Uncertainty Shocks and Liquidity Crisis with Adverse Selection

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Abstract

I propose a new channel by which increased uncertainty has a negative impact on liquidity in financial markets through adverse selection. I show this uncertainty channel on liquidity in a model of securitization-based financial intermediation. Firms are heterogeneous in productivity, and they finance investment by issuing non-contingent debt. Each loan can be securitized and sold as a bundle in a market where households participate as buyers without knowing the quality of underlying assets. This implies adverse selection. Increased uncertainty, defined as a more dispersed quality distribution of firm-specific productivity, has negative effects on financial market dynamics by exacerbating adverse selection and illiquidity: trading volumes and the price of securitized loans fall. This further adversely affects investment at the firm level. I quantify the importance of this uncertainty channel in causing the recent financial crisis.

JEL codes: E32, E44, G21

Keywords: Uncertainty; liquidity; adverse selection; securitization; financial crisis

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1 Introduction

"*market participants lost faith in the collateral or in the creditworthiness of their counterparties – or both. Secured or not, no one wanted to deal with a firm they feared might disappear the next day. But deciding not to deal with a firm could turn that fear into a self-fulfilling prophecy.*" - Henry Paulson (2010)

The instability of the securitization-based financial intermediation has been realized since the recent financial crisis. This paper asks to what extent is uncertainty about the quality of underlying assets of securitized loans responsible for financial market dynamics. This paper proposes a model of securitization-based financial intermediation and studies the link between financial markets and aggregate fluctuations. While the literature has found the important role of financial shocks in explaining business cycles, these studies, by construction, are not able to address what happened in financial markets. This paper looks at the origin of financial shocks: where financial shocks come from and how they are transformed into large macroeconomic downturns.

In the recent financial crisis, two remarkable issues were contrasted. First, the aspect of bank run emerged. Prior to the crisis, the shadow banking system based upon the securitization innovations were widely recognized as an accelerator for achieving credit risk transfer. However, it turned out that the originate-to-distribute banking system become too complicated and it is virtually impossible for ultimate investors to fully monitor the qualities of underlying assets. In the process of numerous downgrades by credit rating agencies, investor become to have fear and doubt about not only qualities of assets trading in markets but also qualities of own assets holding in their balance sheets. I view uncertainty and information asymmetry as important factors contributing to the recent financial crisis, also indispensable ingredients in studying the stability of the financial system. Second, measures of liquidity such as trade volume and bid-ask spreads dramatically worsened. Several financial markets were even completely frozen. For example, Kirabaeva (2011) reports that the demand for asset-backed securities (ABS) fell from \$500 billion in 2007 to \$20 billion in 2009 in the United States.[1] I view illiquidity as a catalyst for the recent financial crisis. Therefore, I study the role of uncertainty about the quality of underlying assets for the securitization-based financial intermediation and how liquidity is affected by information asymmetry in asset markets.

In this paper, a securitization market is introduced into a model with heterogeneous firms. Firms are heterogeneous in productivity, and they finance investment by issuing long-term, non-contingent loans. The default risk of firms depend on their leverage and productivity; however, lenders cannot observe these firm characteristics. When originating loans, lenders also take into account the price of securitized loans in the market as they can securitize and sell them in the market.

After underwriting, lenders observe random liquidity shocks that affect their own cash positions. Each lender also observes a firm-specific productivity shock to the borrower. If the liquidity shock is large enough, lenders need to securitize and sell loans in the market. Alternatively, lenders do so if they learn that the risk of default of the borrower is high. Therefore, the quality of loans traded in the market is heterogeneous: some will be repaid at the face value, while others may not be repaid in full in the event of default. Households participate as buyers of these securitized loans without knowing the quality of underlying assets, implying the problem of adverse selection in the market. On top of these, time-varying uncertainty shocks

[1] See also Pozsar et al. (2012).

are introduced in a way that the firm-specific volatility changes over time. I used this model to examine the impact of uncertainty shocks on a firm's investment, a loan rate schedule offered by lenders, and the dynamics of the securitization market.

Households form beliefs about the quality distribution of securitized loans in the market. Therefore, the market price of the securitized loans is consistent with the expected average quality of loans traded in the market, implying a pooling equilibrium as in Akerlof (1970). Households' beliefs pin down the market price of the securitized loans traded. Under this equilibrium, the adverse selection problem becomes more severe with a larger dispersion of the firm productivity distribution. This is because that default rates rise, leading to the lower expected average quality of loans traded in the market. Therefore, the market price of the securitized loans falls, implying deteriorations of the funding condition of banks and a loan rate schedule offered by banks is adversely affected. This has the negative impact on firms' investment decisions as the unit cost of borrowing rises for firms. Overall, this feedback loop through adverse selection amplifies the impact of uncertainty shocks.

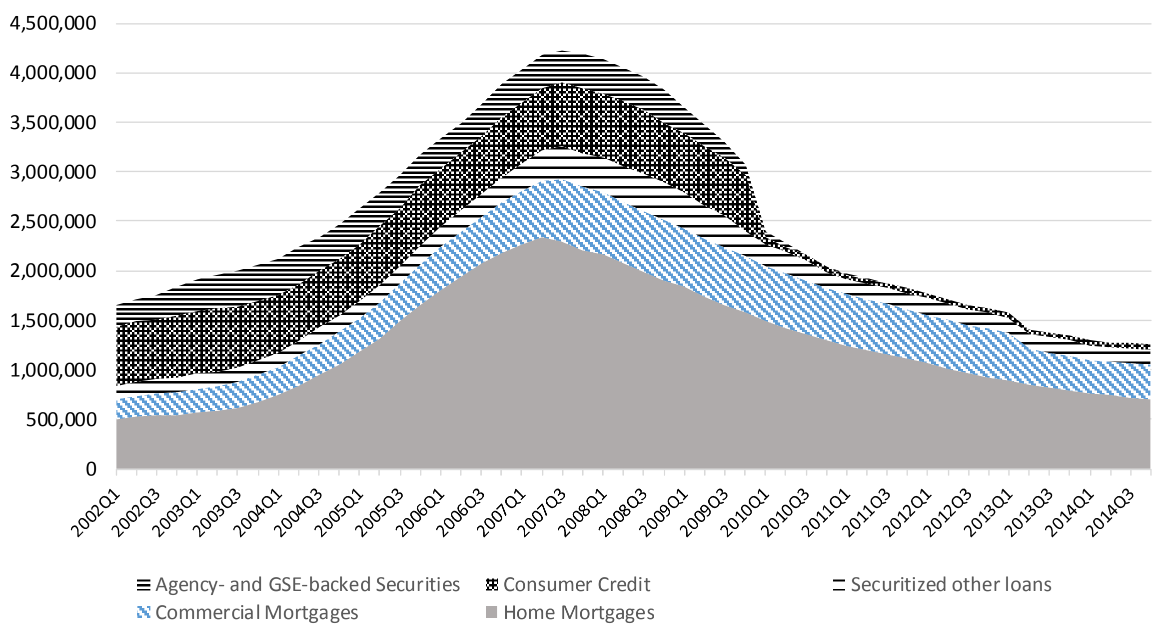
2 Related literature

This paper is related to two different branches of literature. First, this paper builds upon the literature incorporating the interbank market into a general equilibrium model to study its economic role. In particular, I follow the island structure developed by Gertler and Kiyotaki (2010). In their model, the interbank money market plays its role of allocating funds from cash abundant island banks from cash scarce island banks. Each island differs in its random investment opportunities, and thus its demand for funds also is heterogeneous across islands. This model features limited commitment between lenders and borrowers, but all uncertainty is publicly observable. The interbank market studied in Bruche and Suarez (2010) also allocates funds across regionally segmented banks. They consider counterparty risks in the interbank market due to default risks of banks and study the effect of deposit insurance on the allocative efficiency of funds across banks and economic activities in each island. My paper is different from those papers in developing a securitization market model. This allows me to study uncertainty about collateral values as a different source of a financial crisis.

Second, this paper connected to the vast literature on models of liquidity in asset markets. Some recent studies are Duffie, Garleanu and Pedersen (2005), Lagos and Rocheteau (2009), Lagos and Rocheteau (2007), Lagos and Weill (2011), and these search theoretic models of liquidity argue that the liquidity of assets and markets is associated with trading costs unlike a medium of exchange in monetary economics. There, two fundamental trading frictions exist: 1) agents must search for a counterpart, and 2) once matched, the term of trade (ex. asset prices) are determined by bargaining between the two parties. On the other hand, theories of liquidity with adverse selection has been growing such as Eisfeldt (2004), Guerrieri and Shimer (2012) and Chang (2011). Compared to the search theoretic models, origins of liquidity are different: one private information and one the availability of trading opportunities. In Guerrieri, Shimer and Wright (2010), they provide an applications of their adverse selection in competitive search model to asset markets. They show that when lemons exist markets might shut down in the presence asymmetric of information. While Guerrieri and Shimer (2012) build a theory of liquidity without search, Chang (2011) keeps a competitive search for investigating the role of liquidity as a screening mechanism.

3 Empirics

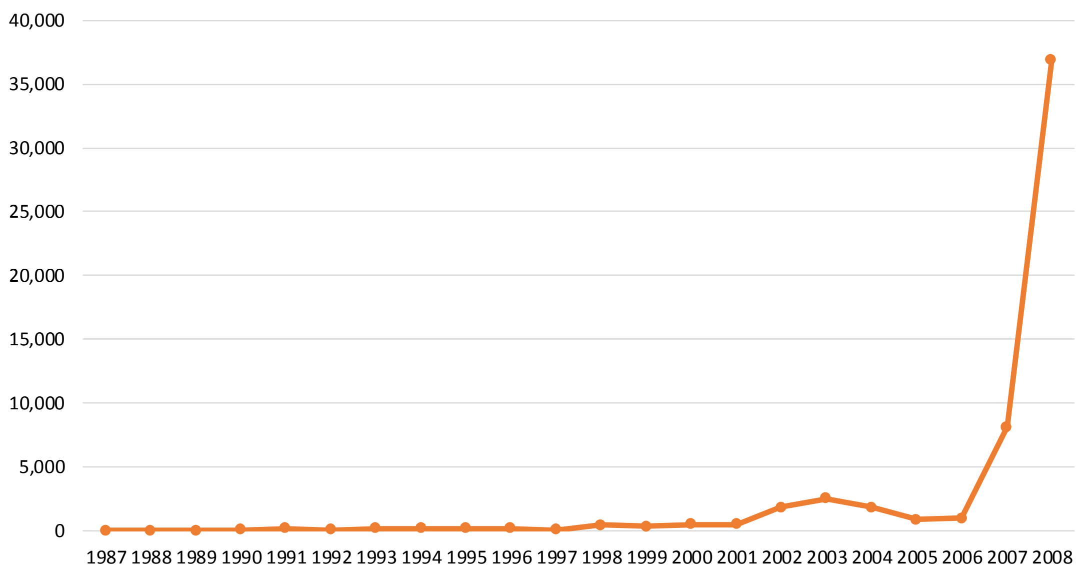
Figure 1: Issuance of asset-backed securities (ABS)



Notes: The figure shows the querterly data on issurances (billions of dollars) of asset-backed securities for each type of issuers. The data is taken from the Z.1 Financial Accounts of the United States collected by the Federal Reserve Board.

This section overviews historical dynamics of the securitization based financial system around the onset of the recent financial crisis. Figure 1 plots the data on issuances of asset-backed securities. Overall, the issuance had peaked around the second quarter of 2007 when we started to observe the reversal in financial market dynamics against the previous trend. The largest share is taken by home mortgage related asset-backed securities, and this contributes a lot to this overall trend. Comparing before and after the financial crisis, in addition to home mortgage asset-backed

Figure 2: Downgrades in Structured Finance Bonds



Notes: The figure shows the anual number of downgrades in total. The data is taken from Benmelech and Dlugosz (2009) that used the Moody's Structured Finance Default Risk Services database.

securities, Agency-backed or GSE-backed securities and consumer credit asset-backed securities dramatically reduced the size of issuances.

To see how this reversal of issuance trend of asset-backed securities during the financial crisis is related to uncertainty, Figure 2 shows the number of downgrades of securitized bonds by credit agencies. This figure reveals the surge in the number of downgrades in 2007 and 2008. Since downgrades imply that the loss due to delinquency rates of underlying loans are not anticipated when credit rating agencies initially report ratings, I view this surge in downgrades as an indicator of increased uncertainty about quality distribution of assets behind asset-backed securities. In the following section, I build a model of securitization-based financial intermediation, and

I study the channel of uncertainty on illiquidity problems in financial markets though adverse selection.

4 Model

4.1 Agents and information

The model economy is perfectly competitive and finite horizon with three periods ($t = 0, 1, 2$). The economy consists of a continuum of islands and each island is populated by a representative local firm and a representative local bank. All local firms and banks are perfectly competitive, risk neutral and owned by risk averse, representative households outside these islands. State variables for a local firm and bank in an island are not observed by any other agents outside the island.

4.2 Actions and timing

A local firm needs to finance its investment by borrowing from a local bank in period $t = 0$. Two periods are required to build new productive capital. A local bank originates two-period loans in period $t = 0$. A local bank observes client (firm) productivity and own balance sheet cost of holding assets in period $t = 1$. A local bank can securitize loans and sell securitized bonds in a secondary market in period $t = 1$. A local firm decides whether to default (or not), and a local bank gets repayment (or confiscates capital stock) in period $t = 2$. Now, I describe the model by looking at production, profit and value of firms. Thereafter, having seen default decisions of firms, I will focus on the determination of a local firm's borrowing cost via the zero profit condition for a local bank. There, I show that there is an interaction between the market price of bank loans in the local, primary/originating market and the market price of the secondary/distributing market. I conclude the section with a brief description of households and equilibrium. Subscripts attached to each variable represent the timings of decisions made.

4.3 Production, profit and value

I assume that firms live only for three periods. All firms are identical across islands in period $t = 0$ and different in their realizations of productivities in period $t = 1$. Firms undertake capital investment by borrowing from banks in period $t = 0$. The level of this investment is the same across all islands since all firms are identical at the time of their investments. I also assume that two periods are required to build new productive capital. Investment in period $t = 0$ become production units in period $t = 2$. Having observed their productivities in period $t = 2$, firms decide whether to repay or default. Conditional on deciding to repay debt, firms hire labor from households and produce. All firms exit at the end of period $t = 2$ and new penniless firms enter, raise funds from banks and undertake capital investment.

I assume an increasing and concave production function, $y = z\varepsilon F(k,n)$,with $F(k,n) = k^{\alpha}n^{\nu}$ and $\alpha > 0$, $\nu > 0$. Here, z represents exogenous stochastic total factor productivity common across all islands, while ε is an island-specific counterpart. I assume z is a Markov chain, $z \in \{z_1, \ldots, z_{N_z}\}$, where $\Pr(z' = z_m \mid z = z_l) \equiv \pi^z_{lm} \geq 0$, and $\sum_{m=1}^{N_z} \pi^z_{lm} = 1$ for each $l = 1, \ldots, N_z$. Similarly, $\varepsilon \in \mathbf{E} \equiv \{\varepsilon_1, \ldots, \varepsilon_{N_\varepsilon}\}$, where $\Pr(\varepsilon' = \varepsilon_j \mid \varepsilon = \varepsilon_i) \equiv \pi_{ij} \geq 0$, and $\sum_{j=1}^{N_\varepsilon} \pi^{\varepsilon}_{ij} = 1$ for each $i = 1, \ldots, N_\varepsilon$. k is predetermined capital stock and n is labor which is hired from households at period $t = 2$. Prior to the opening of period $t = 2$, a firm is identified by its predetermined stock of capital, $k \in \mathbf{K} \subset \mathbf{R}_+$ and its current idiosyncratic productivity level, $\varepsilon \in$

$\{\varepsilon_1, \ldots, \varepsilon_{N_\varepsilon}\}$. I summarize the distribution of firms over (k, ε) using the probability measure μ defined on the Borel algebra, $\mathcal{S}$, generated by the open subsets of the product space, $\mathbf{S} = \mathbf{K} \times \mathbf{E}$. The aggregate state of the economy is fully summarized by (z, μ) .The distribution of firms evolves over time as $\mu' = \Gamma(z, \mu)$.

To examine the end of period decisions of firms in period $t = 2$, I first need to determine the choices of employment conditional on repaying, the firm's profit and value in period $t = 2$.

At the start of period $t = 2$, each firm that decides to repay after observing its productivity level chooses its employment to solve:

$$\pi(k, \varepsilon; z, \mu) = \max_n \Big[z\varepsilon k^\alpha n^\nu - \omega(z, \mu) n \Big].$$

The firm's optimal labor decision is given by

$$n(k, \varepsilon; z, \mu) = \left(\frac{\nu z \varepsilon k^\alpha}{\omega(z, \mu)} \right)^{\frac{1}{1-\nu}}. \tag{1}$$

This, in turn, implies its production,

$$y(k, \varepsilon; z, \mu) = (\varepsilon z)^{\frac{1}{1-\nu}} \left(\frac{\nu}{\omega(z, \mu)} \right)^{\frac{\nu}{1-\nu}} k^{\frac{\alpha}{1-\nu}}, \tag{2}$$

and its flow profits net of labor costs,

$$\pi(k, \varepsilon; z, \mu) = (1 - \nu) y(k, \varepsilon; z, \mu). \tag{3}$$

Finally, total value of firms at the end of period is

$$V(k, \varepsilon; z, \mu) = \pi(k, \varepsilon; z, \mu) + (1 - \delta) k. \tag{4}$$

At the beginning of period $t = 2$, given the realizations of aggregate and idiosyncratic productivities coupled with predetermined capital stock and debt, firms decide between repaying debt by producing or defaulting on debt. Default occurs if $V(k, \varepsilon; z, \mu) - b < 0$. This implies, by the fact that $V(k, \varepsilon; z, \mu)$ is weakly increasing in ε, that there is a cutoff value of $\varepsilon^T(k, z, \mu)$ such that

$$V\left(k, \varepsilon^T; z, \mu\right) - b = 0.$$

In the presence of default risk, each firm cannot borrow at the risk free rate. Default probabilities affect the rates at which firms can borrow, and this loan schedule and investment are interrelated. In this model, how banks price payoff at the maturity of lending is critical in terms of the loan schedule for firms. Therefore, I will start the next subsection by examining the banks' problem. This leads us to determine the loan schedule for firms, investment and borrowing decisions.

4.4 Banks and primary/originating loan market

Banks live only for three periods. In each island, a local firm's capital investment in period $t = 0$ is financed by two-period debt, of which a local bank is the originator. The maturity of the debt is two periods ahead, and as seen above, firms that draw $\varepsilon < \varepsilon^T$ at period $t = 2$ are defaulting. When banks originating a loan to firms at $t = 0$, the payoff at $t = 2$ is priced by taking account of the probability of default, and therefore the rates at which firms can borrow are influenced by their probabilities of default. In this model, however, banks can unload some fraction of existing loan assets in the secondary market at period $t = 1$ after observing ε. This gives them a chance to update the expected payoff. The existence of the secondary market creates additional liquidity for two-period loan assets and the sales availability in the secondary market affects the loan schedule that banks can offer for firms in the primary/originating market in period $t = 0$. I first look at how banks determine the price of loans in the local, primary/originating loan market below.

In period $t = 0$, banks originate loan b_0 at $q_0(k_0, b_0; z_0, \mu_0)$, when a firm undertakes capital investment, k_0, given the current aggregate state (z_0, μ_0). $q_0(k_0, b_0; z_0, \mu_0)$ is determined by the zero profit condition for banks. Notice that, at the time of initiating a loan to a firm, there is no information on firm specific productivity at hands of banks. After initiating a loan, the local firm's productivity ε become available information in each island. Therefore, banks observe z_1 and ε_1 in period $t = 1$ and they update the expected payoff. On entering a period, each bank draws a marginal fixed cost of holding of a loan asset. This cost, $\xi \in [\xi_L, \xi_H]$, is an i.i.d. draw from the distribution $H(\xi)$ and must be paid for the firm to carry its asset holding in period $t = 2$. All those information at hands, banks choose to unload αb_0 at the market price, $p_1(z_1, \mu_1)$. In period $t = 2$, they get repayments if client firms do not default, or confiscate undepreciated capital stock partially in the case of default.

4.4.1 Loan Schedule

When capital investment by firms become a production unit, conditional upon that the local firm is willing to repay its debt, banks receive the repayment for their holding loan assets. I define the market value of two-period debt, $q_0(k, b; z_l, \mu)\, b$, in recursive form as follows:

In $t = 0$ (before observing ε and ξ),

$$q_0(k, b; z_l, \mu)\, b = \sum_{m=1}^{N_z} \pi_{lm}^{z} d_m(z_l, \mu) \int_{\varepsilon_L}^{\varepsilon_H} \int_{\xi_L}^{\xi_H} q_1(k, b, \varepsilon, \xi; z_m, \mu')\, bG(d\varepsilon)H(d\xi). \quad (5)$$

In $t = 1$ (after observing ε and ξ),

$$q_1(k, b, \varepsilon_i, \xi; z_l, \mu)\, b = \max_{\alpha\in[0,1]} \left[d_1 + \sum_{m=1}^{N_z} \pi_{lm}^{z} d_m(z_l, \mu)\, w_2 \right] \quad (6)$$

subject to

$$d_1 = w_0 + p\alpha b - \xi(1-\alpha)b \geq 0 \tag{7}$$

$$\omega_2 = \int_{\varepsilon^T(k,b;z_l,\mu')}^{\varepsilon_H} (1-\alpha)bG(d\varepsilon|\varepsilon) + \int_{\varepsilon_l}^{\varepsilon^T(k,b;z_l,\mu')} \theta(1-\delta)\,kG(d\varepsilon|\varepsilon). \tag{8}$$

In equation (5), the left hand side, $q_0(k,b;z_l,\mu)\,b$, represents the time $t=0$ risk adjusted amount of funds that a bank is going to lend to a firm with capital investment, k, and borrowing, b, when aggregate state is (z_l,μ). By transiting from period $t=0$ to $t=1$, banks will learn the quality of loan assets, ε, and their own cost of holding asset, ξ. $q_0(k,b;z_l,\mu)$ is the price of the bank loan at period $t=0$ given the expectations over the two uncertainty ε and ξ. The payoff is discounted by the price of an Arrow security that pays off if $z' = z_m, \pi^z_{lm} d_m(z_l,\mu)$[2]. Then next, equation (6) defines the time $t=1$ value of loan assets after realizing the quality of loan assets, ε, and their own cost of holding asset, ξ, besides aggregate state. At this point, banks can unload some fraction of loans from the balance sheet. They maximize the current period dividends payments for households and the value of next period. The current period dividends payment in equation (7) is the sum of initial wealth of each bank, w_0, sales of loan in the secondary market, $p\alpha l_0$, and net of holding costs of loan, $\xi(1-\alpha)l_0$. The value in period $t=2$ is ω_2, and in equation 8, the first term is the expected repayment conditional on ε_j, and the second term is the expected amount of undepreciated capital stock that banks can confiscate in the case of default.

[2] The risk-free real interest rate is $\frac{1}{q_0(z,\mu)} - 1$, where: $q_0(z,\mu) = \sum_{m=1}^{N_z} \pi^z_{lm} d_m(z_l,\mu)$.

4.5 Secondary/distributing market

Banks unload loan assets either because loans are likely non-performing due to the high default risk or, unanticipated needs for cash are realized. The expected value of an asset depends on the average quality of traded assets (as in Akerlof 1970).

The market price in the secondary market of bank loan p is given by

$$p(z,\mu) = \int_{\varepsilon_L}^{\varepsilon_H} \lambda_{\varepsilon,k,b}(p(z,\mu))\widetilde{p}(k,b,\varepsilon;z,\mu)G(d\varepsilon) \tag{9}$$

$$\widetilde{p}(k,b,\varepsilon_j;z,\mu)l_0 = \sum_{m=1}^{N_z} \pi_{lm}^z d_m\left(z_l,\mu\right) \int_{\varepsilon^T(k,b;z_l,\mu')}^{\varepsilon_H} l_0 G(d\varepsilon|\varepsilon_j). \tag{10}$$

$\lambda_{\varepsilon,k,b}(p(z,\mu))$ is the probability distribution over loan (k,b,ε_j) and $\widetilde{p}(k,b,\varepsilon_j;z,\mu)$ is no adverse selection market prices of each loan (k,b,ε_j).

4.6 Investment and borrowing

We are now in a position to set up the firm's problem (with initial networth x_0) at time $t=0$. Given the loan schedule, $q_0(k_0,b_0;z_0,\mu_0)$, firms choose how much to invest, k_0, and borrow, b_0, so as to maximize the sum of the current dividends payment for households and the expected discounted equity value at period $t=2$:

$$\max_{(k_0,b_0)} d_0 + \sum_{m=1}^{N_z} \pi_{lm}^z d_m\left(z_l,\mu\right) \sum_{n=1}^{N_z} \pi_{mn}^z d_n(z_m,\mu^{'})[\max(V_2-b_0,0)] \tag{11}$$

subject to:

$$V_2 = \pi\left(k_0,\varepsilon_2;z_2,\mu_2\right) + (1-\delta)\,k_0 \tag{12}$$

$$d_0 = x_0 + q_0(k_0,b_0;z_0,\mu_0)b_0 - k_0 \tag{13}$$

4.7 Households

The model is closed with a unit measure of identical households. Household wealth is held as one-period shares in firms, which I denote using the measure λ.[3] Given the prices for their current shares, $\rho_0(x,\varepsilon;z,\mu)$, and the real wage they receive for their labor effort, $w(z,\mu)$, households determine their current consumption, c, hours worked, n^h, as well as the numbers of new shares, $\lambda'(x',\varepsilon')$, to purchase at prices $\rho_1(x',\varepsilon';z,\mu)$. The households' maximization problem is listed below.

$$V^h(\lambda;z,\mu) = \max_{c,n^h,\lambda'} \left[U\left(c, 1-n^h\right) + \beta \sum_{m=1}^{N_z} \pi^z_{lm} V^h(\lambda';z_m,\mu') \right] \tag{14}$$

subject to

$$c + \int_{\mathbf{S}} \rho_1(x',\varepsilon';z,\mu)\,\lambda'(d[x'\times\varepsilon']) \leq w(z,\mu)\,n^h + \int_{\mathbf{S}} \rho_0(x,\varepsilon;z,\mu)\,\lambda(d[x\times\varepsilon])\,\Pi.$$

Let $C^h(\lambda;z,\mu)$ and $N^h(\lambda;z,\mu)$ represent the household decision rules for consumption and hours worked, and let $\Lambda^h(x',\varepsilon',\lambda;z,\mu)$ be the rule determining the quantity of shares purchased in firms that will begin the next period with net worth x' and idiosyncratic productivity ε'.

In *recursive competitive equilibrium*, each firm solves the problem described by (11) - (13), banks solve the problem described in (5) - (8), households solve the problem described in (14), the markets for labor, output, firm shares and both primary and secondary loan markets clear, and the resulting individual decision rules for firms and households are consistent with the aggregate law of motion, Γ.

Market-clearing requires that (a) the real wage equal the household marginal

[3] Households also have access to a complete set of state-contingent claims. However, as there is no heterogeneity across households, these assets are in zero net supply in equilibrium.

rate of substitution between leisure and consumption:

$$w\left(z,\mu\right)=D_2U\Big(C(z,\mu),1-N(z,\mu)\Big)/D_1U\Big(C(z,\mu),1-N(z,\mu)\Big),$$

that (b) the risk-free bond price, q_0^{-1}, equals the expected gross real interest rate:

$$q_0\left(z,\mu\right)=\beta\sum_{m=1}^{N_z}\pi_{lm}^{z}D_1U\Big(C(z_m,\mu'),1-N(z_m,\mu')\Big)/D_1U\Big(C(z,\mu),1-N(z,\mu)\Big),$$

that (c) firms' state-contingent discount factors are consistent with the household marginal rate of substitution between consumption across states:

$$d_m\left(z,\mu\right)=\beta D_1U\Big(C(z_m,\mu'),1-N(z_m,\mu')\Big)/D_1U\Big(C(z,\mu),1-N(z,\mu)\Big)$$

and that (d) the market price in the secondary market of bank loan p is given by (9) - (10).

5 Results

5.1 Parameter selection

I set the length of a period to one year. I assume that the representative household's period utility is $u(c,L)=\log c+\varphi L$, as in the models of indivisible labor (e.g. Hansen (1985), Rogerson (1988)). The firm-level production function is Cobb-Douglas: $z\varepsilon F(k,n)=z\varepsilon k^{\alpha}n^{\nu}$, where α and ν determine capital and labor's share of income in this economy. Bank balance sheet costs are drawn from a uniform distribution on the interval $[\xi_L,\xi_H]$, and firm-specific productivity follows an AR(1) log-normal process, $\log\varepsilon'=\rho_\varepsilon\log\varepsilon+\eta'$, with $\eta'\sim N\left(0,\sigma_\eta^2\right)$.

The following five parameters are calibrated to match the aggregate moments for the U.S. economy: (1) α: capital's income share, (2) ν: labor's income share, (3)

β: the household discount factor, (4) δ: the depreciation rate and (5) η: the leisure preference. I set ν to 0.60 to reproduce an average labor share of income consistent with Cooley and Prescott (1995). I set α to 0.265 so that the model matches an average private capital-to-output ratio of 2.55. The depreciation rate, δ, is set to yield an average investment-to-capital ratio at 0.08. The average private capital-to-output ratio and the average investment-to-capital ratio are calculated from the U.S. National Income and Product Accounts Tables and Fixed Assets Accounts Tables from 1976 to 2012. I set the household discount factor, β, to match an average real interest rate of 4 percent as in Gomme, Ravikumar and Rupert (2011). Finally, the preference parameter, η, is set to imply an average hours worked of one-third.

The remaining parameters include θ (fraction of firm capital recouped by the lender in the event of default), ξ_L (minimum balance sheet cost), ξ_H (maximum balance sheet cost), alongside ρ_ε and $\sigma^2_{\eta_\varepsilon}$ (persistence and volatility of firm productivity shocks). I consider the case where the financial intermediary confiscates all remaining capital of a firm in the event of default; $\theta = 1$. Given this parameters, I jointly select the remaining parameters so that the model reproduces (1) the average debt-to-assets ratio of nonfarm nonfinancial businesses over 1971-2012 in the Flow of Funds (0.393), (2) the average annual exit rate of firms (0.07), (3) the average mean investment rate (i/k) across establishments (0.122) and (4) the average standard deviation of investment rates (0.337) as reported by Cooper and Haltiwanger (2006).

5.2 Aggregate implication of uncertainty shocks

This section first examines decision rules of banks and firms, and then explores the impact of uncertainty shocks on the securitization market and aggregate economic dynamics. I look at a pooling equilibrium in which households form beliefs about the

Table 1: Parameter Values

β	ν	δ	α	φ	θ
0.96	0.60	0.067	0.265	2.15	1.00
ρ_z	σ_{η_z}	ξ_L	ξ_H	ρ_ε	$\sigma_{\eta_\varepsilon}$
0.852	0.014	0.00	0.05	0.653	0.235

quality distribution of securitized loans in the market, and the market price of the securitized loans reflects the expected average quality of loans traded in the market. Thus, the market price of the securitized loans is sensitive to beliefs of households. Figure 5 depicts a loan rate schedule offered by a bank to a firm within the same island. It shows that loan rates are increasing with capital and decreasing with debt. This is standard result in non-contingent debt contract models that show a higher leverage leads to increased borrowing costs due to the higher default probability. After initiating loans to the firm, the bank can choose to the fraction of loan assets in the balance sheets to unload and sell in the securitization market. This is shown in Figure 6 that plots the fraction of unloading assets as a function of the firm's productivity level and the bank's own liquidity shock. As seen in the figure, the bank with lower productivity levels of the firm will more likely to sell its holdings of loan assets in the market. This is because that the bank anticipates the high default probability of the firm which implies the loss for the bank. The bank faces the trade-off between the expected loss due to the firm's default in the following period and the loss that will be realized in the current period by selling loan assets at the lower price than that would have been when the firm would not default. The bank with larger liquidity shocks also sells off own loan assets: this is simply because it needs funds. This implies that the bank might sell off loan assets even its quality implied by the default probability is high. This additional dimension makes the quality distribution of underlying assets securitized in the market heterogeneous.

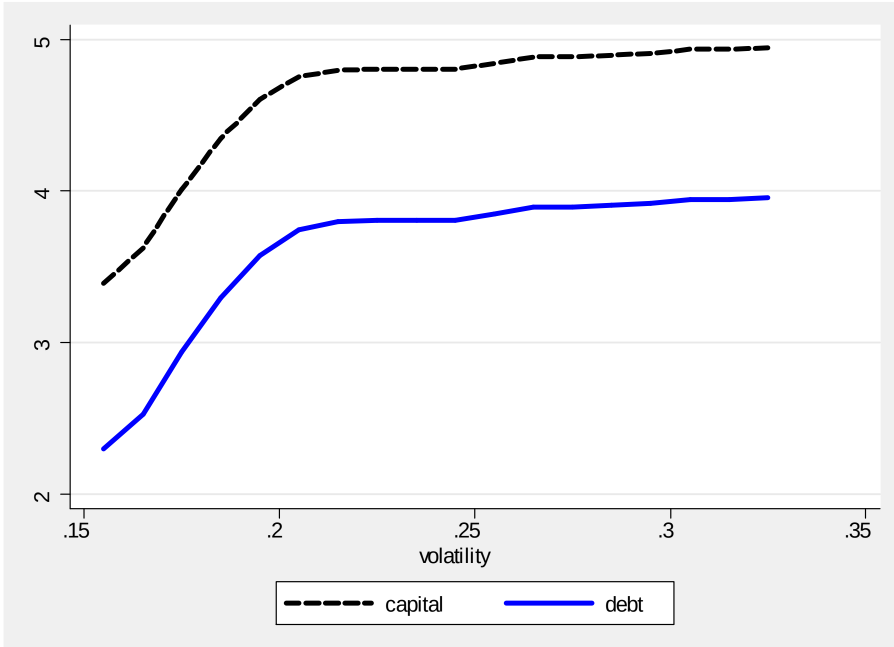
Figure 7 shows capital investment decisions by a firm as a function of its initial net worth and its island bank's initial wealth level. Capital investment increases with both firm's initial net worth and its bank's initial wealth level.

5.2.1 The role of adverse selection

To study the impact of uncertainty shocks, I compare many different stationary equilibrium allocations with different dispersions, which is shown in Figure 3 and 4, and I examine how the securitization market and aggregate economy's dynamics affected. Following a shock to the dispersion of firm productivity, the adverse selection problem gets more severe. First, default rates rise, and the expected average quality of loans traded in the market falls. Consequently, the market price of the securitized loans falls, which deteriorates the funding conditions of lenders, and thus, a loan rate schedule offered by lenders is adversely affected. This will, in turn, affect a firm's investment through the rise in the unit cost of borrowing. This feedback loop through adverse selection amplifies the impact of uncertainty shocks.

This adverse selection is the negative impact of uncertainty on securitization based financial intermediation. As in Figure 4, however, while the market price of securitized loans falls the other liquidity measure, the market volume, increases with more dispersed productivity at the firm level. This is because aggregate investment increases and more bank loans are securitized and sold off in the market. This positive

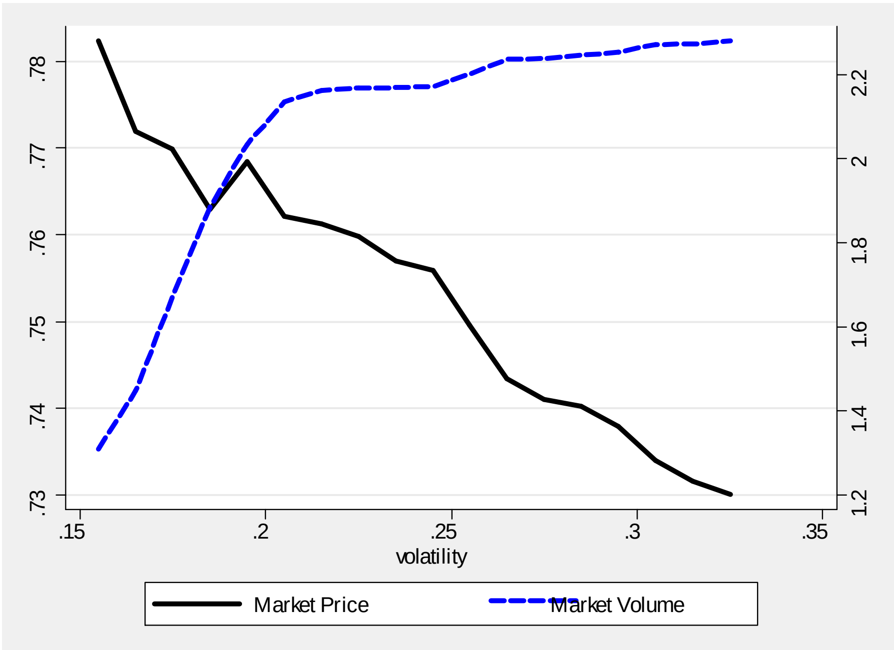
Figure 3: Impacts of uncertainty 1



impact of uncertainty on investment is known as the Oi-Hartman- Abel effects.[4] When the policy function is convex in random variables, the more volatile process for the random variables implies the larger optimal choice. In this paper's case, the more volatile productivity distribution is known and anticipated by firms, they increase investment. This positive impact of uncertainty on investment dominates the negative one implied by adverse selection, and therefore, aggregate capital stock, employment and debt rise with more volatile firm productivity, even funding gets harder for banks with securitized bonds.

[4] The positive impact on investment is studied by Oi (1961), Hartman (1972), and Abel (1983).

Figure 4: Impacts of uncertainty 2



6 Concluding remarks

Economist have been discussing a link between financial markets and aggregate fluctuations since the recent financial crisis. As stated by Bernanke (2008), "*The crisis we face in the financial markets has many novel aspects, [...] at the root of the problem is a loss of confidence by investors and the public in the strength of key financial institutions and markets.*" My approach is to see the liquidity crisis that we witnessed as a result of the loss of confidence by investors, and I built a model to capture such an environment with time-varying uncertainty. I then used this model to explore the link between the deterioration of financial markets and subsequent recessions.

The contribution of this paper is to show that there are both positive and negative effects of uncertainty on firm's investment in a model of securitization based financial intermediation. The positive effect is due to the concavity of production technology, leading to more capital investment with higher levels of uncertainty. The negative effect arises because of the reduced efficiency of bank lending in the face of larger uncertainty about the collateral values in creating asset-backed securities. The latter is a new channel in the literature, and this paper shows that the positive effect is still more powerful than the negative effects so that the overall impacts on liquidity measures such as market volume and price are ambiguous.

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Figure 5: Loan rate schedule

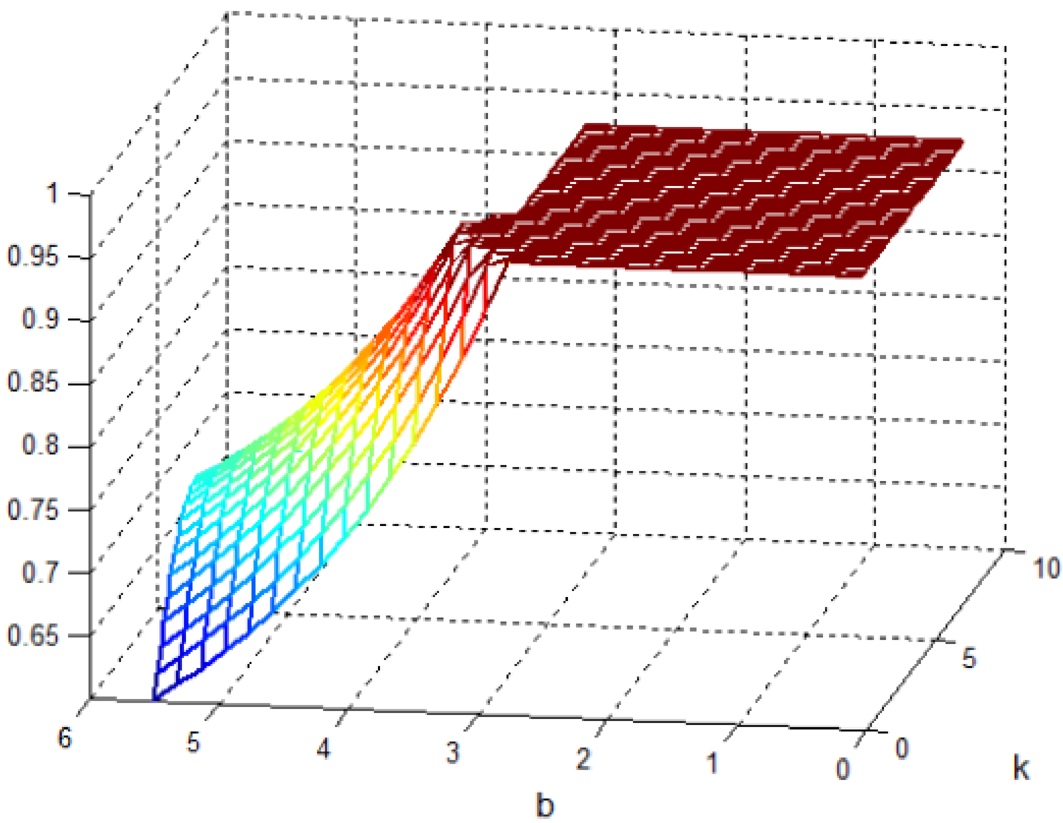

Figure 6: Securitazation decision

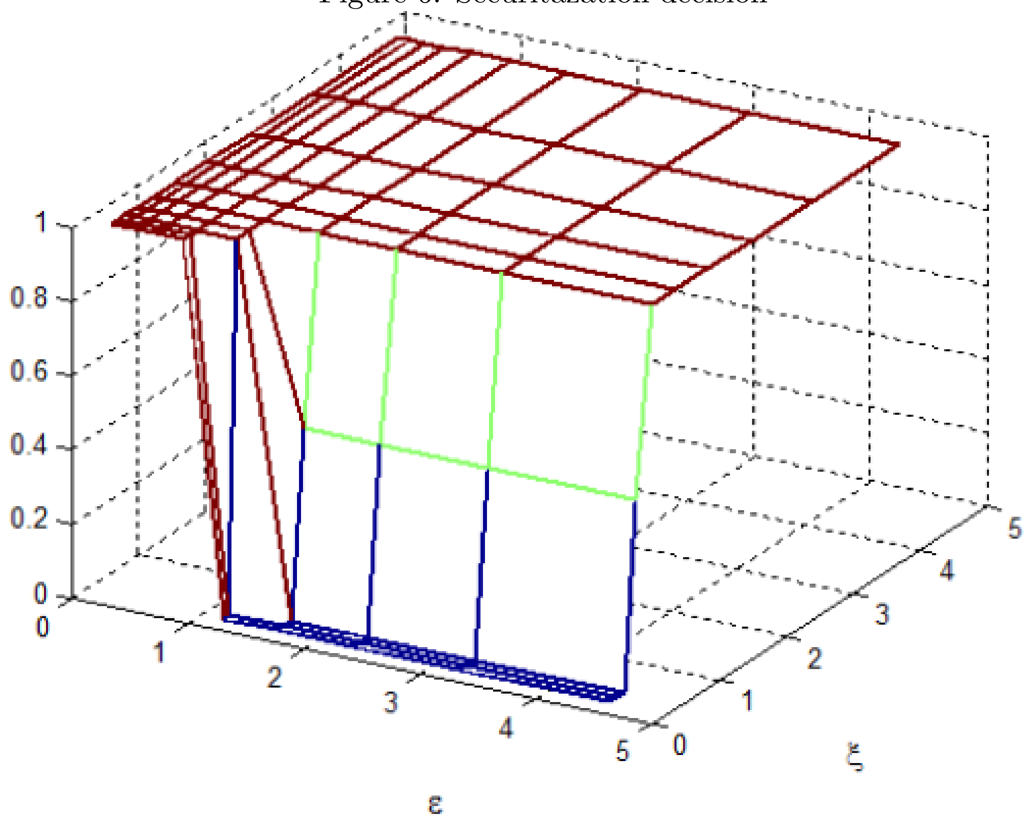

Figure 7: Capital choice

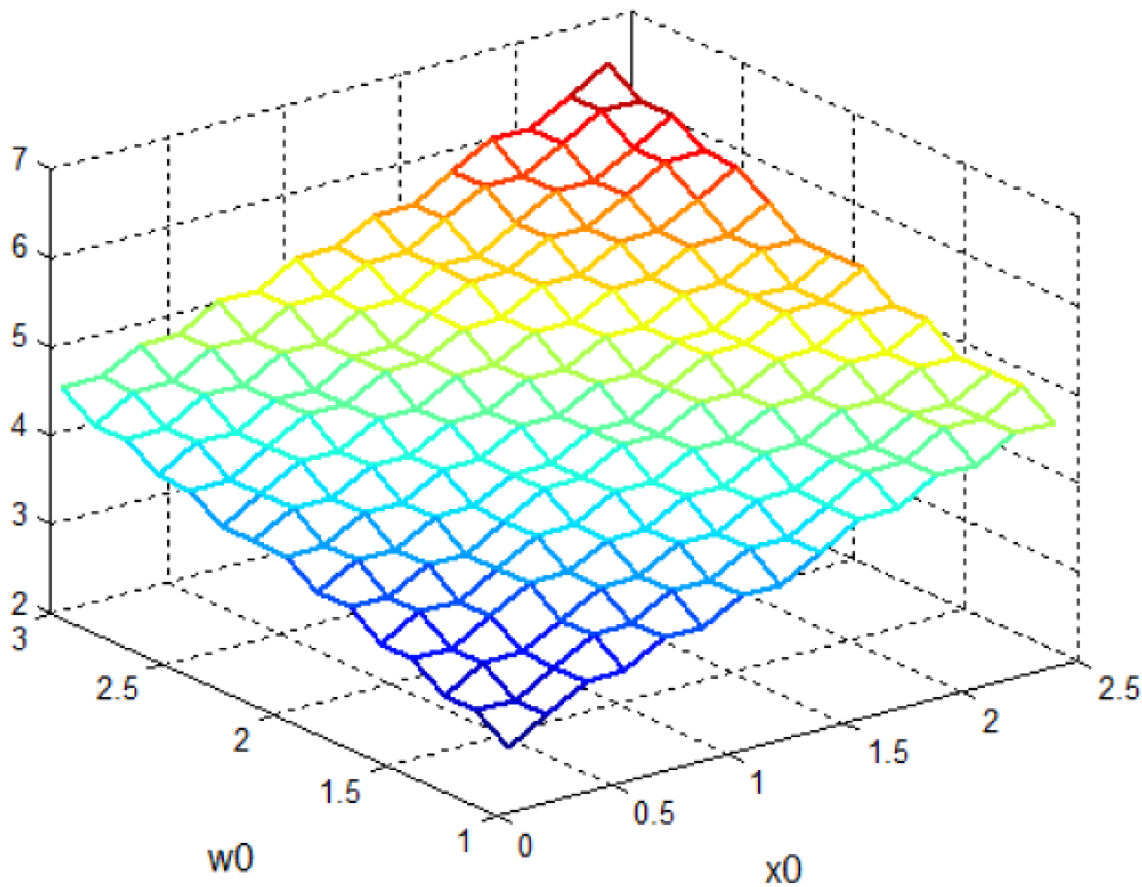

Figure 8: Equilibrium loan rates