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Bank Optimism, Information Accuracy, and Securitization

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Abstract: By setting up behavioral models of loan securitization, we provide explanations for phenomenon during the Global Financial Crisis. Information inaccuracy in our models comes from optimism rather than moral hazard. We show that investors are insensitive to information about underlying loans, certain level of optimism is more profitable to banks than having perfect information, and benefit from securitization enhances banks' optimal optimism level. Moreover, dominance of optimistic banks blurs quality differences in securitization products, leading to symmetric ignorance and higher susceptibility to shocks, which results in investors' "flight-to-quality" in the securitization market. Our numerical analysis demonstrates influences of bank competition, security tranching and capital requirement. The findings highlight the importance of awareness of over-optimism in creating contagion of financial fragility.

Keywords: Securitization; Behavioral Finance; Optimism; Flight-to-quality; Tranching

JEL Codes: D81, D83, G20, G41.

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1. Introduction

Moral hazard and excessive risk taking are well-documented and commonly-cited factors in explaining the Global Financial Crisis. Recent studies, however, suggest that behavioral finance explanations – that beliefs were distorted and participants in the market were not as rational as expected – is another important factor. Cheng et al. (2014), suggests that banks and investors do act on "distortions in beliefs". Barberis (2011) proposes a "belief manipulation hypothesis" for understanding why banks built up large subprime positions and that traders saw subprime loans and related securities as worthy business, but were only vaguely aware of the risk. Shleifer and Vishny (2010) shows that the volatility of bank credit and real investment are highly impacted by investor sentiment, which reflects biased expectations or institutional preferences and constraints.

This paper aims to add insight to this less studied area of "distorted belief" as an explanation of a speedy credit crunch, by focusing on implications of over-optimism in a lending and securitization model. Optimism should not be confused with overconfidence. The former is about overestimating the frequency of favorable outcomes, while the latter is about underestimating the uncertainty (variance) of the outcome. Literature in behavioral finance has identified various driving factors of optimism. For example, Baron and Xiong (2016) identified neglected tail risk (Gennaioli et al. (2012, 2013)), over-extrapolating the past in forming expectations of the future (Barberis et al. (1998)), and wishful thinking (Reinhart and Rogoff (2009)). Barberis (2011) also proposes a lack of competence hypothesis as a cause.The years before the Great Recession form a period of overly optimistic loan underwriting because of an era of low interest rate, rapid price growth and falling subprime defaults. Banks tended to build strong "relationship banking" with some of their clients (see for example, Dougal et. al. (2012)), with more lenient lending. There is an unprecedented growth of securitization of housing loans by financial institutions (broadly called "banks") for higher profits as well as increased investors' demand for asset backed securities (ABS) and collateralized debt obligations (CDOs), which had relatively high rates and spuriously high credit ratings. While earlier literature supports the act of securitization in that it increases risk diversification and improves financial stability (Duffie (2008)), securitization is also accused of stimulating market enthusiasm and then financial instability (Keys et al.(2009), Carbó-Valverdeet al. (2012)). Shleifer and Vishny (2010) also mention that banks transmit mispricing into the market through securitized lending, taking advantage of investor sentiments.

The literature suggests mixed evidence on the relationship between securitization and information asymmetry. On one hand, it is argued that the presence of information asymmetry encourages securitization (Ambrose et al. (2005)), and securitization in turn ameliorates the effects of asymmetric information (DeMarzo(2005)) because banks have to disclose more information about the related loans or assets by issuing securities than keeping assets on the balance sheet. On the other hand, securitization may lead to greater information opacity because information cannot be credibly transmitted to the market (Cheng et al. (2008)), and banks might have less incentive to screen borrowers thoroughly at origination or to keep monitoring them (Gorton and Pennacchi (1995), Schwarcz (2004)).

This paper contributes to the literature by descomposing the impacts of information asymmetry into bank optimism and information inaccuracy, and by modeling interactions among securitization markets, bank lending strategies, and policy effectiveness. We show how bank optimism plus liquidity premiums can lead to a crisis through initial increases in lending and increases in securitizing these loans, coupled with deteriorating loan quality, followed by fragile market, and later investors' "flight-to-quality". Moreover, this paper incorporates roles of biased beliefs in shaping financial sector. Our results are in line with "bad incentives" or "bad models" of Barberis (2011), and with Cheng et al. (2014) that biased/distorted beliefs may interact with incentives, or even reinforce the adverse effects of bad incentives. This paper also adds to the growing literature on motivated beliefs and the value of belief (Brunnermeier and Parker (2015), Bénabou and Tirole (2016)).

2. Securitization Market Equilibrium with Homogeneous Banks

In the primary loan market, banks observe a probability distribution of loan repayments, make an estimation of the true probability for any individual loan based on experience or accumulated relationships with good borrowers and/or other measures such as credit scores,[1] in order to reject or accept the loans. Upon acceptance, the banks decide whether to hold loans on balance sheet or bundle and securitize them. In the secondary loan market, banks compete to sell securities to investors. Banks maximize their overall gain from securitization and from holding loans in balance sheet, while investors maximize their profit in security investment. Investors maximize profit from securitization purchase by trading off security price and acceptable quality, while we assume they have enough funds to buy securities until the marginal profit equals to zero and might shift demand among banks.

2.1 Bank Choice – Loans and Securitization

Consider a one-period securitization decision. There are N firms in the market, each needing capital of \$1. A representative bank grants loans to firms and securitizes part of the loans, while keeping the rest, at the beginning of the period. At the end of the period, payments and returns of all loans and securities are settled. Assume a zero

[1] To simplify theoretical analysis, we assume the same level of information asymmetry across loans, different from DeMarzo and Duffie (1999).

risk-free rate. The no-default probability $q \in [0,1]$ follows a continuous, differentiable, and single-peaked density function $f(q)$ and a corresponding cumulative distribution function $F(q)$. The bank extracts a payoff $R_\sigma > 1$ if the firm does not default, and receives collateral $c < 1$ otherwise. The value of collateral to the firm before default is r_c where $r_c \geq qR > c$ so that the firm cannot gain from default. Each firm's q is private information, while investment payoff R is common knowledge.

The bank makes its estimation of the no-default probability based on an initial level of information σ as:

$$\beta = q\sigma \quad (0 \leq \beta \leq 1, \text{ and } \sigma > 0),$$

where σ indexes optimism. It is greater than 1 when the bank is optimistic and overestimates *q*, equal to 1 for accurate information, or less than 1 for pessimism (underestimating q). The extent of information inaccuracy is measured by $|\sigma - 1|$.

A firm applies a loan if and only if the benefit is not less than cost, that is,

$$qR \geq qR_\sigma + (1-q)r_c \,. \tag{1}$$

The bank will accept the application only when it incrementally adds to banks' expected profit by

$$\beta(R_\sigma - r) + (1-\beta)(c - r) \geq 0 \,, \tag{2}$$

where r is 1 plus its cost of capital, and $r > c$, so that the bank cannot profit from borrowers' default. Equation (2) gives the bank's minimum acceptance level of repayment probability $\beta_{\min} = (r-c)/(R_\sigma - c)$.

The bank retains the lowest quality loans and securitizes some of the rest when it is qualified for securitization and generates more value than holding on balance-sheet (

$\beta R_\sigma + (1-\beta)c < r_s + \delta$).[2] Since this part of loans is bundled into one pool and sold at a single price, the bank will not want to sell high quality loans at the same (low) price if there is only one tranche. Hence, we assume the bank securitizes loans that have repayment probability up to an upper bound of β' (β' can be equal to 1 if the bank only holds the lowest quality loans).

Investors buy the pool of securitized products when they are sold at a reasonable price and the disclosed quality of related loan pools is above a certain threshold $\overline{\beta}_s \in [0,1]$ .Hence, loans with estimated repayment probability $\beta \in [\overline{\beta}_s, \beta']$ will be securitized, while the rest will be kept by the bank. Investors as a whole pays fixed rate r_s to banks in return for uncertain returns from the loan pool, which has the expected income $qR_\sigma + (1-q)c$. Investors undertakes risk that stems from the underlying loans, thus are compensated with a risk premium ($qR_\sigma + (1-q)c > r_s > c$ should hold). Meanwhile, the total gain to the bank from securitizing a \$1 loan is greater than its cost of capital, that is, $r_s + \delta > r$, where $\delta > 0$ is the value from additional liquidity gained from securitizing the loan (this is the liquidity premium in Heuson et al. (2001) and Agostino and Mazzuca (2011), or opportunity cost in Parlour and Plantin (2008)). This constraint ensures that banks are incentivized to securitize loans that are acceptable to investors, rather than rejecting a loan application.

In summary, the decision of are presentative bank on lending and securitizing could be classified into three regions of the bank's no-default probability: a) reject a loan application if $\beta \in (0, \beta_{\min})$, b) accept and hold the loan for $\beta \in [\beta_{\min}, \overline{\beta}_s) \cup [\beta', 1)$, and c) accept and securitize the loan if $\beta \in [\overline{\beta}_s, \beta')$ .Given the total number of loan

[2] In a competitive security market or repeated trading game, it is reasonable for banks to keep some riskier loans in the portfolio, rather than selling them to investors because of regulatory capital arbitrage and reputation concern (Ambrose et al. (2005)).

applications (one per firm) N, the security volume in equilibrium is $V = N\int_{\bar{\beta}_s/\sigma_s}^{\beta'/\sigma} f(q)dq$

,and the volume-weighted average quality level is $Q = \frac{N}{V}\int_{\bar{\beta}_s/\sigma}^{\beta'/\sigma} qf(q)dq$.

2.2 Loan Quality Threshold for Securitization and Security Price

In a competitive securitization market, equilibrium is solved by backward induction. First, choices in loan quality threshold levels of banks and investors are solved in terms of security price. Secondly, since investors are assumed to have unlimited funds they will exhaust investment opportunities until the marginal profit from buying securities equals to zero, thus determining the market security price.

The bank and the investors have different information levels, σ and σ_s respectively. Given initial information levels, banks maximize overall value by setting the securitization cutoff, β', and investors choose the optimal securitization threshold $\bar{\beta}_s$ which maximizes expected profits:

$$\max_{\beta'} \pi_{bank} = N\{\int_{\beta_{\min}/\sigma}^{\bar{\beta}_s/\sigma}\left[qR_\sigma + (1-q)c - r\right]f(q)dq + \int_{\bar{\beta}_s/\sigma}^{\beta'/\sigma}[r_s + \delta - r]f(q)dq + \int_{\beta'/\sigma}^{1}\left[qR_\sigma + (1-q)c - r\right]f(q)dq\} \quad (3)$$

$$\max_{\bar{\beta}_s} \pi_I = N\int_{\bar{\beta}_s/\sigma_s}^{\beta'/\sigma}\left[qR_\sigma + (1-q)c - r_s\right]f(q)dq \quad (4)$$

satisfying $\frac{\bar{\beta}_s}{\sigma_s} < \frac{\beta'}{\sigma} \le 1$. Otherwise, if $\frac{\bar{\beta}_s}{\sigma_s} > \frac{\beta'}{\sigma}$ or $\frac{\bar{\beta}_s}{\sigma_s} \ge 1$, investors become very conservative ($\sigma_s < 1$) and skeptical about loan quality, which could further lead to a shut-down of securitization market. For bank value π_{bank}, the first and third terms in the parentheses are profit from holding loans, while the second term is the value and additional liquidity premium from securitization. The solutions for loan quality threshold levels for the bank and the investors in terms of security price are, respectively:

$$\beta' = \frac{r_s + \delta - c}{R_\sigma - c},$$

$$\bar{\beta}_s = \frac{\sigma_s (r_s - c)}{R_\sigma - c}, \tag{5}$$

and the competitive security price in the securitization market is set implicitly as below:

$$\frac{(r_s - c)(1-\sigma) + \delta}{\sigma^2 (R_\sigma - c)} f\left(\frac{\beta'}{\sigma}\right) = F\left(\frac{\beta'}{\sigma}\right) - F\left(\frac{\bar{\beta}_s}{\sigma_s}\right) \tag{6}$$

The concave second order condition ensures this is a profit maximization solution (Appendix 1).

For the bank and the investors to have mutual agreement on securitization, it must be that $\bar{\beta}_s < \beta'$, which implies, $(r_s - c)(1-\sigma) + \delta > 0$. Notice that in very rare case when, although the marginal profit for the bank to hold the loan is negative, securitization always yields positive marginal value (or, $r_s + \delta - r > 0$). This expansion in credit supply usually happens during an economic boom when investors have abundant funds and thirst for investments, similar to the time before the Great Recession when loans (such as subprime or alt-A mortgages) that were not up to quality if banks have to hold them were actually originated and securitized.

2.3 Irrelevance of Investors' Information

Static analysis of above equilibrium yields Proposition 1 (proofs in Appendix 1).

Proposition 1(Irrelevance of Investors' Information).When there is asymmetric loan quality estimations between a representative bank and investors, the optimal contract for maximizing both banks' value and investors' profit is designed independently of investors' level of information. Specifically,

i) security price r_s, volume V and investors' profit π_I are not affected by investors' information accuracy σ_s, nor by an information gap between the bank and investors $\sigma_s - \sigma$;

ii) investors tend to increase the securitization threshold $\bar{\beta}_s$ when shared information is less precise, but actual quality Q is unaffected by investors' information accuracy σ_s;

iii) investors' profit π_I is negatively related to bank's information inaccuracy σ.

Above proposition provides a theoretical explanation for investors' information insensitiveness upon underlying assets. Investors may rely on the same credit scoring technology accepted by their lenders (Luque and Riddiough, 2015), which contributes to their insensitiveness. In equilibrium after rounds of securitization games, investors may prefer to trust banks, even facing asymmetric estimations of loan quality. Since Proposition 1 shows the irrelevance of investors' information level σ_s, we set $\sigma_s = \sigma$, and therefore denote $\bar{\beta}_s$ as $\bar{\beta}$.

2.4 Comparative Static Analysis

Based on the securitization equilibrium above, we analyze how banks' liquidity needs and optimism affect the equilibrium (proofs shown in Appendix 1). Define

$$H_1 = \frac{(r_s - c)(1-\sigma) + \delta}{\sigma^2 (R_\sigma - c)} f' + \frac{1-\sigma}{\sigma} f \ , \tag{7}$$

where f' denotes the first derivative of the probability density function of $f(q)$ evaluated at $\frac{\beta'}{\sigma}$. Equilibrium impacts of interested variables are related to investors' sensitivess upon security price (proxy by value of H_1). Banks needing more liquidity (i.e. an increase in premium δ) sell securities of higher perceived quality (higher β')

at higher security price r_s. This in turn raises investors' threshold $\bar{\beta}$ when $H_1 > 0$ because they also benefit from having increased marginal profit from the bank securitizing more good loans, albeit charging a higher security price r_s.

Liquidity premiums always have positive impacts on investors' profits (see Appendix 1), partly due to their positive impact on security volume. Hence, it is always better for investors when a bank securitizes more of its loans, subject to acceptable levels of loan quality. However, we have $\frac{\partial \pi_I}{\partial \sigma} = -N \frac{r_s + \delta - c}{\sigma^2 (R_\sigma - c)} \frac{(r_s - c)(1-\sigma) + \delta}{\sigma} f\left(\frac{\beta'}{\sigma}\right) < 0$,which indicates that investors' gains decrease with banks' information inaccuracy, and investors therefore have incentive to retrieve more information when information is inaccurate and banks are optimistic ($\sigma > 1$); and they prefer conservative estimation to perfect information ($\sigma \le 1$).The extent of information asymmetry is measured as $|\sigma - 1|$.

Furthermore, when $H_1 > 0$, $\frac{\partial r_s}{\partial \sigma} < 0$, $\frac{\partial \bar{\beta}}{\partial \sigma} > 0$, and $\frac{\partial \beta'}{\partial \sigma} > 0$. That is, investors demand a higher securitization threshold $\bar{\beta}$ and lower security price r_s if they believe that the information shared by the bank is less accurate. The bank will also be more eager to securitize loans with high perceived quality, i.e. higher β'. Hence, although increases in bank confidence tend to increase both the lower bound $\bar{\beta}$ and upper bound β' for securitization, equilibrium securitization volume V (note that $\frac{\partial V}{\partial \sigma} < 0$) and volume-weighted average quality Q will decrease as investors become more skeptical about the overconfidence of the bank.

2.5 Endogenized Optimism and Information Value

Information inaccuracy affects the gain of the bank in the following way (from equation (3)):

$$\frac{\partial \pi_{bank}}{\partial \sigma} = N\left[\frac{\delta}{\sigma\left(R_\sigma - c\right)}\left(f - \sigma f^{0} \right)\frac{\partial r_s}{\partial \sigma} - \left(1 - \frac{1}{\sigma}\right)\left(r - c\right) f\left(\frac{\beta_{\min}}{\sigma}\right)\frac{\beta_{\min}}{\sigma^2} - \left(1 - \frac{1}{\sigma}\right)\left(r_s + \delta - c\right)\frac{\beta'}{\sigma^2} f \right]. \tag{8}$$

When the bank overestimates the probability of no default (i.e. $\sigma > 1$) and $H_1 > 0$, the bank's equilibrium gain will decrease with increasing information inaccuracy($\frac{\partial \pi_{bank}}{\partial \sigma} < 0$), and the bank has an incentive to improve information precision, and the maximum cost that the bank is willing to pay is limited to $\left|\partial \pi_{bank} / \partial \sigma\right|$.

The bank may not have an incentive to improve information in other cases. It is interesting to see that when there is perfect information, $\sigma = 1$, the second order condition for equilibrium generates a much simpler form of $H_1 = \frac{1}{R_\sigma - c} f'$, and $G_{r_s} < 0$ such that

$$\frac{\partial \pi_{bank}}{\partial \sigma}\Big|_{\sigma=1} = N \frac{\delta^2\left(f - f^0\right)}{\left(R_\sigma - c\right)^2 G_{rs}}\left(\frac{r_s + \delta - c}{R_\sigma - c} f' + f\right)$$

is positive if $\left(f - f^0\right)\left(\frac{r_s + \delta - c}{R_\sigma - c} f' + f\right) < 0$, highly influenced by the shape of the probability dentisity function. When this condition holds, the bank's gain will increase with more asymmetric information, and the extent of this effect can be further enhanced by a higher liquidity premium. Hence, perfect information may not be optimal for a bank that participates in loan securitization, especially when the bank has stronger liquidity needs. Intuitively, banks do not want their investors to have precise information on the quality of their securities if they want to launch bigger volume, as long as the average quality is acceptable by the investors who might be more lenient in good times.

In our model, the information indicator σ can be decomposed into two components ─the optimism component and the pure information inaccuracy component. The former could be derived as the difference between optimistic and conservative equilibrium values of the bank, that is,

$$Value_{opt}(t) = \frac{1}{2}\left[\pi_{bank}(\sigma = 1+t) - \pi_{bank}(\sigma = 1-t)\right] \tag{9}$$

where $t > 0$ is an increment of information indicator. Pure information inaccuracy is then the effect of the information inaccuracy indicator net of optimism and perfect information ($\sigma = 1$), yielding:

$$Value_{Info}(t) = \frac{1}{2}\left[\pi_{bank}(\sigma = 1+t) + \pi_{bank}(\sigma = 1-t)\right] - \pi_{bank}(\sigma = 1) \quad \text{for} \quad t > 0 \tag{10}$$

Equation (10) indicates that information inaccuracy will have a negative impact because bank profit is a concave function of information indicator σ .

We next define the total welfare as the summation of bank and investors' profits[3].

$$W = N\delta\int_{\bar{\beta}/\sigma}^{\beta'/\sigma} f(q)dq + N\int_{\beta_{min}/\sigma}^{1}\left[qR_{\sigma} + (1-q)c - r\right] f(q)dq = \delta V + \pi_{bank}^{ns} \tag{11}$$

where $\pi_{bank}^{ns} = N\int_{\beta_{\min}/\sigma}^{1}\left[qR_{\sigma} + (1-q)c - r\right] f(q)dq$ is bank profit with no securitization. Compared to no securitization, total welfare is enhanced by δV , which includes benefits of both investors and the bank. While the bank earns the liquidity premium (δ), investors now have a new opportunity to invest through V.

In sum, higher liquidity need initially leads to more securitization, and the bank is willing to charge lower security price. This enhances banks' loan market share, total value, profit maximization, as well as total welfare of both the bank and investors. As

[3] Given exogenous average loan rate, deposit and collateral rates, banks' decision on marginal loan rejection ($\beta_{\min}$), and therefore, borrowers' benefit is fixed. Hence, we do not include borrowers' profit in welfare analysis. For welfare analysis in primary loan market, the benefit of securitization on loan applicants comes from more credit supply (Drucker and Puri(2009)) and lower loan rate (Heuson et al. (2001), Hancock and Passmore (2011)). Liquidity premium is also welfare-enhancing to borrowers in the sense of lower borrowing cost relative to loans kept by the bank (Nadauld etal. (2012)).

a result, however, securities on the market have lower volume-weighted average quality, causing investors to be more sensitive to external shocks. Once they reduce their investments because the underlying asset price is too volatile and/or decreases, liquidity will be cut off; this is when “flight-to-quality” occurs. In the extreme, the securitization market would lead to a complete shut-down and a slowdown of the economy as in the recent Global Financial Crisis.

2.6 Numerical Analysis

Consider an arbitrary setting of N =10000 borrowers in the economy, each applying for a \$1 loan. Since the no-default probability q takes on values of [0,1], we adopt a Beta density function whose first order derivative is defined and non-zero. It is a continuous probability distribution defined compactly on the interval [0,1], and is parameterized by two positive shape parameters a and b:

$$f(q) = \frac{1}{B(a,b)} q^{a-1} (1-q)^{b-1}$$

where the beta function $B(a,b)$ is a normalization constant to ensure that the total probability integrates to 1. We set the shape parameters $a = 10$, $b = 2$ for the numerical demonstrations such that the assumed probability distribution is left skewed ($a > b$). While some existing literature endogenizes default probability by parameterizing the bank’s monitoring incentive, we merely assume ageneral distribution of loans’ repayment probability based on some stylized facts about default rates. For example, mean default rate is0.204 in Keijsersy et al. (2015) or 12.1% in Bonfim et al. (2012).

It is well documented that the cost of borrowing and the amount of required collateral varies with business cycles (Aivazian et al.2013). Our analysis mainly focuses on two scenarios as proxies for different macroeconomic environments.[4] In

[4] Result robustness is checked with more scenarios.

Scenario 1, we assume that gross loan rate is 11% ($R_\sigma = 1.11$), deposit rate is 5% ($r = 1.05$), collateral rate c is 0.8, and liquidity premium δ is 0.020.[5] In Scenario 2, the parameters are R_σ =1.085, r =1.02, c=0.9, δ= 0.010. Figure 1 shows the effects of information indicator σ varying from 0.95 to 1.05 (the *x*-axis).

Panel A of Figure 1shows that the security is more valuable (in terms of higher price and quality *Q*) when banks have higher confidence in their information, although quality, and therefore price, quickly deteriorates when there is too much optimism. On the contrary, when the bank is conservative about loan repayment ($\sigma < 1$), a potentially safe loan will be perceived as riskier, and, hence, the price of the security backed by such loan will be lower. As it becomes more optimistic and/or faces more inaccurate information, security prices are not necessarily an indicator of quality (an interval around 1.02 in Scenario 2, r_s is in uptrend, while average quality Q is in downtrend).

In Panel B, narrowing of the gap between $\overline{\beta}$ and β' leads to a lower securitization volume (proportion). However, while credit expands rapidly during an economic boom, more firms tend to borrow for expansion (*N* increase). At the same time, investors have increased appetite for securities, financial institutions have become overly optimistic, and as a result both security price and quality drop.The proportion of good loans being securitized may drop due to optimism, while securitization market size increases. Empirical studies find that loan quality deteriorated in the years leading up to the financial crisis (Demyanyk and Van Hemert(2011));even safe securities rated as AAA are not really safe due to high cash flow correlations (Caballero and Krishnamurthy (2009)).

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[5] We also run different scenarios for other liquidity premium values, which demonstrate similar trends as in Figure 2.

As shown in Panel C, total welfare W (sum of gains of the bank and investors) decreases as the bank becomes more optimistic. While investors' welfare deteriorates with increasing information inaccuracy, banks may optimize their value with not-so-perfect information, and have screening incentive only when the information deviates away from this optimal level of asymmetry (σ =1.004,solved when expression (8) equals to zero). In other words, banks may gain at the cost of investors, especially for banks with greater liquidity needs. Hence, we argue that banks' optimism is fostered by the benefit from securitization.

Following Subsection 2.4, Panel D of Figure 2 shows that optimism and pure information inaccuracy have opposite effects on banks' gain. While the bank can boost might gain, albeit by relatively small amount, by being optimistic, increased imprecision of information can significantly reduces its gain. In other words, although generally difficult to measure empirically, we show from our model that while the bank being optimistic on loans (for example, due to good relation with borrower firms, or writing loans to rapidly expanding sectors) can boost bank value through securitization, information precision is more important. Banks have incentive to enhance information accuracy.

Figure 2 also shows that when the bank needs more liquidity, securities are sold at a lower price r_s, volume-weighted security quality is also lower (Panel A), and more securities are sold (Panel B).Gains for both the bank and investors' (π_I and π_{bank}) are pushed higher (Panel C). Moreover, security price r_s and quality threshold $\overline{\beta}$ move in the same trend, implying that investors are willing to hold lower quality in reaction to lower security price as long as there is a thirst for more securities.

Finally, Figure 3 shows the combined effect of both information inaccuracy and liquidity premium under Scenario 1.As discussed before, rising liquidity premiums will lead to higher security volume at any given information level, and it is beneficial to both the bank and investors (right hand side in Figure 3). However, when the bank has greater liquidity need or become overly optimistic it gains from investors' loss because now the secondary loan market is filled with lower quality securities (upper right area in Figure3). During economic expansion, banks tend to focus on lending to rapidly expanding sectors, whose fast growth and rising collateral values enhance banks' optimism. Both banks and firms are more likely to increase leverage, adding fragility to financial system through more securitization (see Adrian and Shin 2010). Hence, excessive optimism (moving up from the right of the mid-level in Figure 3) could do harm to both banks and investors and become a trigger for financial crisis.

On the other hand, as shown on upper left of Figure 3, it is harmful to both banks and investors when excessive optimism is accompanied by low liquidity premiums, which could be due to abundance liquidity in the market and reduced securitization need from a slowdown of rapidly growing sector. Meanwhile, investors realize the high risk in the securitization market and stop buying, further reducing liquidity accessible to banks. Furthermore, lower liquidity premiums are likely to drag down banks' optimism. As a result, the securitization market becomes inefficient (lower left area of Figure 3).

3. Equilibrium Model with Heterogeneous Banks

We show in this section how increased heterogeneity and bank concentration influence equilibrium of market securitization. Analysis shows that bank optimism blurs investors' choice of return-risk mix given less information precision, thus is more likely to induce flight-to-quality[6].

[6] Flight-to-quality is a financial market phenomenon that investors move capital from perceived risker investments to safer ones. It might be triggered by exogenous shocks and market uncertainty（Caballero and Kurlat, 2008）. Similar concept includes flight-to-liquidity (Vayanos, 2004). Literature such as Caballero and Krishnamurthy (2008), Beber et al. (2009) provide evidences of investors' flight-to-quality and flight-to-liquidity.

3.1. A Model of Bank Interaction

Consider two types of competitive banks in the market, different in liquidity premiums ($\Delta = \delta_2 - \delta_1$, due to balance sheet strength, credit rationing, etc.), level of information inaccuracy ($\varepsilon = \sigma_2 - \sigma_1$, due to relationship banking[7], specialization, economics of scale, etc.), and bank concentration (proxied by share in the loan market, respectively $N-m$ and m for type 1 and 2 banks). Suppose investors have no preference upon banks, but rationally choose the acceptable intrinsic risk level, $\frac{\overline{\beta_1}}{\sigma_1} = \frac{\overline{\beta_2}}{\sigma_2} \equiv \overline{q}_s$, which, together with security prices $r_{s,1}$ and $r_{s,2}$, maximize banks' value and investors' profit

$$\max_{\beta_1'} \pi_1 = (N-m)\{\int_{\frac{\beta_{1,\min}}{\sigma_1}}^{\overline{q}_s} \left[qR_1 + (1-q)c - r\right] f(q)\,dq$$

$$+\int_{\overline{q}_s}^{\frac{\beta_1'}{\sigma_1}} \left[r_{s,1} + \delta_1 - r\right] f(q)\,dq + \int_{\frac{\beta_1'}{\sigma_1}}^{1} \left[qR_1 + (1-q)c - r\right] f(q)\,dq\}$$

$$\max_{\beta_2'} \pi_2 = m\{\int_{\frac{\beta_{2,\min}}{\sigma_2}}^{\overline{q}_s} \left[qR_2 + (1-q)c - r\right] f(q)\,dq$$

$$+\int_{\overline{q}_s}^{\frac{\beta_2'}{\sigma_2}} \left[r_{s,2} + \delta_2 - r\right] f(q)\,dq + \int_{\frac{\beta_2'}{\sigma_2}}^{1} \left[qR_2 + (1-q)c - r\right] f(q)\,dq\}$$

$$\max_{r_{s,1}, r_{s,2}, \overline{q}_s} \pi_I = (N-m)\int_{\overline{q}_s}^{\frac{\beta_1'}{\sigma_1}} \left[qR_1 + (1-q)c - r_{s,1}\right] f(q)\,dq + m\int_{\overline{q}_s}^{\frac{\beta_2'}{\sigma_2}} \left[qR_2 + (1-q)c - r_{s,2}\right] f(q)\,dq$$

Banks choose their minimum qualities $\beta_{1,\min} = \frac{r-c}{R_1 - c}$ and $\beta_{2,\min} = \frac{r-c}{R_2 - c}$ to accept loan applications. With these criteria, we obtain the following Proposition (derivation given in Appendix 2).

Proposition 2. With distorted beliefs and information inaccuracy, two types of banks competing in securitization market yields the following equilibrium securitization threshold $\overline{q}_s$ and rates $r_{s,1}$, $r_{s,2}$:

[7]A recent study by Raunig et al. (2016) also suggests bank-customer relationship is the reason why small banks do not lend less when uncertainty increases.

$$\bar{q}_s = \frac{(N-m)(r_{s,1}-c)+m(r_{s,2}-c)}{(N-m)(R_1-c)+m(R_2-c)} \tag{12}$$

$$\frac{(r_{s,1}-c)(1-\sigma_1)+\delta_1}{\sigma_1^2(R_1-c)} f(\frac{\beta_1'}{\sigma_1}) = F(\frac{\beta_1'}{\sigma_1}) - F(\bar{q}_s) \tag{13}$$

$$\frac{(r_{s,2}-c)(1-\sigma_2)+\delta_2}{\sigma_2^2(R_2-c)} f(\frac{\beta_2'}{\sigma_2}) = F(\frac{\beta_2'}{\sigma_2}) - F(\bar{q}_s) \tag{14}$$

where the upper bounds of securitization are $\beta_1' = \frac{r_{s,1}+\delta_1-c}{R_1-c}, \beta_2' = \frac{r_{s,2}+\delta_2-c}{R_2-c}$.

For notation simplicity, we denote f_i as the probability distribution function evaluated at $\frac{\beta_i'}{\sigma_i}$, for i =1 and 2, f_i' as the first derivative of the probability distribution function f_i, and f_q^0 as the probability distribution function evaluated at $\bar{q}_s$ .The volume of securitization and the average quality of the securitization pool at equilibrium are correspondingly:

$$V_1 = (N-m)\int_{\bar{q}_s}^{\frac{\beta_1'}{\sigma_1}} f(q)dq, \quad V_2 = m\int_{\bar{q}_s}^{\frac{\beta_2'}{\sigma_2}} f(q)dq, \quad V = V_1 + V_2,$$

$$Q_1 = \frac{(N-m)}{V_1}\int_{\bar{q}_s}^{\frac{\beta_1'}{\sigma_1}} qf(q)dq, \quad Q_2 = \frac{m}{V_2}\int_{\bar{q}_s}^{\frac{\beta_2'}{\sigma_2}} qf(q)dq, \quad Q = \frac{1}{V}\left[V_1\int_{\bar{q}_s}^{\frac{\beta_1'}{\sigma_1}} qf(q)dq + V_2\int_{\bar{q}_s}^{\frac{\beta_2'}{\sigma_2}} qf(q)dq\right]$$

Given information gap ε between the two bank types, we have:

$$\frac{\partial r_{s,2}}{\partial \varepsilon} = \frac{\tilde{G}_1}{\sigma_2^2\left(\tilde{G}_1\tilde{G}_2 - K_1K_2\right)}\left[\beta_2'\Phi_2 + \frac{\delta_2}{R_2-c} f_2\right], \quad \frac{\partial r_{s,1}}{\partial \varepsilon} = -\frac{K_2}{\tilde{G}_1}\frac{\partial r_{s,2}}{\partial \varepsilon}$$

and
$$\frac{\partial \bar{q}_s}{\partial \varepsilon} = \frac{\tilde{G}_1 - K_1}{\sigma_2^2\left(\tilde{G}_1\tilde{G}_2 - K_1K_2\right)}\frac{K_2}{f^0}\left[\beta_2'\Phi_2 + \frac{\delta_2}{R_2-c} f_2\right]$$

where $\Phi_2 = \frac{\left(r_{s,2}-c\right)\left(1-\sigma_2\right)+\delta_2}{\sigma_2^2\left(R_2-c\right)} f_2' + 2\left(\frac{1}{\sigma_2}-1\right) f_2$, $K_1 = \frac{N-m}{(N-m)\left(R_1-c\right)+m\left(R_2-c\right)} f^0$,

$K_2 = \frac{m}{(N-m)\left(R_1-c\right)+m\left(R_2-c\right)} f^0$, $H_i = \frac{\left(r_{s,i}-c\right)\left(1-\sigma_i\right)+\delta_i}{\sigma_i^2\left(R_i-c\right)} f_i' + \left(\frac{1}{\sigma_i}-1\right) f_i$ for $i = 1, 2$

and $\tilde{G}_i = \frac{1}{\sigma_i (R_i - c)} (H_i - f_i) + K_i$ are notations for second order conditions (proofs available upon request). The information gap, ε , simultaneously affects security prices $r_{s,1}$ and $r_{s,2}$ with different magnitudes but in the same direction. All the three expressions above are positive when $H_2 = \frac{(r_{s,2} - c)(1-\sigma_2) + \delta_2}{\sigma_2^2 (R_2 - c)} f_2' + \left(\frac{1}{\sigma_2} - 2 \right) f_2 > 0$, and are otherwise indeterminate (same as H_1 in Section 2.4).

Given Type 1 banks' information indicator, σ_1 ,

$$\frac{\partial \pi_I}{\partial \varepsilon} = -m \frac{r_{s,2} + \delta_2 - c}{\sigma_2^2 (R_2 - c)} \frac{(r_{s,2} - c)(1-\sigma_2) + \delta_2}{\sigma_2} f_2 < 0 ,$$

implying that investors' profits worsen when banks are more heterogeneous, which could be further magnified by a bigger market share of relatively more optimistic Type 2 banks (higher m),because of an increase in the market average of information inaccuracy. Furthermore, the difference in banks' liquidity premium Δ generates the following,

$$\frac{\partial r_{s,2}}{\partial \Delta} = -\frac{\tilde{G}_1}{\tilde{G}_1 \tilde{G}_2 - K_1 K_2} \Psi_2 , \quad \frac{\partial r_{s,1}}{\partial \Delta} = -\frac{K_2}{\tilde{G}_1} \frac{\partial r_{s,2}}{\partial \Delta} , \text{ and } \frac{\partial \bar{q}_s}{\partial \Delta} = -\frac{K_2}{f^0} \frac{\Psi_1 \Psi_2}{\tilde{G}_1 \tilde{G}_2 - K_1 K_2}$$

where $\Psi_i = \frac{1}{\sigma_i (R_i - c)} \left[\frac{(r_{s,i} - c)(1-\sigma_i) + \delta_2}{\sigma_i^2 (R_i - c)} f_i' + \left(\frac{1}{\sigma_i} - 2 \right) f_i \right]$, for $i = 1, 2$. Hence, changes in liquidity gap,Δ, push security prices $r_{s,1}$, and $r_{s,2}$ in the same direction because $\tilde{G}_1 < 0$ and $K_2 > 0$ .Moreover, $\Psi_i < 0$ for $i = 1, 2$ according to the second order conditions. Thus, when $\tilde{G}_1 \tilde{G}_2 - K_1 K_2 < 0$, an increment in liquidity gap Δ will lead to a lower security price, and reduced quality requirements from investors.

3.2 Numerical Analysis with Heterogeneous Banks

Considering the complexity of the model with heterogeneous banks, we demonstrate the effects more clearly with numerical analysis. As in the homogenous bank model, we consider two scenarios, and set $R_1 = R_2$ for simplicity. We fix Type 1 banks' information indicator so that $\sigma_1 = 0.97$ in Scenario 1 and $\sigma_1 = 1.02$ in Scenario 2.Since results of both scenarios are robust, we list only Scenario 1 here.

3.2.1 The Information Gap

The effects of an information gap on different factors in equilibrium are summarized in Figure 4, where we control for liquidity premium gap ($\Delta = 0$), set Type 2 banks as $\sigma_2 = \sigma_1 + \varepsilon$ (where $\varepsilon > 0$), and vary information gap ε . Panel A shows prices and qualities of the banks' securities when Type 1 banks have a conservative estimate of information of $\sigma_1 = 0.97$. Note that to the left of the graph, $\varepsilon < 0$ means Type 2 banks are even more pessimistic than Type 1 banks, thus the price of their securities will be lower. When $\varepsilon = 0$, there is no difference in perceived information between the two bank types, and therefore $r_{s,1} = r_{s,2}$. Furthermore, the Figure shows that even if both types of banks have the same information precision level ($\varepsilon = 0.6$, i.e. $\sigma_1 = 0.97, \sigma_2 = 1.03$), optimism grants Type 2 banks a relative advantage (value of optimism) in the form of a higher security price (Panel A) and higher profit (Panel B),though securities of Type 2 banks have relatively lower average quality. Hence their overall market share (right axis of Panel B) declines sharply from equal market share (when $\varepsilon = 0$) as the information gap rises.

In general, by keeping a moderate level of information gap, Type 2 banks might outperform their rivals, without losing too much security market share.

3.3.2 Loan Market Share

To see how market competition or concentration affects equilibrium, Figure 5 depicts the simulation results of (1) unequal loan market shares, whereby Type 2 banks occupy a majority of the loan market, and (2) equal loan market shares. In the first scenario, investors demand higher security quality (in terms of higher securitization threshold $\bar{q}_s$) whenever the average securities are backed by loans from the more optimistic Type 2 banks, which have bigger loan market share (80%),and are more optimistic (Panel A). As a result, securities of Type 2 banks are at least as expensive as those of Type 1 banks, and the spread between the two securities gets bigger until they become too optimistic (the far right ends of the graph).

In Panel B of Figure 5, when there is no information gap between the two Bank types, the security market shares are the same as the loan market shares. However, to the left of this point, the security market share of Type 2 banks is higher than their loan market share (e.g. $V_2 / V = 0.82$ when $\varepsilon = -0.02$ and loan market share is 0.8) because investors prefer higher perceived qualities of the securities from Type 2 banks. When Type 2 banks get more optimistic (to the right of the graph), its security market share drops fast. Furthermore, the average security quality difference ($Q_1 - Q_2$) is slightly lower when Type 2 banks have larger loan market share, implying that dominance of optimistic banks blurs quality differences in securitization products.

Panel C shows that Type 2 banks with more loan market share have more to securitize and have higher efficiency in terms of value per unit of securitization. Difference in banks' value per loan is more sensitive to information gap, when one Bank type dominates the market. On the other side, investors are better off when there is more competition, as expected, and banks are optimistic (right of the intersection), but worse off with competition when all banks are pessimistic (left of the intersection). The impact of competition on total welfare (Panel D) is similar. Competition is better for total welfare when banks tend to be optimistic.

3.2.3 Liquidity Premiums

Banks that are temporarily short of liquidity will assign higher liquidity premiums to each unit of liquidity from loan securitization. For numerical demonstration, we fix the liquidity premium of Type 1 banks at $\delta_1 = 0.015$, and vary that of Type 2 banks, $\delta_2 = \delta_1 + \Delta$ where $\Delta > 0$ implies liquidity is more valuable to Type 2 banks. Figure 6 shows the simulation results.[8] From the perspective of banks, less demand for liquidity (liquidity advantage) must be compensated with higher security prices (Panel A of Figure 6, $r_{s,2} > r_{s,1}$ to the left of the intersection, where $\Delta = 0$) and higher security quality (Q_1), though Type 2 banks have higher gains (partially from fulfilling the liquidity demand (Panel B)).

Both Types of banks have their profit increased, although profits of Type 2 banks are more significant and the overall proportion of their securities decreased. The higher liquidity need from Type 2 banks, causes a drop in overall investors' perceived quality in the securities market (Panel A for individual Bank Types, and Panel C for overall) because of the lower security prices. Besides, the overall welfare of banks plus investors increases(*W* in Panel C). This provides an explanation for "flight-to-quality" by investors from banks with weak balance-sheets to their competitors.

We also simulated the combined effects from both information gaps and liquidity premiums gaps, though not depicted here (available upon request). We assume Type 1 banks have stronger balance sheets than Type 2 banks, and therefore lower liquidity premiums from securitization ($\delta_1 = 0.015$, $\delta_2 = 0.020$). Now all results lie on somewhere between Figure 4 and Figure 6: total welfare decreases slower with information gaps, and liquidity advantages could offset the banks' information disadvantages.

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[8] Results are robust for different scenarios and information levels ($\sigma_1 = \sigma_2 = 1.02$ or 0.97).

4. Model Extensions and Related Issues

4.1 Tranching

We assume two tranches for securitization: the junior tranche and the senior tranche. Denote $\overline{\beta}_{jun}$ and $\overline{\beta}_{sen}$ as the quality thresholds of the two tranches, respectively ($\overline{\beta}_{jun} < \overline{\beta}_{sen}$), and the bank's loan approving threshold is $\beta_{\min} = \dfrac{r-c}{R_\sigma + \mu - c}$. There are loan rate and security price spreads between the two tranches. Suppose the loan rate spread μ is exogenously determined. Without loss of generality, assume that the loan rate for retained low quality loans is R_{jun} , and the rate for higher quality loans is $R_{sen} = R_{jun} + \mu$. Denote $r_{s,jun}$ (or r_s) and $r_{s,sen}$ as security prices of the two tranches, respectively. We assume the risk premium of the junior tranche is a function of estimated loan quality threshold difference, $r_{s,jun} - r_{s,sen} = \tilde{\omega}\left(\overline{\beta}_{jun}, \overline{\beta}_{sen}\right) = \tilde{\omega}\left(\overline{\beta}_{sen} - \overline{\beta}_{jun}\right)$, where

$$\frac{\partial \tilde{\omega}\left(\overline{\beta}_{jun}, \overline{\beta}_{sen}\right)}{\partial \overline{\beta}_{jun}} = -\tilde{\omega}' < 0, \quad \frac{\partial \tilde{\omega}\left(\overline{\beta}_{jun}, \overline{\beta}_{sen}\right)}{\partial \overline{\beta}_{sen}} = \tilde{\omega}' > 0.$$

Then the securitization contract depends on $\overline{\beta}_{jun}, \overline{\beta}_{sen}$, β' and r_s .

A representative bank's gain and investors' profits become:

$$\begin{aligned}\pi_{Tr,bank} = {} & N\int_{\frac{\beta_{\min}}{\sigma}}^{\frac{\overline{\beta}_{jun}}{\sigma}} \left[qR_{jun} + (1-q)c - r \right] f(q)dq + N\int_{\frac{\overline{\beta}_{jun}}{\sigma}}^{\frac{\overline{\beta}_{sen}}{\sigma}} \left(r_{jun} + \delta - r \right) f(q)dq \\ & + N\int_{\frac{\overline{\beta}_{sen}}{\sigma}}^{\frac{\beta'}{\sigma}} \left(r_{s,sen} + \delta - r \right) f(q)dq + \int_{\frac{\beta'}{\sigma}}^{1} \left[qR_{sen} + (1-q)c - r \right] f(q)dq\end{aligned}$$

$$\pi_{Tr,I} = N\left\{ \int_{\frac{\overline{\beta}_{jun}}{\sigma}}^{\frac{\beta'}{\sigma}} \left[qR_\sigma + (1-q)c - r_s \right] f(q)dq + \int_{\frac{\overline{\beta}_{jun}}{\sigma}}^{\frac{\overline{\beta}_{sen}}{\sigma}} \left[\mu q - \tilde{\omega}\left(\overline{\beta}_{jun}, \overline{\beta}_{sen}\right) \right] f(q)dq \right\}.$$

yielding the bank's upper securitization threshold $\beta' = \frac{r_s + \delta - c}{R_\sigma - c}$, and the implicit solutions of the contract parameters $\overline{\beta}_{jun}, \overline{\beta}_{sen}$ and r_s are:

$$\int_{\frac{\overline{\beta}_{jun}}{\sigma}}^{\frac{\beta'}{\sigma}} f(q)dq = \frac{(r_s - c)(1-\sigma) + \delta}{\sigma} f\left(\frac{\beta'}{\sigma}\right) \frac{1}{\sigma(R_\sigma - c)} \tag{15}$$

$$\tilde{\omega}' \int_{\frac{\overline{\beta}_{jun}}{\sigma}}^{\frac{\overline{\beta}_{sen}}{\sigma}} f(q)dq = \left[\mu \frac{\overline{\beta}_{sen}}{\sigma} - \tilde{\omega}\left(\overline{\beta}_{jun}, \overline{\beta}_{sen}\right)\right] f\left(\frac{\overline{\beta}_{sen}}{\sigma}\right) \frac{1}{\sigma} \tag{16}$$

$$\tilde{\omega}' \int_{\frac{\overline{\beta}_{jun}}{\sigma}}^{\frac{\overline{\beta}_{sen}}{\sigma}} f(q)dq = \left[\frac{\overline{\beta}_{jun}}{\sigma}\left(R_\sigma - c\right) + c - r_s + \mu \frac{\overline{\beta}_{jun}}{\sigma} - \tilde{\omega}\left(\overline{\beta}_{jun}, \overline{\beta}_{sen}\right)\right] f\left(\frac{\overline{\beta}_{jun}}{\sigma}\right) \frac{1}{\sigma} \tag{17}$$

When $\tilde{\omega}\left(\overline{\beta}_{jun}, \overline{\beta}_{sen}\right) = 0$ and $\mu = 0$, the above equilibrium reduces to the case of homogeneous banks.

The volume-weighted loan rate at each information level from the two-tranche equilibrium is:

$$R_{avg} = \frac{V_{down}}{V_{down} + V_{up}} R_{jun} + \frac{V_{up}}{V_{down} + V_{up}} R_{sen} = R_\sigma + \frac{V_{down}}{V_{down} + V_{up}} \mu \tag{18}$$

where $V_{down} = N \int_{\frac{\beta_{\min}}{\sigma}}^{\frac{\overline{\beta}_{sen}}{\sigma}} f(q)dq$ is the volume of loans which has rates averaged to R_{jun}, and $V_{up} = N \int_{\frac{\overline{\beta}_{sen}}{\sigma}}^{1} f(q)dq$ is volume of all loans which has rates averaged to R_{sen}. With R_{avg} and other parameters (δ, c, r) fixed, we can obtain the one-tranche equilibrium and compare itwith (volume-weighted) the two-tranche equilibrium. Figure 7 compares the results of the two-tranche security market

$$r_{s,two-tranche} = \frac{V_{jun}}{V_{all}} r_{s,jun} + \frac{V_{sen}}{V_{all}} r_{s,sen} = r_{s,sen} + \frac{V_{jun}}{V_{all}} \tilde{\omega}\left(\overline{\beta}_{sen} - \overline{\beta}_{jun}\right) \tag{19}$$

with the corresponding one-tranche price $r_{s,one-tranche}$. We arbitrarily set a 1% risk compensation on risker loans that are classified as junior tranche, that is, $\mu = R_{jun} - R_{sen} = 0.01$, and set the first derivative of security price spread $\tilde{\omega}' = \omega = 1$.[9,10]

When banks are not very conservative, their gains, and therefore overall welfare, with two tranches are lower than gains with one-tranche (top-right graph and bottom-left graph in Panel A of Figure 7 respectively), which is a result of lower volume-weighted average price of the securities (top-left graph in Panel A). This means banks could not create more value simply by adding more tranches if securities are properly designed, absent cheating between banks and investors ($r_{s,pool} > r_{s,\text{tranche}}$).

The effect of pure information inaccuracy of one-tranche securities, which has a negative effect on bank values, is of larger magnitude than that of two-tranche securities, implying that banks have more incentive to improve their information accuracy in the non-tranche case (bottom-right graph of Panel A). This is in line with DeMarzo (2005), which argues that an uninformed seller prefers pure pooling to tranching in order to avoid underpricing. Tranching does not affect investors overall profit and volume demanded.

The senior tranche takes the majority of all securities ($V_{sen} / V >$ 80%) in our scenarios.Panel B shows that although the proportion of senior tranche is negatively related with bank's optimism (left graph), but positively related with bank's liqidity needs. The senior tranche is referred to by Hanson and Sunderam (2013) as information insensitive, and its popularity reduces the number of informed investors in the market, which exacerbates primary market collapses in bad times. Overall, with

[9] Robustness results are run for $\omega = 2$. We also tried larger loan rate spreads such as $\mu = 0.02$. Although equilibrium results show the same trend, the solvable range of information level becomes narrower (especially on the side of $\sigma > 1$). The lengthy results are not reported in here.

[10] The equilibrium impacts of information accuracy and liquidity premium on each tranche are analogue to the homogeneous bank model, and are thus omitted.

tranching, banks will be less keen on improving information accuracy, and less optimistic. Even though banks cannot improve their value through tranched securitization, tranching improves the securitization market by providing higher quality securities.

4.2 Capital Requirement Implications

Banks have to meet regulatory requirements, typically in the form of a minimum capital ratio, k_0. Since required return on equity is greater than the costs of deposit and debts, banks prefer to fund with deposit and debts/securitization if possible and hold a minimum amount of equity capital required by regulators;

$$r_{CR} = (1-k_0)r + k_0 r_e$$

where, r_e is the minimum expected return to bank equity. If loan risk is transferred to investors through securitization, the minimum capital ratio is lowered to k_1 where $k_1 < k_0$. Investors' profit and the value of a representative bank become

$$\pi_{I,CR} = N\int_{\frac{\bar{\beta}}{\sigma}}^{\frac{\beta'}{\sigma}} \left[qR_\sigma + (1-q)c - r_s\right] f\left(q\right) dq$$

$$\pi_{bank,\mathrm{CR}} = N\int_{\frac{\beta_{\min}}{\sigma}}^{1} \left[qR_\sigma + (1-q)c - (1-k_1)r - k_1 r_e\right] f(q)dq + \delta V - \pi_{I,\mathrm{C}R}$$

with $\beta' = \dfrac{r_s + \delta - c + (k_0 - k_1)(r_e - r)}{R_\sigma - c}$. The corresponding optimal securitization threshold and price are:

$$\bar{\beta} = \frac{\sigma(r_s - c)}{R_\sigma - c} \tag{20}$$

$$\frac{(r_s - c)(1-\sigma) + (k_0 - k_1)(r_e - r) + \delta}{\sigma^2 (R_\sigma - c)} f\left(\frac{\beta'}{\sigma}\right) = F\left(\frac{\beta'}{\sigma}\right) - F\left(\frac{\bar{\beta}}{\sigma}\right). \tag{21}$$

This is analogous to the homogeneous bank model, except that the bank can now enjoy a less stringent capital requirement due to securitization, or alternatively, more liquidity $(k_0 - k_1)(r_e - r) + \delta$ instead of liquidity premium δ in the base model. All equilibrium effects of information indicator σ and liquidity premium δ are parallel to the base model, with $H_{1,CR} = \frac{(r_s - c)(1-\sigma) + (k_0 - k_1)(r_e - r) + \delta}{\sigma^2 (R_\sigma - c)} f' + \frac{1-\sigma}{\sigma} f$.[11]

Our theoretical analysis indicates that both $(k_0 - k_1)$ and the wedge between costs of bank's equity and debt (deposit) $(r_e - r)$ strengthen all the equilibrium effects, making positive effects more positive, and negative effects more negative, consistent with Athanasogloua *et al*. (2014). This explains why securitization has lost its popularity for a while after the Crisis ─ regulatory bodies would not like to see risks transferred to investors through over-confident securitization as a result of reducing the minimum capital requirement.

Figure 8 provides a comparison of three sets of policy parameters.[12] All equilibrium results are similar to the base model. A higher gap between required capital ratios ($k_0 - k_1$) yields higher security volume *V*, investors' profit $\pi_{I,WACC}$, and value of optimism because the higher gap also implies confidence of the regulatory bodies in the securitization market. A higher required capital ratio gap ($k_0 - k_1$) for optimistic banks, but with inaccurate information ($\sigma > 1.025$), leads to a higher average quality and therefore higher security price. However, when banks are relatively conservative or have more accurate information, the magnitude of ($k_0 - k_1$) hardly affects average quality.

Larger k_1 lowers a bank's value $\pi_{bank,CR}$ (versus information level). For the same k_1, higher k_0 leads to higher bank value, especially when banks are more optimistic, although not overly so. Lower k_1 , or a wider required capital ratio gap ($k_0 - k_1$),

[11] Proofs are available upon request.

[12] We also simulate the impact of different deposit rates and thus different cost wedge levels $(r_e - r)$. It shows that higher cost wedge grants banks more incentive to securitize (both *V*and optimism value increase).

improves overall welfare, mainly due to enhanced bank incentives for securitization and additional investment opportunities for investors (security volume V increase).

Hence, our analysis provides the useful implication that regulators wanting to better regulate a potentially overheated securitization market, in terms of controlling security volume V and banks' optimism, should not reduce the minimum capital requirement because of securitization. On the other hand, lowering required capital ratios will be a good incentive to boost the securitization market.

4.3 Effect of Endogenizing Dominance in the Loan Market on Equilibrium

Consider two posibilities of endogenized banks' loan market dominance − determined by loan rate or information level. First, suppose that a bank's dominance in the loan market is represented by a higher loan market share. Hence, if Type 1 banks are dominate banks, we set, for illustrative purposes, the following equation:

$$\text{Loan Market Share of Type 2 banks} = \frac{R_1 - 1}{R_1 + R_2 - 2}$$

where R_1 and R_2 are the loan rates of both bank types, and $R_1 < R_2$; the impact of endogenized market dominance in equilibrium follows from the relative strength of banks' loan rates, and not a specific functional form.

We performed numerical analysis with $R_1 = 1.10$, $c = 0.8$, $r = 1.05$, $\delta_1 = \delta_2 = 0.02$, $\sigma_1 = \sigma_2 = 0.97$ (not reported here)and found that Type 2 banks offer lower volume-weighted average quality securities than do Type 1 banks (top-left graph) upon losing loan and security market shares. Type 2 banks' security market share declines fast when their share in the loan market decreases with increasing loan rate ($R_2 > R_1$). Furthermore, with higher returns from the loan pool, Type 2 banks charge higher security prices, leading to higher gains than for Type 1 banks. This confirms our insights in the previous models that security price is not necessarily an indicator for quality.

For a second scenario, we assume banks' dominance in the loan market comes from their information levels according to the following equation:

$$\text{Loan Market Share of Type 2 banks} = \frac{\sigma_1}{\sigma_1 + \sigma_2}$$

Numerical analysis of scenario 1 ($R_1 = R_2 = 1.11$, $c = 0.8$, $r = 1.05$, $\delta_1 = \delta_2 = 0.02$, $\sigma_1 = 0.97$) shows robust equilibrium results as does the model with heterogeneous banks. This is due to Type 1 banks' relative advantages with respect to both information level and market share. Although Type 2 banks' security market share declines much faster than its loan market share, its equilibrium conditions are similar to the heterogeneous bank model. Generally, our results are robust under this information-determined loan market share setting.

4.4 Endogenizing Loan Rate

In our main models, we use bank's average loan rate R_σ to simplify theoretical analysis. We now consider endogenizing loan rates that are risk-adjusted, such as below,

$$R_\sigma = R_0 + k / \beta ,$$

where k is risk premium per unit of estimated risk, β. In equilirium, the upper and lower bounds of securitization will both be shifted down by $\frac{k}{R_\sigma - c}$, and bank's acceptance level of granting loans as well. The implicit solution of price r_s in $\beta' = \frac{r_s + \delta - c}{R_\sigma - c}$ (Section 2.2) still holds. In this case, our simplification loan rate R_σ does not significantly affect our results. All proofs and numerical demonstrations are not reported, but available upon request.

5. Discussions

5.1 Optimism, Trust and Symmetric Ignorance

Our models show that a certain level of optimism is value enhancing for banks, while investors need to pay higher security prices. The optimistic banks are more likely to be the empire-building managers in Manove and Padilla (1999), who relax lending standards, explore new market (such as emerging market) or borrower category, and pay little attention to or are unaware of the hidden dangers. Moreover, banks are more likely to encounter optimistic borrowers during market uptrend, especially from fast growing industries. Competition may lead banks to be insufficiently conservative (Manove and Padilla (1999)). Competition with shadow banking further blurs the differences in securitization products, as in our model of heterogeneous banks. On the other side, investors, especially foreign investors (Ghosh (2012)), tend to rely on public information, and put their trust on financial institutions. Different from pure information inaccuracy, bank optimism increases investors' confidence to "invest more and at higher fees" (Gennaioli et al.(2015)). But this comes with a cost as a result of more inaccurate information.

Banks' optimism mixed with investors' trust lead to symmetric ignorance (like that in Dang et al. (2012), Holmström (2014)). Although market participants tend to partially ignore the abnormally increasing proportion of senior securities (in tranching model), they become increasingly sensitive to underlying asset price movements, given cross correlations among securities (Caballero and Krishnamurthy (2009)). Once trust or confidence is shaken, investors start withdrawing their capital from the affected financial institutions, sectors or countries, which causes inefficient credit flows and problematic financial markets.

5.2 Liquidity Dilemmas and Credit Allocation

Liquidity need ss incentive for security origination, but additional liquidity from securitization makes banks more susceptible to liquidity and funding crises. Loutskina (2011) argues that banks' securitization ability has become an integral part of their liquidity-risk management. Our models propose testable predictions about investors' and banks' behaviors. In response to banks' increasing optimism, investors tend to raise acceptable level of security quality. However, investors rely too much on public information (defined as "information-acquisition-insensitive" by Dang *et al.* (2015)). Taking advantage of this, there are at least two possible tricks for banks to keep clients. First, banks can reduce security price, which is also partially due to competition in securitization market. Second, they can increase the proportion of high quality securities, through tranching and credit enhancing. This is further reinforced by increases in liquidity premiums. Moreover, many financial institutions tend to hold securitization products of other institutions (Erelet al.(2013)), thus creating a higher potential for contagion in fragility when the market is at its downturn.

5.3 Effectiveness of Regulations

Bankers' unrealistic optimism could threaten the stability of financial system; capital requirements can serve as devices to restrain optimistic banks. Researchers have been analyzing problems of existing regulations and proposing suggestions on more efficient policies. Examples are Keys et al. (2009),Parlour and Plantin (2008),Hanson and Sunderam (2013) and Jeon and Nishihara (2014). Through our analysis, we illustrate the importance of regulatory arbitrage, proxied by the gap between capital requirement ratios with and without securitization. A narrower arbitrage space helps regulators to control the proportion of securitization, investors' enthusiasm, as well as banks' optimism.

6. Conclusion

This paper presents a new perspective that bank optimism can lead to "flight-to-quality". We show that profit-maximizing behavior of banks tends to breed optimism, which in turn leads to aggressive strategies in the securitization market and destabilize the financial system. This is consistent with Shleifer and Vishny (2010) that profit-maximizing behavior of banks creates systemic risk. Furthermore, we show that bank optimism can be fostered by additional benefits from financial innovation (securitization in our content) and trust from investors.

In particular, we firstly build an equilibrium securitization model for homogenous banks under distorted beliefs and information inaccuracy, which demonstrates how once trust is shaken investors start withdrawing their capital from the affected financial institutions, and the contagion can spread, leading to a shut-down of securitization markets similar to that right after the Great Recession. Then with heterogeneous banks, investors' "flight-to-quality" occurs when some banks have more inaccurate information or higher liquidity need and therefore more aggressive securitizing strategies. Competition in the securitization market is welfare and investors' profit enhancing when banks are optimistic. However, market domination is welfare enhancing when banks are conservative. Dominance of optimistic banks blurs quality differences in securitization products. Moreover, we show that tranching is welfare enhancing for investors in the form of lower average price, higher average quality, and higher surplus, but not value creating for banks when there are no regulatory concerns. Banks have more incentive to improve information accuracy in the non-tranche case, but are also more likely to be optimistic. Numerical analysis supports our theoretical analysis. Our analysis on capital requirement confirms that required capital ratios are powerful regulatory tools.

Our models provide new perspectives for understanding how investors' trust in financial institutions and "flight-to-quality", and bank's aggressive securitization strategies, can lead to market inefficiency or even shut-down. Hence, our findings not only provide explanation for bank's aggressive strategy in securitization markets, they also highlight the important link between securitization and information inaccuracy, due to banks' optimism. We note the policy implication that regulators can use capital requirements to alleviate contagion due to the fragile financial markets from over-optimism and over-securitization.

References

[1] Adrian, T., and H. S. Shin, 2010, "Liquidity and leverage." *Journal of Financial Intermediation* 19, 418-437.

[2] Agostino, M., and M. Mazzuca, 2011, "Empirical investigation of securitisation drivers: the case of Italian banks." *The European Journal of Finance* 17, 623-648.

[3] Aivazian, V., X. Gu, J. Qiu, and B. Huang, 2015, "Loan collateral, corporate investment, and business cycle." *Journal of Banking & Finance* 55, 380-392.

[4] Ambrose, B. W., M. LaCour-Little, and A. B. Sanders 2005, "Does Regulatory Capital Arbitrage, Reputation, or Asymmetric Information Drive Securitization?" *Journal of Financial Services Research* 28, 113-133.

[5] Athanasoglou, P. P., I. Daniilidis, and M. D. Delis, 2014, "Bank procyclicality and output: Issues and policies." *Journal of Economics and Business* 72, 58-83.

[6] Barberis, N., 2011, "Psychology and the Financial Crisis of 2007-2008." *Available at SSRN 1742463*.

[7] Beber, A., M. Brandt and K. A. Kavajecz, 2009, "Flight-to-quality or flight-to-liquidity? Evidence from the Euro-area bond market". Review of Financial Studies, 22, 925-957.

[8] Barberis, N., A. Shleifer, and R. Vishny, 1998, "A model of investor sentiment1." *Journal of Financial Economics* 49, 307-343.

[9] Baron, M., and W. Xiong, 2016, "Credit expansion and neglected crash risk."

NBER Working paper No. 22695.

[10] Bénabou, R., and J. Tirole, 2016, "Mindful economics: The production, consumption, and value of beliefs." *The Journal of Economic Perspectives* 30, 141-164.

[11] Bolton, P., T. Santos, and J. A. Scheinkman, 2018, "Savings Gluts and Financial Fragility." *Available at SSRN 2743700*.

[12] Bonfim, D., D. A. Dias, and C. Richmond, 2012, "What happens after corporate default? Stylized facts on access to credit." *Journal of Banking & Finance* 36, 2007-2025.

[13] Brunnermeier, M. K., and J. A. Parker, 2005, "Optimal expectations." *The American Economic Review* 95, 1092-1118.

[14] Caballero, R. and A. Krishnamurthy, 2008, "Collective risk management in a flight to quality episode". *Jounal of Finance*, 63, 2195-2230.

[15] Caballero, R. and P. Kurlat, 2008, "Flight to quality and bailouts: policy remarks and a literature review". *MIT Department of Economics Working Paper No. 08-21*.

[16] Caballero, R. J., and A. Krishnamurthy, 2009, "Global Imbalances and Financial Fragility." *American Economic Review* 99, 584-88.

[17] Carbó-Valverde, S., H. Degryse, and F. Rodriguez-Fernandez, 2012, "Lending relationships and credit rationing: the impact of securitization." *Available at SSRN 2164218*.

[18] Cheng, M., D. Dhaliwal, and M. Neamtiu, 2008, "Banks' asset securitization and information opacity." *Working paper, The University of Arizona*.

[19] Cheng, I.-H., S. Raina, and W. Xiong, 2014, "Wall Street and the Housing Bubble." *American Economic Review* 104, 2797-2829.

[20] Dang, T. V., G. Gorton, and B. Holmström, 2012, "Ignorance, debt and financial crises." *Yale University and Massachusetts Institute of Technology, working paper*.

[21] Dang, T. V., G. Gorton, and B. Holmström, 2015, "The information sensitivity of a security." *Unpublished working paper, Yale University*.

[22] Demarzo, P., and D. Duffie, 1999, "A Liquidity-based Model of Security Design." *Econometrica* 67, 65-99.

[23] DeMarzo, P. M., 2005, "The Pooling and Tranching of Securities: A Model of Informed Intermediation." *Review of Financial Studies* 18, 1-35.

[24] Demyanyk, Y., and O. Van Hemert, 2011, "Understanding the Subprime Mortgage Crisis." *Review of Financial Studies* 24, 1848-1880.

[25] Dougal, C., J. Engelberg, C. A. Parsons, and E. D. Van Wesep, 2011, "Anchoring and the cost of capital." *Working paper, University of North Carolina*.

[26] Drucker, S., and M. Puri, 2009, "On Loan Sales, Loan Contracting, and Lending Relationships." *Review of Financial Studies* 22, 2835-2872.

[27] Duffie, D., 2008, "Innovations in credit risk transfer: Implications for financial stability.", *Woking paper*.

[28] Erel, I., T. Nadauld, and R. M. Stulz, 2013, "Why Did Holdings of Highly Rated Securitization Tranches Differ So Much across Banks?" *Review of Financial Studies*.

[29] Gennaioli, N., A. Shleifer, and R. Vishny, 2012, "Neglected risks, financial innovation, and financial fragility." *Journal of Financial Economics* 104, 452-468.

[30] Gennaioli, N., A. Shleifer, and R. Vishny, 2013, "A model of shadow banking." *The Journal of Finance* 68, 1331-1363.

[31] Gennaioli, N., A. Shleifer, and R. Vishny, 2015, "Money Doctors." *The Journal of Finance* 70, 91-114.

[32] Ghosh, A., 2012, *Managing risks in commercial and retail banking*: John Wiley & Sons.

[33] Gorton, G. B., and G. G. Pennacchi, 1995, "Banks and loan sales Marketing nonmarketable assets." *Journal of Monetary Economics* 35, 389-411.

[34] Hancock, D., and W. Passmore, 2011, "Did the Federal Reserve's MBS purchase program lower mortgage rates?" *Journal of Monetary Economics* 58, 498-514.

[35] Hanson, S. G., and A. Sunderam, 2013, "Are there too many safe securities? Securitization and the incentives for information production." *Journal of Financial Economics* 108, 565-584.

[36] Heuson, A., W. Passmore, and R. Sparks, 2001, "Credit Scoring and Mortgage Securitization: Implications for Mortgage Rates and Credit Availability." *The Journal of Real Estate Finance and Economics* 23, 337-363.

[37] Holmström, B., 2015, "Understanding the role of debt in the financial system". *BIS Working Papers No 479*.

[38] Jeon, H., and M. Nishihara, 2012, "Securitization under asymmetric information and risk retention requirement." *Available at SSRN 2116770*.

[39] Keijsers, B., B. F. Diris, and E. Kole, 2015, "Cyclicality in Losses on Bank Loans". *Tinbergen Institute Discussion Paper 15-050/III*.

[40] Keys, B. J., T. Mukherjee, A. Seru, and V. Vig, 2009, "Financial regulation and securitization: Evidence from subprime loans." *Journal of Monetary Economics* 56, 700-720.

[41] Loutskina, E., 2011, "The role of securitization in bank liquidity and funding management." *Journal of Financial Economics* 100, 663-684.

[42] Luque, J., and T. Riddiough, 2015, "A Theory of Subprime Mortgage Lending with Appliactions to The Rise and Fall of the Subprime Conduit Mortgage Market". *Working paper*.

[43] Manove, M., and A. J. Padilla, 1999, "Banking (conservatively) with optimists." *The RAND Journal of Economics*, 324-350.

[44] Nadauld, T. D., and M. S. Weisbach, 2012, "Did securitization affect the cost of corporate debt?" *Journal of Financial Economics* 105, 332-352.

[45] Raunig, B., J. Scharler, and F. Sindermann, 2017, "Do Banks Lend Less in Uncertain Times?" *Economica*, 84(336), 682-711.

[46] Reinhart, C. M., and K. S. Rogoff, 2009, “This time is different: eight centuries of financial folly”. Princeton University Press.

[47] Schwarcz, S. L., 2004, "Rethinking the disclosure paradigm in a world of complexity." *University of Illinois Law Review* 2004.

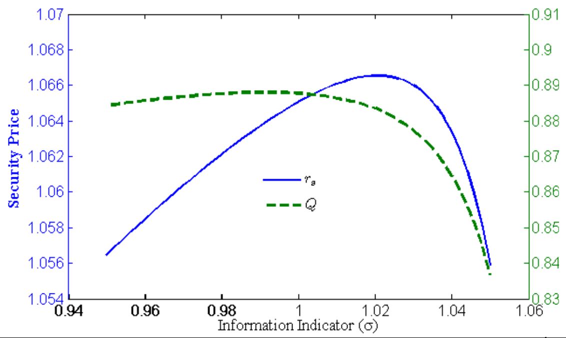
[48] Shleifer, A., and R. W. Vishny, 2010, "Unstable banking." *Journal of Financial Economics* 97, 306-318.

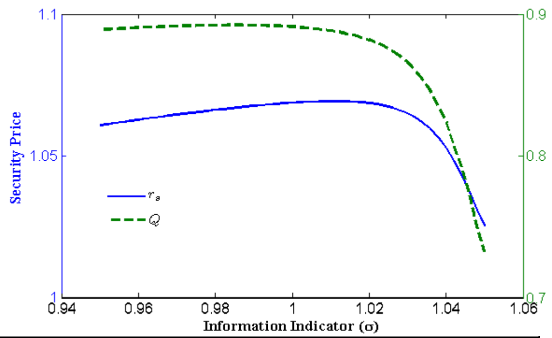
[49] Vayanos, D., 2004, “Flight to quality, flight to liquidity, and the pricing of risk”, *NBER Working Paper No. 10327*.

Figure 1 Equilibrium Effects of Information Indicator σ (Base Model)

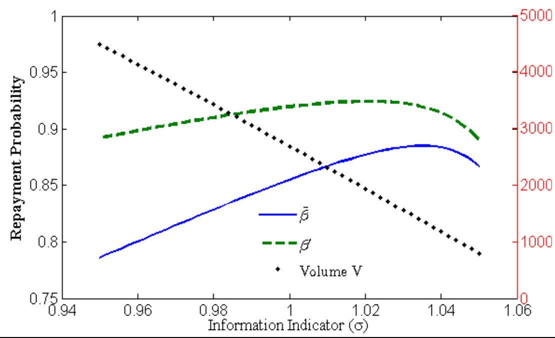
Scenario 1 ($R_\sigma = 1.11,\ c = 0.8,\ r = 1.05,\ \delta = 0.020$)	Scenario 2 ($R_\sigma = 1.085,\ c = 0.9,\ r = 1.02,\ \delta = 0.010$)

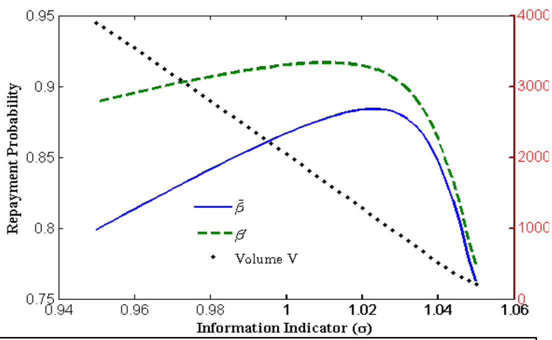
Panel A: Security price and volume-weighted average quality



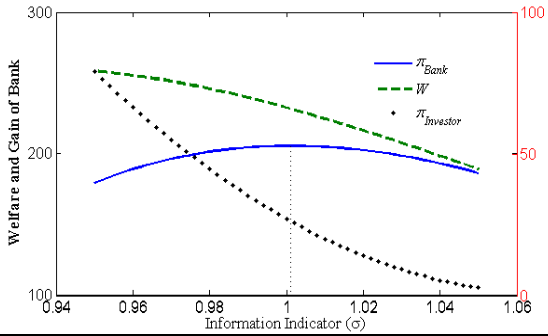


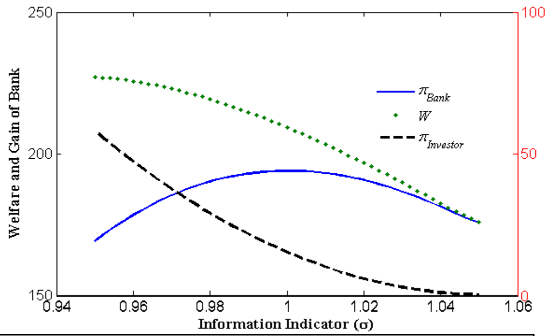
Panel B: Bounds of repayment probabilities for securitized loans and security volume



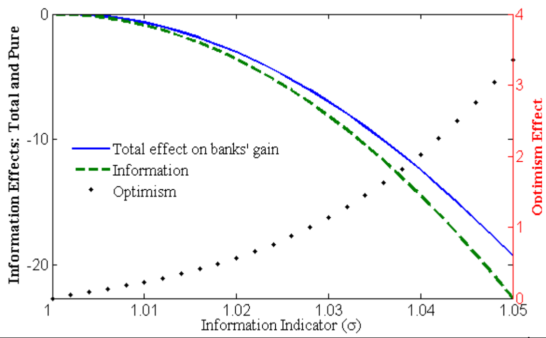


Panel C: Profits of banks and investors and total welfare





Panel D: Information and optimism value for banks



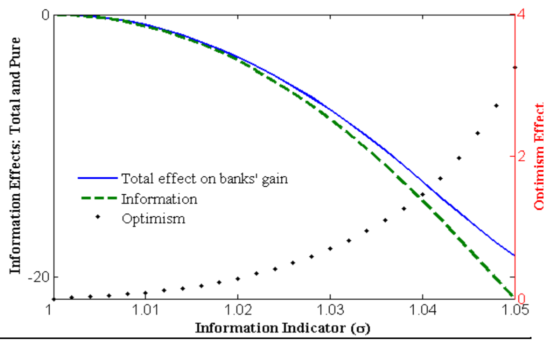
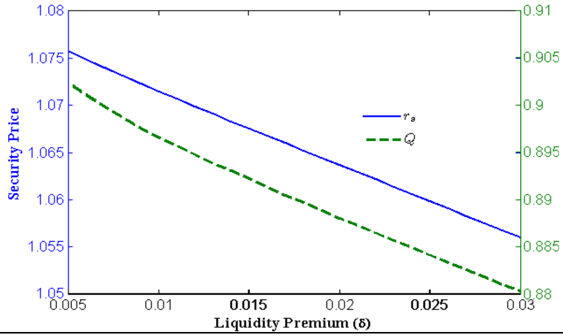
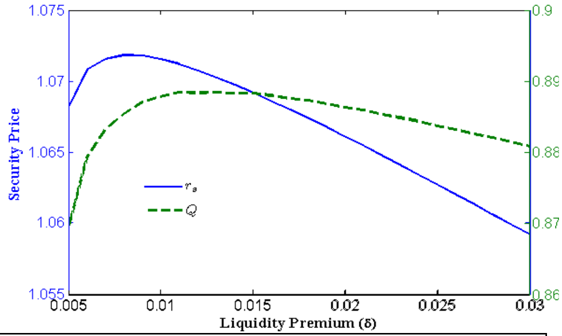


Figure 2 Equilibrium Effects of Liquidity Premium (R_σ = 1.11, c = 0.8, r = 1.05)

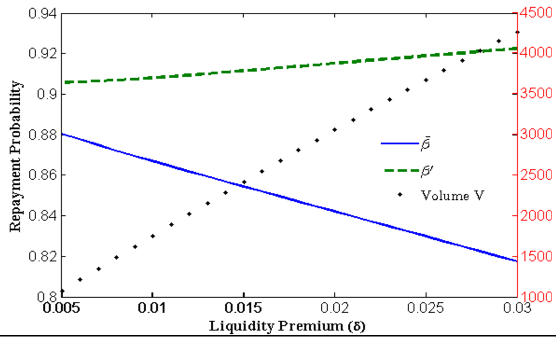
Information Indicator σ = 0.99	σ = 1.01

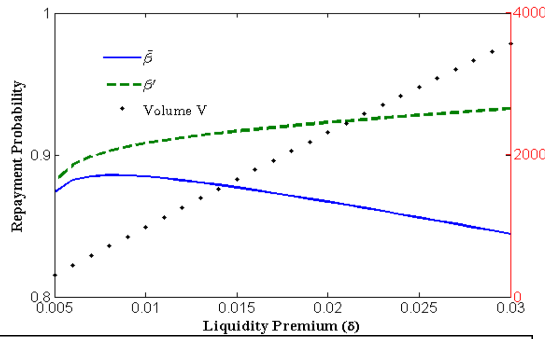
Panel A: Security price and volume-weighted average quality



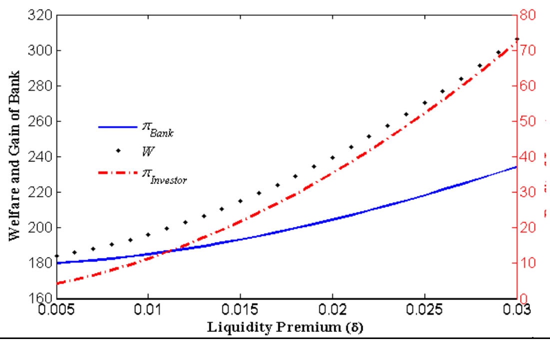


Panel B: Bounds of repayment probabilities for securitized loans and security volume





Panel C: Profits of banks and investors and total welfare



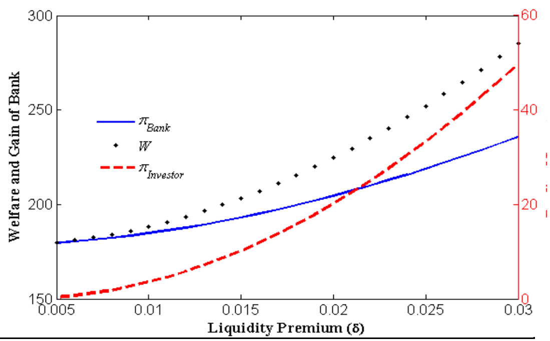


Figure 3 Equilibrium on δ - σ Panel and Conflict of Interest between Banks and Investors
(R_σ = 1.11, c = 0.8, r = 1.05)

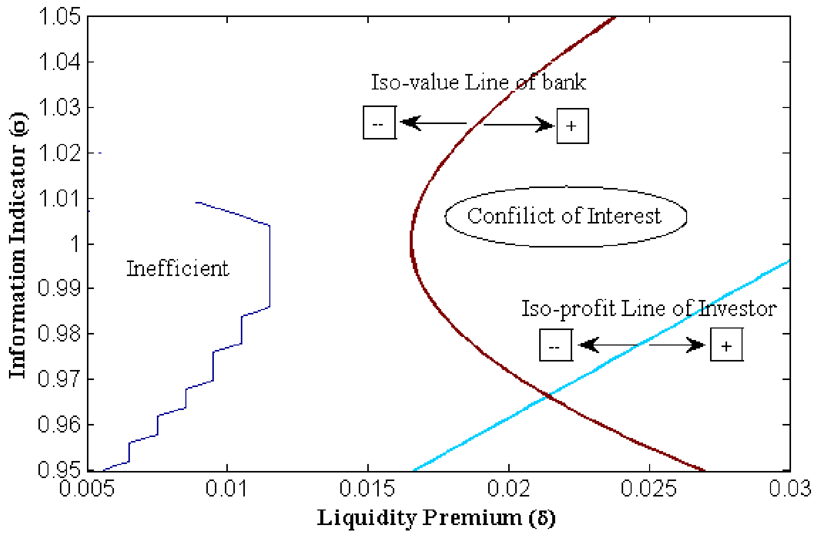
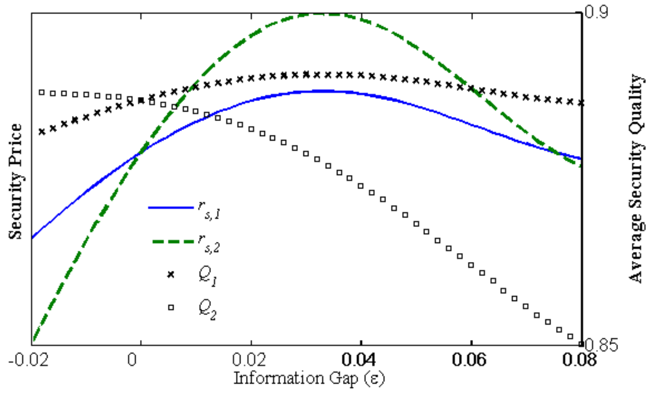


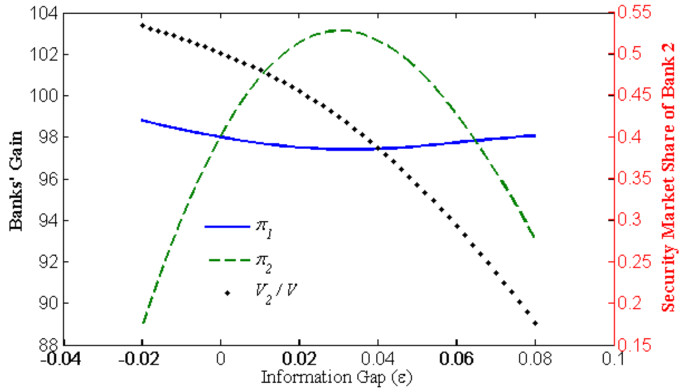
Figure 4 Equilibrium Effects of Information Gap ε

($R_1 = R_2 = 1.11$, $\delta_1 = \delta_2 = 0.020$, $c = 0.8$, $r = 1.05$, $N = 10000$, $m = 0.5*N$, $\sigma_1 = 0.97$, $\sigma_2 = \sigma_1 + \varepsilon$)

Panel A: Security price and quality



Panel B: Profits of banks and securitization market share of Type 2 bank



Panel C: Profits of investors, total welfare and volume-weighted average quality

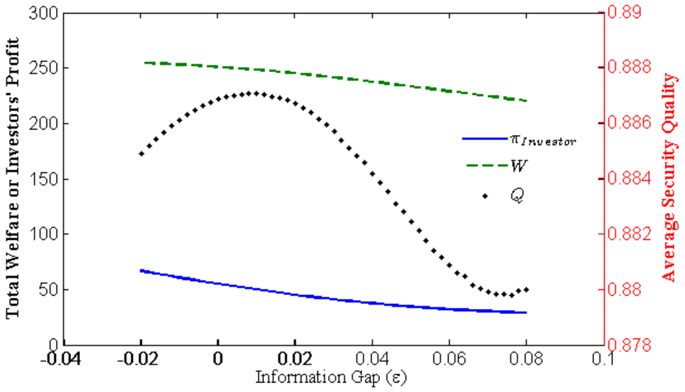
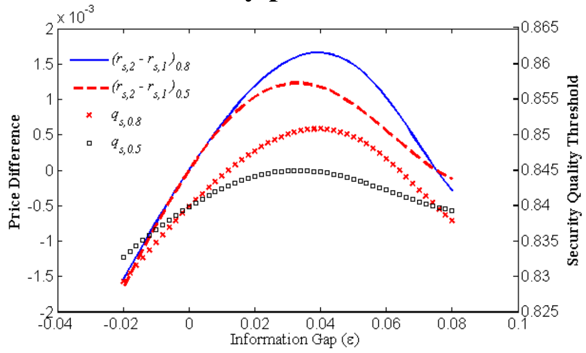


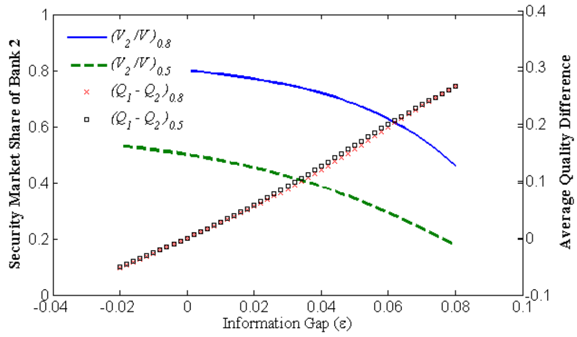
Figure 5 Equilibrium Effects of Loan Market Share

($R_1 = R_2 = 1.11$, $\delta_1 = \delta_2 = 0.020$, $c = 0.8$, $r = 1.05$, N= 10000, m= 0.8*N or 0.5*N, $\sigma_2 = \sigma_1 + \varepsilon$, σ_1 =0.97)

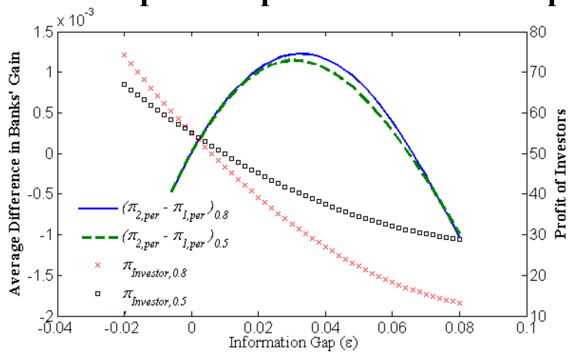
Panel A: Differences in banks' security prices and investors' acceptable quality



Panel B: Securitization market share of Type 2 bank and differences in average security quality



Panel C: Difference in banks' per loan profit and investors' profit



Panel D: Total welfare

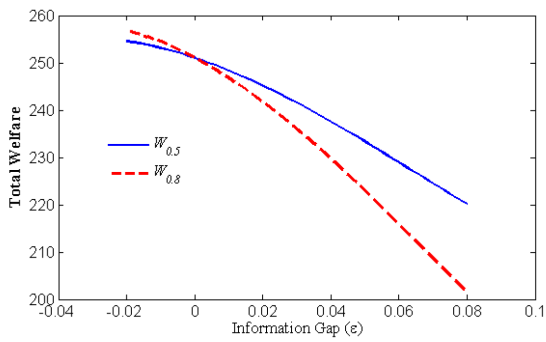
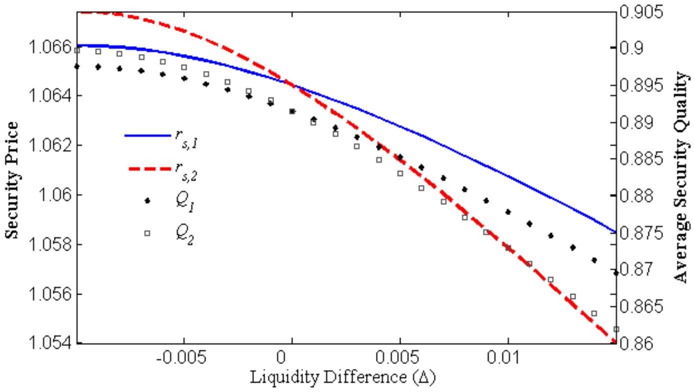
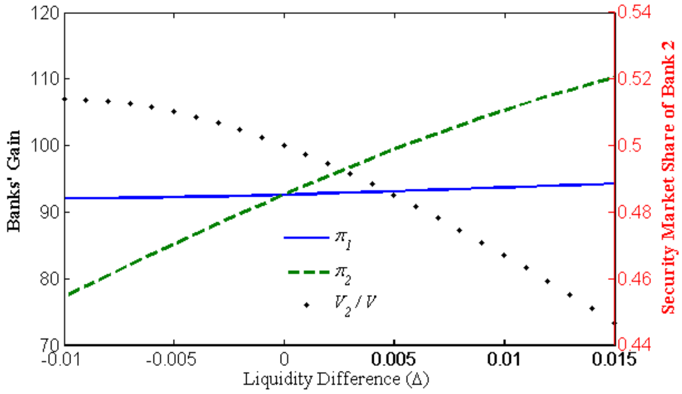


Figure 6 Equilibrium Effects of Liquidity Premium Gap Δ
($R_1 = R_2 = 1.11$, $\sigma_1 = \sigma_2 = 0.97$, $c = 0.8$, $r = 1.05$, $N = 10000$, $m = 0.5*N$, $\delta_1 = 0.015$, $\delta_2 = \delta_1 + \Delta$)

Panel A: Security price and quality



Panel B: Profits of banks and securitization market share of Type 2 bank



Panel C: Profits of investors, total welfare and volume-weighted average quality

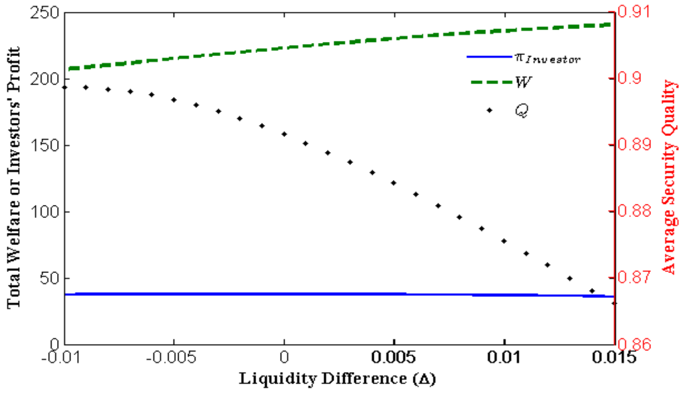
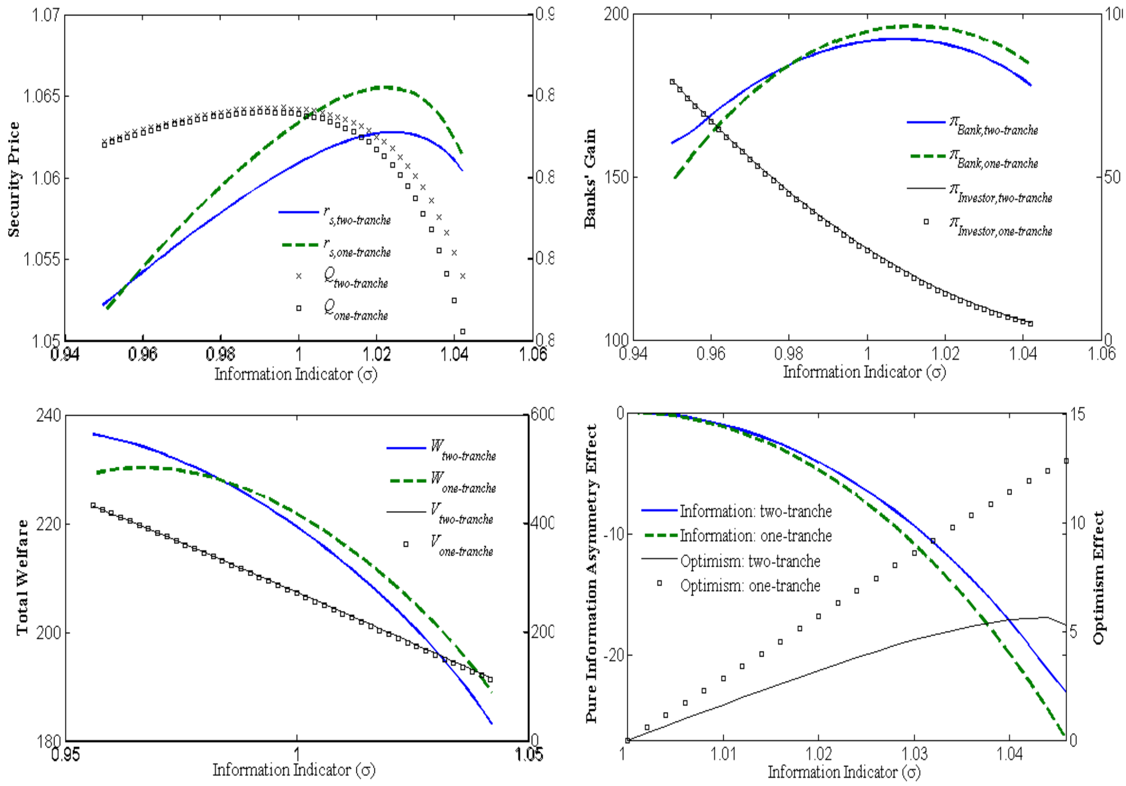
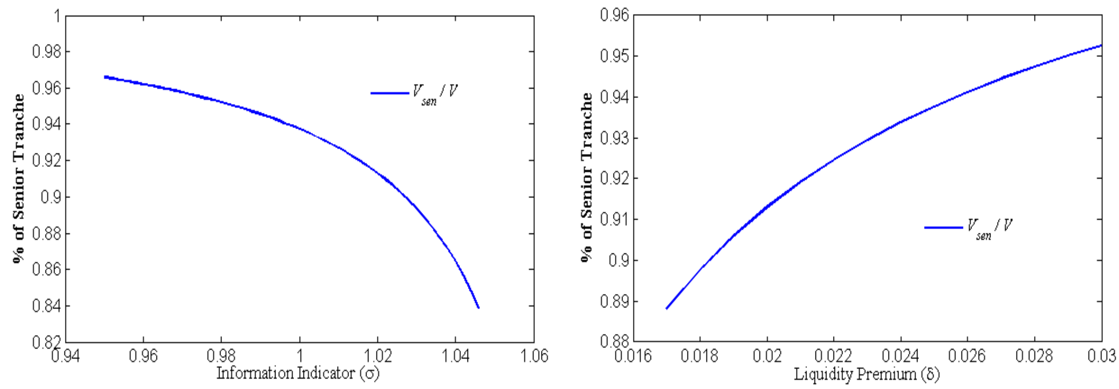


Figure 7 Equilibrium Impacts of Tranching

Panel A: Comparison between Two-tranche Security and Corresponding One-tranche Equilibrium



Panel B: Proportion of Senior Tranche

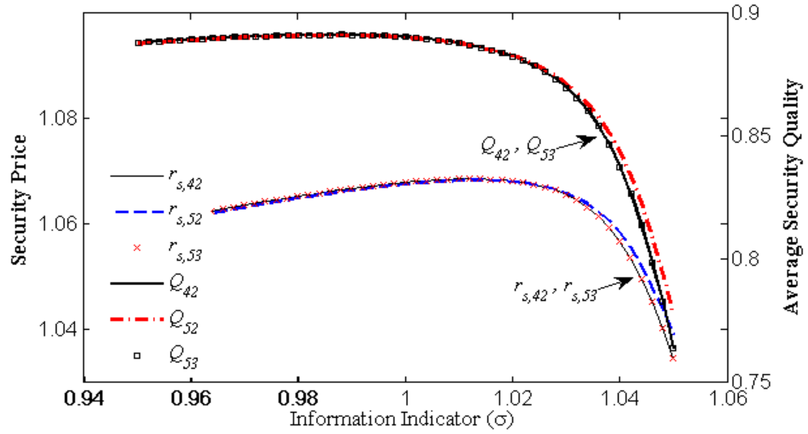


Note: Two-tranche security (junior and senior tranches): $R_\sigma = 1.105$, $c = 0.8$, $r = 1.05$, $\delta = 0.020$, $N = 10000$, $\mu = 0.01$ and $\omega = 1$. For the corresponding one-tranche security, average loan rate is calculated as volume-weighted average loan rate of two-tranche security (Equation (22), for each information indicator value), and $c = 0.8$, $r = 1.05$, $\delta = 0.020$, $N = 10000$.

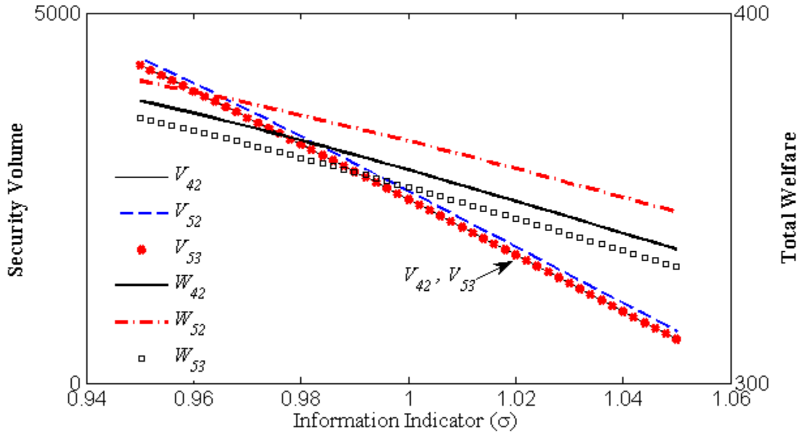
Figure 8 Equilibrium Impacts of Policy Parameter

(R = 1.11, c = 0.8, r_e = 1.10 r = 1.05, δ = 0.015, N = 10000)

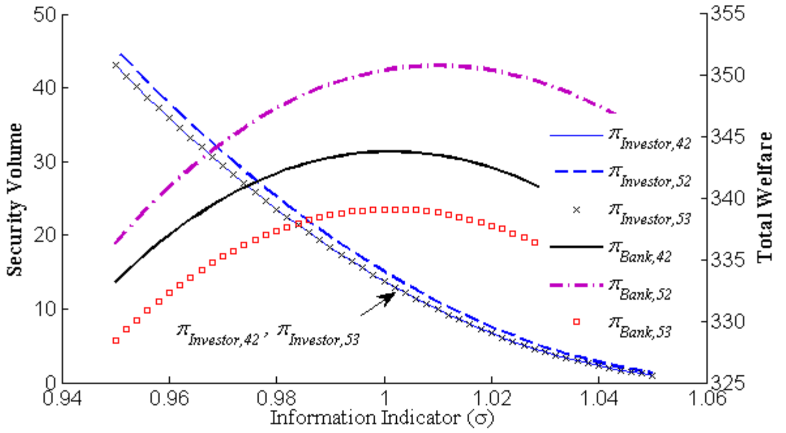
Panel A: Security price and volume-weighted average quality



Panel B: Security volume and total welfare



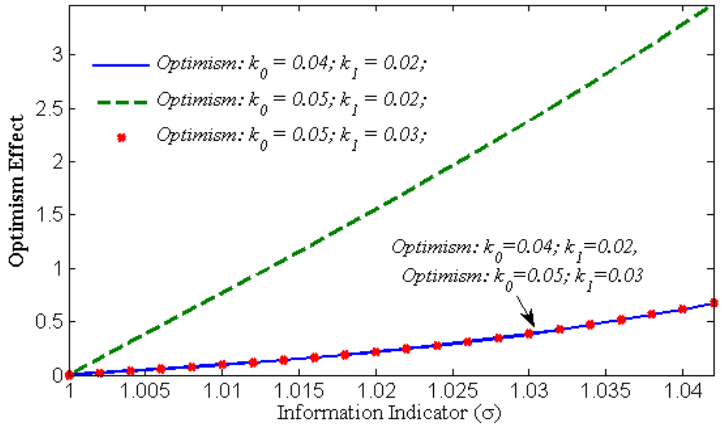
Panel C: Profits of investors and banks



(Continued…)

(Figure 8 Continued)

Panel D: Optimism value for banks



Note: The three scenarios of minimum capital requirements k_0 and k_1 are respectively: (1) $k_0 = 0.04$, $k_1 = 0.02$; (2) $k_0 = 0.05$, $k_1 = 0.02$; (3) $k_0 = 0.05$, $k_1 = 0.03$.

Appendices

Appendix 1: Proofs of Homogeneous Banks Model

Suppose banks and investors hold different information levels, σ and σ_s respectively, then the security design problem becomes:

$$\max_{\beta'} \pi_{bank} = N\{\int_{\beta_{\min}/\sigma}^{\bar{\beta}_s/\sigma} \left[qR_\sigma + (1-q)c - r\right] f(q)dq$$

$$+ \int_{\bar{\beta}_s/\sigma}^{\beta'/\sigma} [r_s + \delta - r] f(q)dq + \int_{\beta'/\sigma}^{1} \left[qR_\sigma + (1-q)c - r\right] f(q)dq\}$$

$$\max_{\bar{\beta}_s} \pi_I = N\int_{\frac{\bar{\beta}_s}{\sigma_s}}^{\frac{\beta'}{\sigma}} \left[qR_\sigma + (1-q)\mathrm{c} - r_s\right] f(q)dq$$

where $\beta_{min} = \dfrac{r-c}{R_\sigma - c}$. Assume positive solutions for β', $\bar{\beta}_s$ and r_s, first order conditions yield:

$$\frac{\partial \pi_I}{\partial \bar{\beta}_s} = -\frac{N}{\sigma_s}\left[\frac{\bar{\beta}_s}{\sigma_s} R_\sigma + \left(1 - \frac{\bar{\beta}_s}{\sigma_s}\right)c - r_s\right] f\left(\frac{\bar{\beta}_s}{\sigma_s}\right) = 0$$

$$\frac{\partial \pi_{bank}}{\partial \beta'} = -\frac{N}{\sigma}\left[\frac{\beta'}{\sigma} R_\sigma + \left(1 - \frac{\beta'}{\sigma}\right)c - r_s - \delta\right] f\left(\frac{\beta'}{\sigma}\right) = 0$$

which gives:

$$\beta' = \frac{r_s + \delta - c}{R_\sigma - c} \tag{A1.1}$$

$$\bar{\beta}_s = \frac{\sigma_s(r_s - c)}{R_\sigma - c} \tag{A1.2}$$

By backward induction, substitute β' and $\bar{\beta}_s$ into expression of investor profit, security price is determined when investors' marginal profit equals zero, that is,

$$\frac{\partial \pi_I}{\partial r_s} = \frac{\mathrm{N}}{\sigma(R_\sigma - c)}\left[\frac{\beta'}{\sigma} R_\sigma + \left(1 - \frac{\beta'}{\sigma}\right)c - r_s\right] f\left(\frac{\beta'}{\sigma}\right) - N\int_{\frac{\bar{\beta}_s}{\sigma_s}}^{\frac{\beta'}{\sigma}} f(q)dq = 0 .$$

Thus the security price is implicitly determined as:

$$\frac{(r_s - c)(1-\sigma) + \delta}{\sigma^2(R_\sigma - c)} f\left(\frac{\beta'}{\sigma}\right) = F\left(\frac{\beta'}{\sigma}\right) - F\left(\frac{\bar{\beta}_s}{\sigma_s}\right) \tag{A1.3}$$

Second-order Conditions

For a maximum to exist, the Hessian matrix must be negative definite. Total differentiation of first order conditions leads to:

$$\frac{\partial^2 \pi_{bank}}{\partial(\beta')^2} = -\frac{N}{\sigma^2}\left[\frac{\beta'}{\sigma}R_\sigma + \left(1-\frac{\beta'}{\sigma}\right)c - r_s - \delta\right] f'\left(\frac{\beta'}{\sigma}\right) - \frac{N}{\sigma^2}(R_\sigma - c) f\left(\frac{\beta'}{\sigma}\right)$$

$$= -\frac{N}{\sigma^2}(R_\sigma - c) f\left(\frac{\beta'}{\sigma}\right) < 0 \text{ always holds.}$$

$$\frac{\partial^2 \pi_I}{\partial \bar{\beta}^2} = -\frac{N}{\sigma_s^2}\left[\frac{\bar{\beta}_s}{\sigma_s}R_\sigma + \left(1-\frac{\bar{\beta}_s}{\sigma_s}\right)c - r_s\right] f'\left(\frac{\bar{\beta}_s}{\sigma_s}\right) - \frac{N}{\sigma^2}(R_\sigma - c) f\left(\frac{\bar{\beta}_s}{\sigma_s}\right)$$

$$= 0 - \frac{\mathrm{N}}{\sigma_s^2}(R_\sigma - c) f\left(\frac{\bar{\beta}_s}{\sigma_s}\right) < 0 \text{ always holds.}$$

$$\frac{\partial^2 \pi_I}{\partial r_s^2} = \frac{N}{\sigma^2(R_\sigma - c)^2}\frac{(r_s - c)(1-\sigma)+\delta}{\sigma} f'\left(\frac{\beta'}{\sigma}\right) + \frac{N}{\sigma(R_\sigma - c)}\left(\frac{1}{\sigma} - 2\right) f\left(\frac{\beta'}{\sigma}\right)$$

Then $\frac{\partial^2 \pi_I}{\partial r_s^2} < 0$ requires:

$$\frac{(r_s - c)(1-\sigma)+\delta}{\sigma^2(R_\sigma - c)} f' + \left(\frac{1}{\sigma} - 2\right) f < 0 \qquad \text{(A1.4)}$$

where f' denotes the first derivative of the probability density function $f(q)$ evaluated at $\frac{\beta'}{\sigma}$, f as the pdf evaluated at $\frac{\beta'}{\sigma}$.

Alternatively, substitute equations (A1.1) and (A1.2) into (A1.3) eliminates β' and $\bar{\beta}$ as an explicit choice variable, we could state second-order conditions to the single choice variable r_s. Let

$$G = \frac{(r_s - c)(1-\sigma)+\delta}{\sigma^2(R_\sigma - c)} f\left(\frac{\beta'}{\sigma}\right) - F\left(\frac{\beta'}{\sigma}\right) + F\left(\frac{\bar{\beta}_s}{\sigma_s}\right)$$

Partial differentiation of G with respect to r_s is:

$$G_{r_s} = \frac{(r_s - c)(1-\sigma)+\delta}{\sigma^3 (R_\sigma - c)^2} f'\left(\frac{\beta'}{\sigma}\right) + \frac{(1-\sigma)}{\sigma^2 (R_\sigma - c)} f\left(\frac{\beta'}{\sigma}\right) - \frac{1}{\sigma(R_\sigma - c)} f\left(\frac{\beta'}{\sigma}\right) + \frac{1}{(R_\sigma - c)} f\left(\frac{\overline{\beta}_s}{\sigma_s}\right)$$

Denote f' as first the derivative of the probability distribution function (pdf) evaluated at $\frac{\beta'}{\sigma}$, f as the pdf evaluated at $\frac{\beta'}{\sigma}$, and f^0 as the pdf evaluated at $\frac{\overline{\beta}_s}{\sigma_s}$, then we derive another second-order condition:

$$(R_\sigma - c) G_{r_s} = \frac{1}{\sigma}\left[\frac{(r_s - c)(1-\sigma)+\delta}{\sigma^2 (R_\sigma - c)} f' + \left(\frac{1}{\sigma} - 2\right) f\right] + f^0 < 0 \qquad \text{(A1.5)}$$

Specifically, when $\sigma = 1$ it becomes:

$$(R_\sigma - c) G_{r_s} = \left(\frac{\delta}{R_\sigma - c} f' - f\right) + f^0 < 0.$$

As in equation (7), denote $H_1 = \frac{(r_s - c)(1-\sigma)+\delta}{\sigma^2 (R_\sigma - c)} f' + \frac{1-\sigma}{\sigma} f$, then equation (A1.5) becomes $\sigma(R_\sigma - c) G_{r_s} = H_1 + (\sigma f^0 - f) < 0$, indicating that: $f - \sigma f^0 > H_1$.

Irrelevant of Investors' Information

For investors' information effect, we take the partial derivative of the first order conditions with respect to σ_s, which leads to

$$\left[\frac{(r_s - c)(1-\sigma)+\delta}{\sigma^2 (R_\sigma - c)} f' + \left(\frac{1}{\sigma} - 2\right) f + \sigma f^0\right] \frac{\partial r_s}{\partial \sigma_s} = 0$$

That is, $\frac{\partial r_s}{\partial \sigma_s} = 0$, indicating that r_s is not affected by investors' own information accuracy. Moreover,

$$\frac{\partial \beta'}{\partial \sigma_s} = \frac{1}{(R_\sigma - c)} \frac{\partial r_s}{\partial \sigma_s} = 0,$$

$$\frac{\partial \overline{\beta}_s}{\partial \sigma_s} = \frac{\sigma_s}{R_\sigma - c} \frac{\partial r_s}{\partial \sigma_s} + \frac{r_s - c}{R_\sigma - c} = \frac{r_s - c}{R_\sigma - c}, \text{ and } \frac{\partial \left(\frac{\overline{\beta}_s}{\sigma_s}\right)}{\partial \sigma_s} = \frac{\partial \frac{r_s - c}{R_\sigma - c}}{\partial \sigma_s} = \frac{1}{R_\sigma - c} \frac{\partial r_s}{\partial \sigma_s} = 0.$$

The intuition of these loan quality critical values is: β' is set by bank and not affected by investors' information accuracy; $\frac{\partial \bar{\beta}_s}{\partial \sigma_s} > 0$ means that investors tend to raise acceptable threshold with less accurate information. Moreover, since $\frac{\partial r_s}{\partial \sigma_s} = 0$. Then $\frac{1}{N}\frac{\partial V}{\partial \sigma_s} = f\left(\frac{\beta'}{\sigma}\right)\frac{1}{\sigma\left(R_\sigma - c\right)}\frac{\partial r_s}{\partial \sigma_s} - f\left(\frac{\bar{\beta}_s}{\sigma_s}\right)\frac{1}{R_\sigma - c}\frac{\partial r_s}{\partial \sigma_s} = 0$, indicating that security volume V is also not affected by investors' information accuracy.

By substituting first order conditions into the expression of $\frac{\partial \pi_I}{\partial \sigma_s}$, we have.

$$
\begin{aligned}
\frac{\partial \pi_I}{\partial \sigma_s} &= N\left[\frac{\beta'}{\sigma}R_\sigma + \left(1-\frac{\beta'}{\sigma}\right)c - r_s\right] f\left(\frac{\beta'}{\sigma}\right)\frac{\partial\left(\frac{\beta'}{\sigma}\right)}{\partial \sigma_s} - N\frac{\partial r_s}{\partial \sigma_s}\int_{\frac{\bar{\beta}_s}{\sigma_s}}^{\frac{\beta'}{\sigma}} f\left(q\right)dq \\
&\quad - N\left[\frac{\bar{\beta}_s}{\sigma_s}R_\sigma + \left(1-\frac{\bar{\beta}_s}{\sigma_s}\right)c - r_s\right] f\left(\frac{\bar{\beta}_s}{\sigma_s}\right)\frac{\partial\left(\frac{\bar{\beta}_s}{\sigma_s}\right)}{\partial \sigma_s} \\
&= -N\left[\frac{\beta'}{\sigma}R_\sigma + \left(1-\frac{\beta'}{\sigma}\right)c - r_s\right] f\left(\frac{\beta'}{\sigma}\right)\frac{1}{\left(R_\sigma - c\right)}\frac{\partial r_s}{\partial \sigma_s} = 0
\end{aligned}
$$

By straight forward calculation and using equilibrium conditions (A1.1) and (A1.2), we obtain:

$$
\begin{aligned}
\frac{\partial \pi_I}{\partial \sigma} &= N\left[\frac{\beta'}{\sigma}R_\sigma + \left(1-\frac{\beta'}{\sigma}\right)c - r_s\right] f\left(\frac{\beta'}{\sigma}\right)\frac{\partial \frac{\beta'}{\sigma}}{\partial \sigma} - N\frac{\partial r_s}{\partial \sigma}\int_{\frac{\bar{\beta}_s}{\sigma}}^{\frac{\beta'}{\sigma}} f\left(q\right)dq \\
&\quad - N\left(\frac{\bar{\beta}_s}{\sigma}R_\sigma + \left(1-\frac{\bar{\beta}_s}{\sigma}\right)c - r_s\right) f\left(\frac{\bar{\beta}_s}{\sigma}\right)\frac{\partial \frac{\bar{\beta}_s}{\sigma}}{\partial \sigma} \\
&= 0 - N\frac{1}{\sigma\left(R_\sigma - c\right)}\left[\frac{\beta'}{\sigma}R_\sigma + \left(1-\frac{\beta'}{\sigma}\right)c - r_s\right] f\left(\frac{\beta'}{\sigma}\right)\frac{r_s + \delta - c}{\sigma} < 0
\end{aligned}
$$

Above all, the security is irrelevant to investors' information, or alternatively, is information insensitive.Investors cannot extract extra profit by using better information, and hence do not have incentives to improve their own information. In short, security investors rely too much on banks.■

Equilibrium Analysis of Bank's Information Indicator σ

In order to find $\frac{\partial r_s}{\partial \sigma}$, we firstly have $\frac{\partial \bar{\beta}}{\partial \sigma}=\frac{r_s-c}{R_\sigma-c}+\frac{\sigma}{R_\sigma-c}\frac{\partial r_s}{\partial \sigma}$, and $\frac{\partial \beta'}{\partial \sigma}=\frac{1}{R_\sigma-c}\frac{\partial r_s}{\partial \sigma}$.

Differentiating both sides of the first order conditions (A1.2) with respect to σ gives:

$$\left[\frac{(r_s-c)(1-\sigma)+\delta}{\sigma^2(R_\sigma-c)}f'+\left(\frac{1}{\sigma}-2\right)f+\sigma f^0\right]\frac{\partial r_s}{\partial \sigma}$$

$$=\frac{r_s+\delta-c}{\sigma}\left[\frac{(r_s-c)(1-\sigma)+\delta}{\sigma^2(R_\sigma-c)}f'+\left(\frac{1}{\sigma}-1\right)f\right]+\frac{(r_s-c)(1-\sigma)+\delta}{\sigma^2}f$$

Using the notations G_{r_s} and H_1, then

$$\frac{\partial r_s}{\partial \sigma}=\frac{r_s+\delta-c}{\sigma^2(R_\sigma-c)}\frac{H_1}{G_{r_s}}+\frac{(r_s-c)(1-\sigma)+\delta}{\sigma^3(R_\sigma-c)G_{r_s}}f$$

If $H_1>0$, then $\frac{\partial r_s}{\partial \sigma}<0$. Moreover, under the same condition $H_1>0$, we have

$$\frac{\partial \bar{\beta}}{\partial \sigma}=\frac{r_s-c}{R_\sigma-c}+\frac{\sigma}{R_\sigma-c}\frac{\partial r_s}{\partial \sigma}>0\text{, and }\frac{\partial \beta'}{\partial \sigma}=\frac{1}{R_\sigma-c}\frac{\partial r_s}{\partial \sigma}>0$$

and

$$\begin{aligned}\frac{\partial V}{\partial \sigma}&=Nf\left(\frac{\beta'}{\sigma}\right)\left[\frac{1}{\sigma(R_\sigma-c)}\frac{\partial r_s}{\partial \sigma}-\frac{1}{\sigma^2}\frac{r_s+\delta-c}{R_\sigma-c}\right]-Nf\left(\frac{\bar{\beta}}{\sigma}\right)\frac{1}{R_\sigma-c}\frac{\partial r_s}{\partial \sigma}\\&=\frac{N}{\sigma(R_\sigma-c)}\left(f-\sigma f^0\right)\frac{\partial r_s}{\partial \sigma}-N\frac{r_s-c}{R_\sigma-c}f^0<0\end{aligned}. \blacksquare$$

Equilibrium Analysis of Liquidity Premium δ

Since $\frac{\partial \beta'}{\partial \delta}=\frac{1}{R_\sigma-c}\left(\frac{\partial r_s}{\partial \delta}+1\right)$, $\frac{\partial \bar{\beta}}{\partial \delta}=\frac{\sigma}{R_\sigma-c}\frac{\partial r_s}{\partial \delta}$, then partially differentiating the first order conditions (A1.2) with respect to δ yields:

$$\frac{\partial r_s}{\partial \delta}=-\frac{1}{\sigma(R_\sigma-c)G_{r_s}}\left[\frac{(r_s-c)(1-\sigma)+\delta}{\sigma^2(R_\sigma-c)}f'+\frac{1-\sigma}{\sigma}f\right]$$

which has the same sign as H_1. Moreover, $\frac{\partial \bar{\beta}}{\partial \delta}=\frac{\sigma}{R_\sigma-c}\frac{\partial r_s}{\partial \delta}$ also has the same sign as H_1. According to the second order condition $f-\sigma f^0>H_1$,

$$\frac{\partial V}{\partial \delta} = Nf\left(\frac{\beta'}{\sigma}\right)\frac{1}{\sigma}\frac{\partial \beta'}{\partial \delta} - Nf\left(\frac{\bar{\beta}}{\sigma}\right)\frac{1}{\sigma}\frac{\partial \bar{\beta}}{\partial \delta} = Nf\left(\frac{\beta'}{\sigma}\right)\frac{1}{\sigma\left(R_\sigma - c\right)}\left(\frac{\partial r_s}{\partial \delta} + 1\right) - Nf\left(\frac{\bar{\beta}}{\sigma}\right)\frac{1}{R_\sigma - c}\frac{\partial r_s}{\partial \delta}$$

$$= \frac{N}{\sigma\left(R_\sigma - c\right)}\left(f - \sigma f^0\right)\frac{\partial r_s}{\partial \delta} + \frac{N}{\sigma\left(R_\sigma - c\right)} f$$

is positive when $f - \sigma f^0 < 0$ or $H_1 > 0$. Finally, the impact of liquidity premiums on investors profit is always positive.

$$\frac{\partial \pi_I}{\partial \delta} = N\left[\frac{\beta'}{\sigma}R_\sigma + \left(1 - \frac{\beta'}{\sigma}\right)c - r_s\right] f\left(\frac{\beta'}{\sigma}\right)\frac{1}{\sigma}\frac{\partial \beta'}{\partial \delta} - N\left[\frac{\bar{\beta}}{\sigma}R_\sigma + \left(1 - \frac{\bar{\beta}}{\sigma}\right)c - r_s\right] f\left(\frac{\bar{\beta}}{\sigma}\right)\frac{1}{\sigma}\frac{\partial \bar{\beta}}{\partial \delta} - N\frac{\partial r_s}{\partial \delta}\int_{\frac{\bar{\beta}}{\sigma}}^{\frac{\beta'}{\sigma}} f\left(q\right)dq$$

$$= N\left[\frac{\beta'}{\sigma}R_\sigma + \left(1 - \frac{\beta'}{\sigma}\right)c - r_s\right] f\left(\frac{\beta'}{\sigma}\right)\frac{1}{\sigma\left(R_\sigma - c\right)} = N\frac{\left(r_s - c\right)\left(1 - \sigma\right) + \delta}{\sigma^2\left(R_\sigma - c\right)} f\left(\frac{\beta'}{\sigma}\right) > 0$$

where this second equality holds due to the first order condition (A1.2). ■

Appendix 2: Heterogeneous Banks

The securitization problem in this case is:

$$\max_{r_{s,1}, r_{s,2}, \bar{q}_s} \pi_I = \left(N - m\right)\int_{\bar{q}_s}^{\frac{\beta_1'}{\sigma_1}}\left[qR_1 + \left(1 - q\right)c - r_{s,1}\right] f\left(q\right)dq + m\int_{\bar{q}_s}^{\frac{\beta_2'}{\sigma_2}}\left[qR_2 + \left(1 - q\right)c - r_{s,2}\right] f\left(q\right)dq$$

where the upper bounds $\beta_1' = \frac{r_{s,1} + \delta_1 - c}{R_1 - c}, \beta_2' = \frac{r_{s,2} + \delta_2 - c}{R_2 - c}$ set by banks. First order conditions yields:

$$\bar{q}_s = \frac{\left(N - m\right)\left(r_{s,1} - c\right) + m\left(r_{s,2} - c\right)}{\left(N - m\right)\left(R_1 - c\right) + m\left(R_2 - c\right)} \tag{A2.1}$$

$$\frac{\left(r_{s,1} - c\right)\left(1 - \sigma_1\right) + \delta_1}{\sigma_1^2\left(R_1 - c\right)} f\left(\frac{\beta_1'}{\sigma_1}\right) = F\left(\frac{\beta_1'}{\sigma_1}\right) - F\left(\bar{q}_s\right) \tag{A2.2}$$

$$\frac{\left(r_{s,2} - c\right)\left(1 - \sigma_2\right) + \delta_2}{\sigma_2^2\left(R_2 - c\right)} f\left(\frac{\beta_2'}{\sigma_2}\right) = F\left(\frac{\beta_2'}{\sigma_2}\right) - F\left(\bar{q}_s\right) \tag{A2.3}$$

Corresponding second order conditions are:

$$\tilde{G}_1 \equiv \frac{1}{\sigma_1\left(R_1 - c\right)}\left[\frac{\left(r_{s,1} - c\right)\left(1 - \sigma_1\right) + \delta_1}{\sigma_1^2\left(R_1 - c\right)} f_1' + \left(\frac{1}{\sigma_1} - 2\right) f_1\right] + \frac{\left(N - m\right)}{\left(N - m\right)\left(R_1 - c\right) + m\left(R_2 - c\right)} f_q^0 < 0$$

(A2.4)

$$\tilde{G}_2 \equiv \frac{1}{\sigma_2 (R_2 - c)} \left[\frac{(r_{s,2} - c)(1 - \sigma_2) + \delta_2}{\sigma_2^2 (R_2 - c)} f_2' + \left(\frac{1}{\sigma_2} - 2 \right) f_2 \right] + \frac{m}{(N - m)(R_1 - c) + m(R_2 - c)} f_q^0 < 0$$

(A2.5)

where f_i' denotes the first derivative of the probability distribution function (pdf) $f(q)$ evaluated at $\frac{\beta_i^{'}}{\sigma_i}$ for $i = 1, 2$, f_i is the pdfevaluated at $\frac{\beta_i'}{\sigma_i}$, f_q^0 is the pdfevaluated at $\overline{q}_s$.