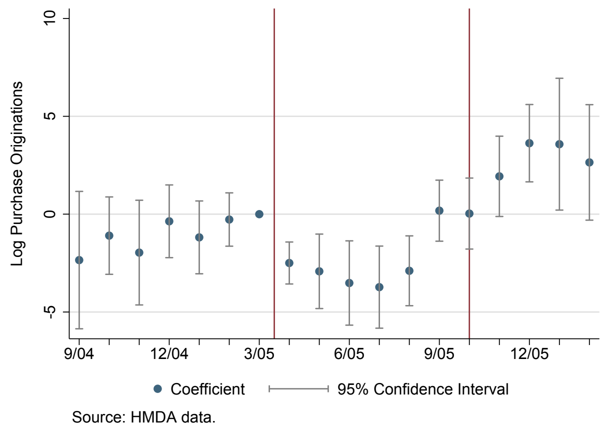
(b) All IMCs

Notes: Figures plot the dynamic response of refinance mortgage originations in a given county to the 2004 market share of independent mortgage companies (IMCs) in that county. I run the regression

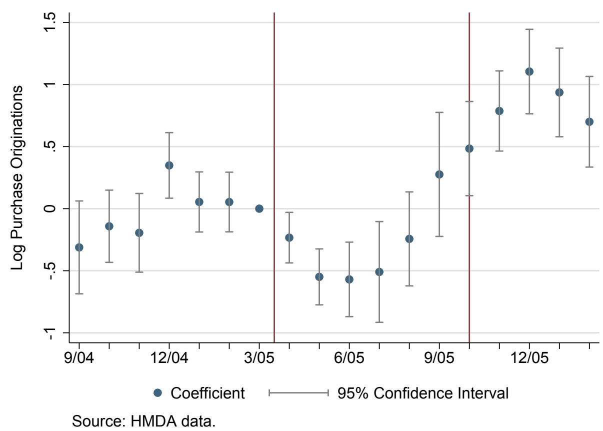
$$Y_{c,t} = \gamma_c + \eta_{s,t} + \sum_T \beta_T (Treated) IMCMarketShare_{c,2004} \times \mathbb{1}_{t=T} + \epsilon_{c,t}$$

$Y_{c,t}$ is log($Refinance\ Originations_{c,t}$) in county, c at time t. γ_c represents county level fixed effects, $\eta_{s,t}$ represents $state \times month$ fixed effects, $(Treated)IMCMarketShare_{c,2004}$ is the IMC county level market share in a given county in 2004, the year before the shock occurs. β_T is the coefficient of interest. It is the coefficient on the indicator variable that interacts $(Treated)IMCMarketShare_{c,2004}$ with an indicator for each month pre and post the shock. I set the reference month to March 2005, the month prior to the passage of BAPCPA. I use the Public HMDA data to compute the 2004 county level IMC market share and the county month HMDA data to study originations.

Figure B.2. IMC County Market Share Effect on Purchase Mortgage Originations



(a) Six Treated IMCs



(b) All IMCs

Notes: Figures plot the dynamic response of purchase mortgage originations in a given county to the 2004 market share of independent mortgage companies (IMCs) in that county. I run the regression

$$Y_{c,t} = \gamma_c + \eta_{s,t} + \sum_{T} \beta_T (Treated) IMCMarketShare_{c,2004} \times \mathbb{1}_{t=T} + \epsilon_{c,t}$$

$Y_{c,t}$ is $\log(Purchase\ Originations_{c,t})$ in county, c at time t. γ_c represents county level fixed effects, $\eta_{s,t}$ represents $state \times month$ fixed effects, $(Treated)IMCMarketShare_{c,2004}$ is the IMC county level market share in a given county in 2004, the year before the shock occurs. β_T is the coefficient of interest. It is the coefficient on the indicator variable that interacts $(Treated)IMCMarketShare_{c,2004}$ with an indicator for each month pre and post the shock. I set the reference month to March 2005, the month prior to the passage of BAPCPA. I use the Public HMDA data to compute the 2004 county level IMC market share and the county month HMDA data to study originations.

Table B.1. IMC County Market Share Effect on Refinance Originations

(a) Treated IMC County Market Share Effect

	(1) log(Refinance Originations)	(2) log(Refinance Originations)
Post × TreatedIMCMarketShare$_{c,2004}$	2.397***	0.981*
	(0.318)	(0.558)
CountyFE	Yes	Yes
StatexMonthFE	No	Yes
r2	0.9671	0.9933
N	8728	8572

(b) All IMC County Market Share Effect

	(1) log(Refinance Originations)	(2) log(Refinance Originations)
Post × IMCMarketShare$_{c,2004}$	0.157***	0.285**
	(0.021)	(0.113)
CountyFE	Yes	Yes
StatexMonthFE	No	Yes
r2	0.9671	0.9933
N	8728	8572

Notes: Tables report the response of refinance mortgage originations in a given county to the 2004 market share of independent mortgage companies (IMCs) in that county. I run the regression

$$Y_{c,t} = \gamma_c + \eta_{s,t} + \beta \ Post_t \times (Treated)IMCMarketShare_{c,2004} + \epsilon_{c,t}$$

$Y_{c,t}$ is log($Refinance\ Originations_{c,t}$) in county, c at time t. γ_c represents county level fixed effects, $\eta_{s,t}$ represents $state \times month$ fixed effects, $(Treated)IMCMarketShare_{c,2004}$ is the IMC county level market share in a given county in 2004, the year before the shock occurs. β is the coefficient of interest. It is the coefficient on the interaction between $(Treated)IMCMarketShare_{c,2004}$ and the post period. This coefficient measures the change in the dependent variable if $(Treated)IMCMarketShare_{c,2004}$ increased from 0% to 100%. I use the Public HMDA data to compute the 2004 county level IMC market share and the county month HMDA data to study originations. [a]

[a]Neil Bhutta publishes the HMDA data reported at the county month level on his personal website: https://sites.google.com/site/neilbhutta/data.

Table B.2. IMC County Market Share Effect on Purchase Originations

(a) Treated IMC County Market Share Effect

	(1) log(Purchase Originations)	(2) log(Purchase Originations)
Post × TreatedIMCMarketShare$_{c,2004}$	8.202***	0.693
	(0.390)	(1.036)
CountyFE	Yes	Yes
StatexMonthFE	No	Yes
r2	0.9415	0.9901
N	8728	8572

(b) All IMC County Market Share Effect

	(1) log(Purchase Originations)	(2) log(Purchase Originations)
Post × IMCMarketShare$_{c,2004}$	0.565***	0.226**
	(0.013)	(0.100)
CountyFE	Yes	Yes
StatexMonthFE	No	Yes
r2	0.9432	0.9902
N	8728	8572

Notes: Tables report the response of purchase mortgage originations in a given county to the 2004 market share of independent mortgage companies (IMCs) in that county. I run the regression

$$Y_{c,t} = \gamma_c + \eta_{s,t} + \beta \; Post_t \times (Treated)IMCMarketShare_{c,2004} + \epsilon_{c,t}$$

$Y_{c,t}$ is log($Purchase\ Originations_{c,t}$) in county, c at time t. γ_c represents county level fixed effects, $\eta_{s,t}$ represents $state \times month$ fixed effects, $(Treated)IMCMarketShare_{c,2004}$ is the IMC county level market share in a given county in 2004, the year before the shock occurs. β is the coefficient of interest. It is the coefficient on the interaction between $(Treated)IMCMarketShare_{c,2004}$ and the post period. This coefficient measures the change in the dependent variable if $(Treated)IMCMarketShare_{c,2004}$ increased from 0% to 100%. I use the Public HMDA data to compute the 2004 county level IMC market share and the county month HMDA data to study originations. [a]

[a] Neil Bhutta publishes the HMDA data reported at the county month level on his personal website: https://sites.google.com/site/neilbhutta/data.

5 years for example. However, eventually the loan will enter a recast period when the payments reset to a fully amortizing schedule. These loans can be risky for inexperienced borrowers who might experience payment shock when the payment schedule is recast and who are more likely to experience negative equity in an environment where home prices are falling. In Figure B.3, I plot the fraction of negative amortization mortgages originated in counties with higher IMC market shares. I find that prior to the shock, there is no statistical difference between the fraction of negative amortizing mortgage originations between counties with high and low IMC market shares in 2004. Post shock, there is a statistically significant increase in the use of negative amortization mortgages in counties with a higher market share of all independent mortgages companies in 2004.

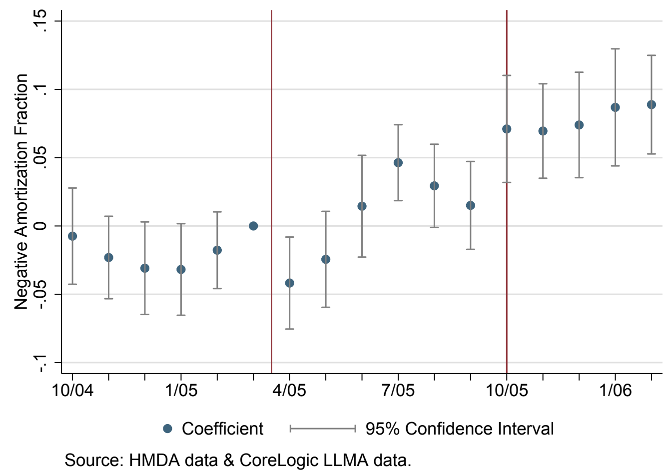
A quote from the annual report from a mortgage company in my sample states:

> "Borrowers with adjustable-rate mortgage loans will likely be exposed to increased monthly payments ... A **decline in housing prices** ... [could] leave borrowers with insufficient equity in their homes to permit them to refinance ... borrowers who intend to sell their properties ... may find that they cannot sell their properties for an amount equal to or greater than the unpaid principal balance of their loans, especially in the case of **negative amortization mortgage loans.** These events could **cause borrowers to default** on their mortgage loans." [1]

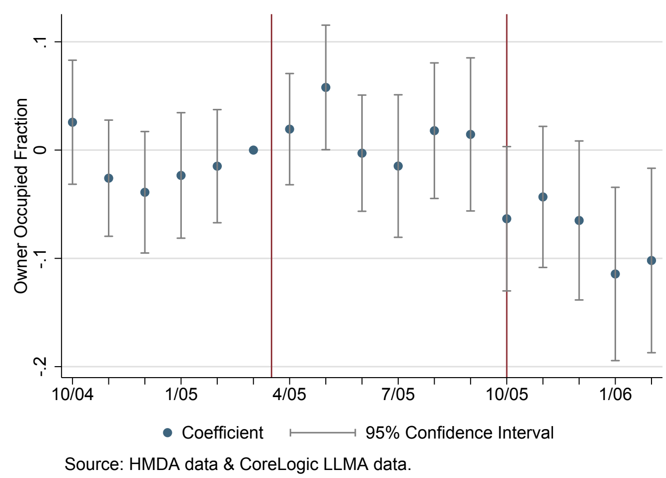
There is also a statistically significant decrease in owner-occupied mortgage originations in these areas post shock.

[1] Mortgage Company 2005 Annual Report

Figure B.3. All IMC County Market Share Effect on Mortgage Characteristics



Fraction of Negative Amortization Originations



Fraction of Owner Occupied Originations

Notes: Figures plot the dynamic response of county level mortgage characteristics as a function of county level market share of independent mortgage companies (IMCs) in 2004. I run the regression

$$Y_{c,t} = \gamma_c + \eta_{s,t} + \sum_T \beta_T \; IMCMarketShare_{c,2004} \times \mathbb{1}_{t=T} + \epsilon_{c,t}$$

in county, c at time t. γ_c represents county level fixed effects, $\eta_{s,t}$ represents $state \times month$ fixed effects, $IMCMarketShare_{c,2004}$ is the IMC county level market share in a given county in 2004, the year before the shock occurs. β_T is the coefficient of interest. My standard errors are clustered at the county level.

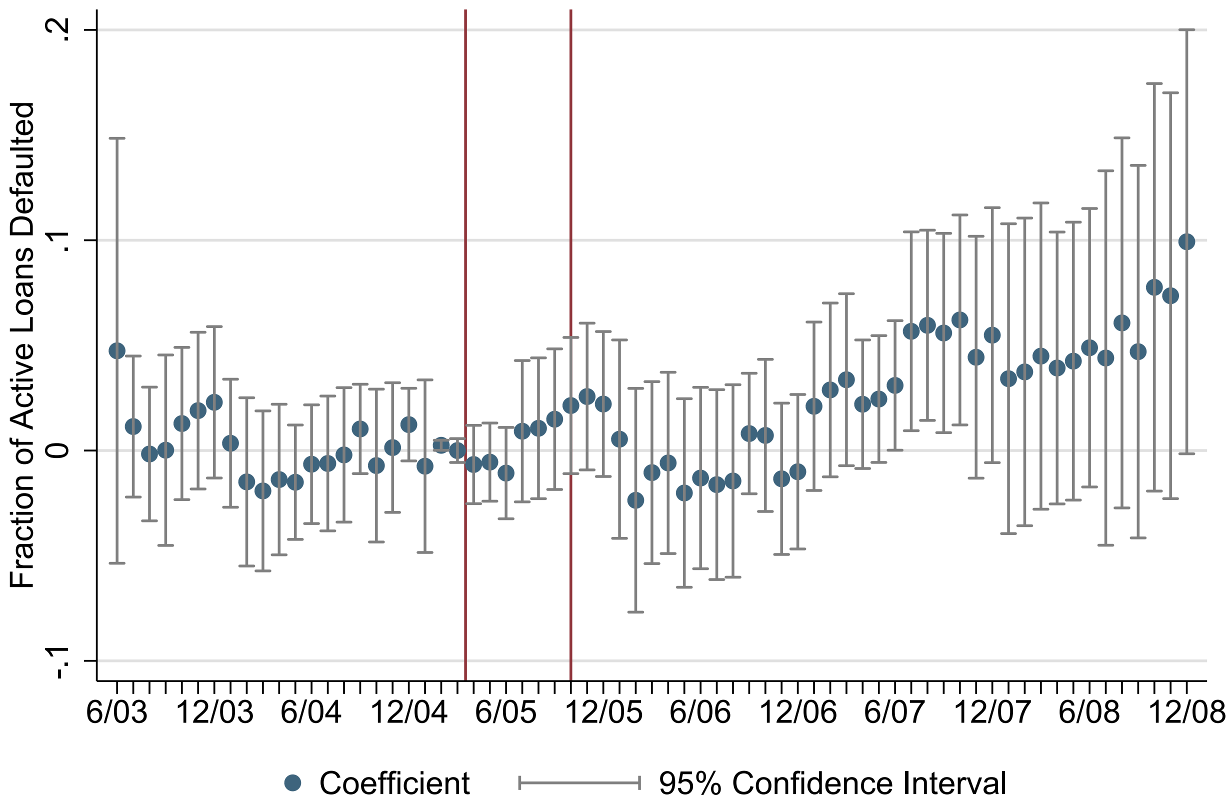
B.2 Default Rate as a Function of All IMC Market Share in 2004

I also examine an alternative measure of default - defaults as a fraction of active loans in the month that they default. Counties with a higher share of IMCs in 2004, before the policy change, also experienced increased default rates post shock. I run the regression in Equation 3.1 that examines the dynamic effect of $IMCMarketShare_{c,2004}$ on the defaults as a fraction of the active loans in a given month. In Figure B.4 I show that post BAPCPA counties with higher IMC market share in 2004 began to experience higher default rates. I plot the coefficient the indicator variable that interacts $IMCMarketShare_{c,2004}$ with an indicator for each month pre and post the shock. Prior to BAPCPA, the fraction of defaults experienced by these counties were not significantly different than the fraction of defaults with low $IMCMarketShare_{c,2004}$ however the fraction of defaults in these counties clearly begins to increase relative to other counties post shock and becomes pronounced during the Financial Crisis. This evidence is consistent with risky mortgages that were sensitive to interest rate increases and whose solvency depended on a rising home price environment (so that borrowers could refinance the mortgage or sell the home). When home prices stopped increasing, and interest rates reset, borrowers in negative amortizing or balloon loans with teaser initial interest rates would be at higher risk of default when their interest rates reset. This risk would increase with falling home prices since borrowers in these mortgages would be at high risk of having negative equity which would make it difficult to refinance their mortgage.

B.3 Calculating Aggregate Effect of BAPCPA on Mortgage Originations

(1) Only treated IMCs affected: 2.3% increase in mortgage originations per month:

Figure B.4. All IMC County Market Share Effect on Fraction of Loans 90 plus Days Past Due, Foreclosed, or REO Properties



Source: HMDA data & CoreLogic LLMA data.

Notes: Figure plots the dynamic response of fraction of active loans in a given month that are 90 plus days past due, foreclosed on or REO properties. I run the regression

$$Y_{c,t} = \gamma_c + \eta_{s,t} + \sum_T \beta_T IMCMarketShare_{c,2004} \times \mathbb{1}_{t=T} + \epsilon_{c,t}$$

$Y_{c,t}$ is $Fraction\ Past\ Due\ Mortgages_{c,t}$ in county, c at time t. γ_c represents county level fixed effects, $\eta_{s,t}$ represents $state \times month$ fixed effects, $IMCMarketShare_{c,2004}$ is the IMC county level market share in a given county in 2004, the year before the shock occurs. β_T is the coefficient of interest. It is the coefficient on the indicator variable that interacts $IMCMarketShare_{c,2004}$ with an indicator for each month pre and post the shock. I set the reference month to March 2005, the month prior to the passage of BAPCPA. My standard errors are clustered at the county level. I use the CoreLogic LLMA Loan Performance data for this analysis.

market share of $TreatedIMCs = 0.027$

$\beta^{orig} = 0.87$

increase in mortgages originated in response to BAPCPA: $0.027 \times 0.87 = 0.023$

$\beta^{ED} = 1.1$

increase in average hazard rate due to BAPCPA: $0.027 \times 1.1 = 0.03$ percentage points

pre-shock mortgage hazard rate in data $= 0.13$

implied average hazard rate post BAPCPA: $.13 + .03 = .16$

implied marginal hazard rate on loans originated in response to BAPCPA:

$$\frac{100}{102} \times 0.13 + \frac{2}{102} \times X = .16$$

$$X = 1.65$$

100% of loans originated in response to BAPCPA default. Average hazard rate in the data post BAPCPA: 16.8 %. Estimate that loans originated because of BAPCPA accounted for $\frac{.023}{.168} = 13.7\%$ of defaults in the post period.

(2) All IMCs affected: 9.1% increase in mortgage originations per month

market share of all $IMCs = 0.34$

$\beta^{orig} = 0.268$

increase in mortgages originated in response to BAPCPA: $0.34 \times 0.268 = 0.091$

$\beta^{ED} = 0.141$

increase in average hazard rate: $0.34 \times 0.141 = 0.0479$ percentage points pre-shock mortgage hazard rate in data = 0.13

implied average hazard rate post BAPCPA: $0.13 + .0479 = .1779$

implied marginal hazard rate on loans originated in response to BAPCPA:

$$\frac{100}{109} \times 0.13 + \frac{9}{109} \times X = .1779$$
$$X = 0.71$$

71% of loans originated in response to BAPCPA default ($.71 \times .09 = 0.064$ loans). Average hazard rate in data post BAPCPA: 16.8 %. Estimate that loans originated because of BAPCPA accounted for $\frac{.064}{.168} = 38\%$ of all defaults in the post period.

(3) All IMCs and Dealers affected: 15.2% increase in mortgage originations per month

market share of all IMCs plus dealers = 0.568

$\beta^{orig} = 0.268$

increase in mortgages originated in response to BAPCPA: $0.568 \times 0.268 = 0.152$

$\beta^{ED} = 0.141$

increase in average hazard rate: $0.568 \times 0.141 = 0.08$ percentage points

pre-shock mortgage hazard rate in data = 0.13

implied average hazard rate post BAPCPA: $0.13 + .08 = .21$

implied marginal hazard rate on loans originated in response to BAPCPA:

$$\frac{100}{115} \times 0.13 + \frac{15}{115} \times X = .21$$
$$X = 0.74$$

74% of loans originated in response to BAPCPA default ($0.74 \times 0.15 = 0.11$ loans). Average hazard rate in data post BAPCPA: 16.8 %. Estimate that loans originated because of BAPCPA accounted for $\frac{.11}{.168} = 66\%$ of all defaults in the post period.