

Information Acquisition vs. Liquidity in Financial Markets

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Abstract

This paper presents a model of securitization that highlights the link between information acquisition at the loan screening stage and liquidity in markets where securities backed by loan cashflows are sold. While information is beneficial ex-ante when used to screen loans, it becomes detrimental ex-post because it introduces a problem of adverse selection. The model matches key features of the securitization practice, such as the tranching of loan cashflows, and it predicts that when gains from securitization are ‘sufficiently’ large, loan screening is inefficiently low. There are two channels that drive this inefficiency. First, when gains from trade are large, a loan issuer is tempted ex-post to sell a large portion of its cashflows, and lower retention reduces incentives to screen loans. Second, the presence of adverse selection in secondary markets creates informational rents for issuers holding low quality loans, reducing the value of loan screening. This suggests that incentives for loan screening not only depend on the portion of loans retained by issuers, but also on how the market prices different securities. Turning to financial regulation, I characterize the optimal mechanism and show that it can be implemented with a simple tax scheme. This paper, therefore, contributes to the recent debate on how to regulate securitization.

Keywords. Securitization, information acquisition, liquidity, security design, moral hazard, adverse selection.

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1 Introduction

Markets for securitized assets have played an important role in providing lending capacity to the banking industry and the real economy.¹ In 2007, for example, more than 25 percent of outstanding consumer credit in the U.S. had been financed through the securitization of consumer loans. Some common examples include MBS, CMBS, CLOs, and consumer credit ABS.² In the financial crash of 2008, however, in which some of these securities played a crucial part, we witnessed a collapse in issuance of securitized assets. As a response, policy makers geared their efforts towards reviving these markets. The Financial Stability Board stated that “re-establishing securitization on a sound basis remains a priority in order to support provision of credit to the real economy and improve banks’ access to funding.”³

In this paper, I present a model of securitization with two main ingredients: a problem of incentives at the loan origination stage, and a resulting problem of asymmetric information at the loan securitization stage. Loan originators acquire private information about potential borrowers, use this information to screen loans, and *later* issue securities backed by these loans, given their private information, to exploit gains from securitization. The model is consistent with key facts of the securitization practice, such as the issuance of separate tranches of underlying cashflows. I use this framework to investigate the inefficiencies associated with securitization. I find that when gains from securitization are ‘sufficiently’ large, and originators lack commitment to pre-designed securities, the quality of loan screening is inefficiently low. I provide policy interventions that maximize ex-ante efficiency. These policies differ from those that would arise in environments with moral hazard at origination or adverse selection in securitization separately, and they suggest that regulators should not only focus on retention levels for securitizers but also on how the market prices different securities.

The key trade-offs analyzed in this paper are motivated by substantial evidence that a problem of incentives at the loan screening stage and asymmetric information at the securitization stage are important features of the securitization process. First, it has been

¹A securitized asset is a security whose payoff is derived from and collateralized by a specified pool of underlying assets. Securitization is the practice of creating and selling securitized assets.

²These are acronyms for: MBS: mortgage-backed securities, CMBS: commercial-mortgage backed securities, CLO: collateralized loan obligations (backed by debt, mostly corporate), ABS: asset-backed securities (backed by consumer loans: credit card, student, auto loans, residential equity lines, etc.)

³Financial Stability Board, Progress Since the Washington Summit in the Implementation of the G20 Recommendations for Strengthening Financial Stability, Report to G20 Leaders (Nov. 2010).

shown that the increase in securitization that occurred prior to the financial crisis has led to a decline in lending standards.⁴ Second, there is evidence that securitizers have used private information about loan quality when choosing which loans to securitize.⁵ A natural question arises: how should securities be designed to provide incentives to screen loans and, at the same time, to preserve liquidity in markets for securitized assets? The literature on security design has studied these problems in isolation.⁶ However, by doing so, a fundamental trade-off between incentives and liquidity has been overlooked: while securities that provide incentives to screen loans may expose the issuer to less liquid markets, more liquid securities tend to worsen originator’s incentives.

The model is stylized and yet able to capture some key complexities inherent to the process of securitization. It has three periods and features a bank and a market of potential investors. The bank has capital that it can invest risklessly or use to finance one risky project (make a loan) that pays in the final period. In the first period, the bank privately invests in information and observes two signals about project quality: while the first signal is used to screen project quality; the second signal is observed after the loan is originated.⁷ In the intermediate period, the bank sells securities backed by loan cashflows to “uninformed” investors to exploit gains from trade/securitization. In the final period, loan cashflows are realized and the bank pays investors. In this framework, information acquisition is desired in the loan origination stage, when used to screen loans, but detrimental in the securitization stage, where it introduces a problem of asymmetric information: gains from loan screening need to be traded-off with gains from securitization.

This paper makes two contributions to the security design literature. First, I characterize the optimal security design in markets where the issuer has private information and

⁴It has been shown that credit standards in the mortgage market have fallen more in areas where lenders sold a larger fraction of the originated loans, and that performance has been worse for securitized loans (Dell’Ariccia et al. (2008), Elul (2009), Jaffee et al. (2009), Keys et al. (2008), Mian and Sufi (2009).) Bernt and Gupta (2008) find that borrowers of the syndicated loan market with more liquid secondary markets under-perform in the long run.

⁵Differences in unobservable loan characteristics known by the issuer are not fully compensated by loan pricing in secondary markets (Jiang et al. (2010), Downing et al. (2008), Calem et al. (2010), and Agarwal et al. (2012).

⁶On security design for the provision of incentives: Innes (1990), Hartman-Glaser et al. (2013). On security design with adverse selection: Nachman and Noe (1994), DeMarzo and Duffie (1999), Biais and Mariotti (2005), DeMarzo (2005).

⁷The second signal is a reduced form to represent the information acquired by the bank in the loan screening stage that cannot be inferred by the market through the initial screening decisions: soft information acquired while establishing a lending relationship. For an alternative interpretation, see Plantin (2009) where he introduces the concept of *learning by holding*.

lacks the ability to commit to retain cashflows. This lack of commitment has not been studied in the literature, and it provides a new rationale for slicing underlying cashflows into different seniority tranches. Second, I characterize the optimal security design before loan origination where the trade-off between loan screening quality and securitization levels is internalized. I do so by finding the optimal mechanism that maximizes ex-ante efficiency, and I use these results to propose policy interventions that decentralize the optimal mechanism when market participants lack commitment.

In the first half of the paper, I study the case where securities are designed and priced after loan origination (ex-post security design). To capture some of the opacities inherent to these markets, I impose a *No Transparency* assumption that prevents the bank from committing to retain cashflows and investors from observing all the securities a bank issues. As a result, retention of cashflows cannot be enforced by investors, and since retention is essential to signal loan quality, separating equilibria cannot arise (DeMarzo and Duffie (1999), DeMarzo (2005)).⁸ In this scenario, the bank is able to issue multiple securities and will do so in equilibrium. Thus, the predictions of this model are in sharp contrast to those of the security design literature. I find that standard debt (the senior tranche) is the security chosen by the bank with good loans since it minimizes the lemon's discount in the market. Consequently, banks with bad loans issue standard debt to mimic those with good loans and receive an implicit subsidy, and issue their remaining cashflows (junior tranches) in a separate market to further exploit gains from trade. Evidence of this behavior can be found in Ashcraft, Gooriah, and Kermani (2014), who document that (a) the amount of first-loss retention has a significant impact on the probability of more senior tranches defaulting, and (b) this risk is not priced at origination; i.e. interest rates on senior securities are uncorrelated with retention levels.⁹

The model generates several testable predictions. First, securitizers slice underlying cashflows into senior and junior tranches that are sold separately. Second, originators with better quality loans should retain the junior tranches, while those with bad quality loans should sell them. Third, the quality of originated loans is decreasing in the fraction of cashflows being securitized. Fourth, loans for which very little information (e.g. credit cards) or a lot of information (e.g. corporate loans) is acquired in equilibrium should be easier to securitize than those for which information acquisition is intermediate. Finally,

⁸This is meant to capture the difficulties associated with individual investors monitoring until contract maturity not only that the issuer retains certain cashflows on balance sheet but also that it is not hedging the exposure to this cashflows with other financial assets.

⁹They find evidence of this in the conduit Commercial Mortgage-Backed-Security (CMBS) Market.

this non-monotonicity of securitization levels on the quality of information gives rise to multiple equilibria, where depending on market sentiment, three equilibria may arise: (i) high-quality loan screening and low securitization levels, (ii) low-quality loan screening and high securitization levels, or (iii) collapse of risky lending.

I find that when securities are designed and priced after loan origination, equilibria are ex-ante inefficient. In particular, when gains from securitization are large, information acquisition and loan screening are inefficiently low. Two separate forces drive this inefficiency. First, after originating the loan, the bank wants to maximize gains from securitization, and does not internalize that lower retention implements worse loan screening in equilibrium. Second, adverse selection in secondary markets further distorts incentives by creating informational rents for banks holding bad loans. However, when the adverse selection problem in secondary markets is sufficiently severe, securitization levels are inefficiently low and information acquisition too high. This suggests that the concern for provision of incentives to loan originators is only relevant for asset classes with high securitization levels.

In the second half of the paper, I characterize the optimal mechanism that maximizes ex-ante efficiency (ex-ante security design). I show that standard debt continues to be the optimal design because it minimizes the expected adverse selection *and* it provides the best incentives for loan screening by exposing the bank to the most informationally-sensitive cashflows. Debt levels and market transfers are chosen to optimally trade-off gains from securitization with gains from loan screening. I find that retention of cashflows is essential to have loan screening. Furthermore, retention levels should be weakly increasing in the quality of underlying cashflows. Incentives for loan screening are further improved by transferring surplus to banks with good loans to compensate them for being exposed to a lemon's problem.

I show that a simple tax scheme can decentralize the optimal mechanism. The optimal policy has to attain two goals. First, differential retention levels to securitizers have to be imposed. Second, participation in the market for senior tranches should be subsidized while participation in the market for more junior tranches should be taxed. This result is in contrast with models that only focus on adverse selection, where transfers across banks in secondary markets do not affect ex-ante efficiency. This suggests that regulators should not only focus on retention levels for securitizers but also on how the market prices the different issued tranches.

Policymakers in the US and Europe have proposed the “Skin in the Game” rule that

requires originators/securitizers to retain a fraction of the underlying assets. My model rationalizes this type of intervention *only* for securities that feature high securitization levels. The model further suggests that policies that demand the same retention levels for all issuers may impose excessive costs by hindering securitization without necessarily improving incentives. This result is in contrast with the literature on security design in the presence of moral hazard, where imposing a unique retention level is optimal ex-ante.

Several papers have highlighted the trade-off between incentives to issue good assets and secondary market liquidity. The idea that secondary market liquidity reduces incentives to screen asset quality is explored by Parlour and Plantin (2008) and Malherbe (2012).¹⁰ Chemla and Hennessy (2013), in a framework similar to mine, study how different levels of asymmetric information in secondary markets affect incentives of securitizers. In contrast to their work, in my setting the level informational asymmetries that gives rise to liquidity problems is endogenous and tightly connected to the quality of loan screening. This results in a non-monotonic relation between information acquisition and securitization. In addition, I characterize the optimal mechanism.

My work builds on the extensive literature on security design in the presence of adverse selection, started with Myers and Majluf (1984) and Nachman and Noe (1994). I follow Duffie and DeMarzo (1999), Biais and Mariotti (2005), and DeMarzo (2005) very closely in my security design problem. As opposed to much of the prior literature, I endogenize the decision to originate assets, and in addition, the securitizer in my model is unable to commit to retaining some designated portion of cashflows. These two ingredients change the established predictions on the optimal security design ex-post (pooling and tranching), but also on the optimal security design ex-ante (trade-off between loan screening and liquidity). Finally, this paper also contributes to the literature on security design in the presence of moral hazard (Innes (1990), Cremer, Khalil, and Rochet (1998), Dang et al. (2010), Fender and Mitchell (2009), Hartman-Glaser et al. (2012), Yang (2013), Yang and Zeng (2013)).¹¹ In contrast to these papers, I analyze a moral hazard problem followed by an adverse selection problem, and show that the interaction between both frictions is non-trivial.

¹⁰The trade-offs between incentives and liquidity have also been studied in non-banking contexts by Coffee (1991), Bhidé (1993), Maug (1998), Dewatripont and Tirole (1994), Winton (2001), Aghion, Bolton, and Tirole (2004), Faure-Grimaud and Gromb (2004), Medrano and Vives (2004) who focus on the relation between shareholder control and real investment decisions and stock market trading.

¹¹A related question is addressed in Bolton, Santos, and Scheinkman (2014) where they study how the structure and design of secondary markets (exchange vs. other-the-counter) can affect investor's incentives to acquire information.

Organization. In Section 2, I describe the setup of the model, and characterize the first-best of this economy. In Section 3, I study markets for securitized assets, where securities are designed and priced after loan origination. In Section 4, I characterize the optimal mechanism that maximizes ex-ante efficiency and I present the policy implications of the model. Section 5 concludes.

2 The Model

2.1 Setup

The model has three periods, indexed by $t \in \{0, 1, 2\}$. There is a single bank and a market of potential investors. The bank is risk-neutral with a payoff function $V_0 = \theta c_1 + c_2$ where c_t denotes the cashflows of the bank at time t , and $\theta > 1$ denotes the bank's marginal value of funds in $t = 1$. When $\theta > 1$, the bank values funds more than investors and there are thus gains from trade in the intermediate period.¹² At $t = 0$, the bank has an endowment of one and it cannot borrow additional funds from the market. This assumption can be motivated by assuming that the bank is against its capital constraint and therefore can only raise funds by selling assets.

Investment Technology. In the initial period, the bank can store its endowment at the risk free rate, normalized to one, or invest in risky projects (i.e. loans). There is a unit mass of risky projects that produce cashflows X at $t = 2$ if they receive one unit of investment at $t = 0$. Projects can be of high or low quality. There is a fraction π_H of high quality projects with payoff $X \sim G_H$ and a fraction $1 - \pi_H$ of low quality projects with payoff $X \sim G_L$. I assume that (i) the distributions are related by the monotone likelihood ratio property (MLRP): $\frac{g_H(x)}{g_L(x)}$ increasing in x ; (ii) unscreened projects have negative net present value (NPV): $\pi_H \mathbb{E}_H[X] + (1 - \pi_H) \mathbb{E}_L[X] < 1$ and (iii) high quality projects have positive NPV: $\mathbb{E}_H[X] > 1$. The quality of projects is not known by the bank nor by investors.

Project Screening and Information Acquisition. The bank has access to a technology to

¹²Gains from trade captured by $\theta > 1$ should be interpreted as gains from securitization not addressed in this paper. There are many reasons why a bank might want to raise funds by selling assets. If the bank is against its capital constraints, and new exclusive investment opportunities arise, it will benefit from selling a fraction of its loans to finance these new investments. Alternatively, securitization may allow the bank to share-risks with the market or to reduce bankruptcy costs by creating bankruptcy remote instruments.

privately screen project quality.¹³ By investing $C(a)$ in information, the bank has access to signals with precision “ a ” about the underlying quality of projects, where $C : [\frac{1}{2}, 1) \rightarrow \mathbb{R}^+$, $C' \geq 0$, $C'' \geq 0$ and $\lim_{a \rightarrow 1} C(a) = \infty$. I assume that information acquisition is a bank’s hidden action. Privately investing $C(a)$ in information gives the bank access to two independent binary signals for all available projects, $s_0, s_1 \in \{H, L\}$, where s_0 is observed at $t = 0$ and s_1 is observed after a loan has been issued. These signals are independently distributed across projects, with conditional distributions given by $P(s_0 = H|q = H) = P(s_0 = L|q = L) = a$ and $P(s_1 = H|q = H) = P(s_1 = L|q = L) = \tau(a)$, where $q \in \{H, L\}$ denotes project quality and $\tau(\cdot)$ is a function with $\tau(\frac{1}{2}) = \frac{1}{2}$ and $0 \leq \tau'(a) \leq 1$. While signal s_0 will be used to screen loans, and thus inferred by the market in equilibrium, signal s_1 will determine the bank’s private information. This novel two binary signal structure is a reduced form to capture the fact that not all private information acquired by the bank in the loan screening stage is inferred by the market through the loan screening decision: some relevant information remains private. This is why the precision of both signals is increasing in the level of investment in information done by the bank when screening loans, and $\tau'(a)$ aims to capture how much of the information acquired in the screening stage remains private.¹⁴ This simple setup captures the notion that the quality of a bank’s private information about its borrowers should improve as investment in information in the loan screening stage is improved.

After observing a given signal, the bank updates its beliefs about firm quality using Bayes rule. Since the bank evaluates a continuum of projects in $t = 0$, it observes a project with $s_0 = H$ with probability one, for any level of information acquisition a . Thus, the bank always chooses to finance a project with $s_0 = H$, where note that what this implies for the quality of the issued loan will strongly depend on the precision of this signal, a .¹⁵ The following two conditional probabilities will be used extensively throughout the paper: (i) the probability of a loan being high quality given the initial screening ($s_0 = H$), and defined as $\rho(a)$; and (ii) the probability of receiving the second high signal $s_1 = H$ for

¹³Evidence of banks being special lenders can be found in Fama (1985), and of banks having the ability to acquire private information about borrowers in Mikkelsen and Partch (1986), Slovin, Sushka, Polonchek (1993), Plantin (2009), Botsch and Vanasco (2013), among others.

¹⁴The second signal can also be interpreted as private information acquired by the bank while holding the loan, as in Plantin (2009).

¹⁵This restriction is at no loss, since I will show that in equilibrium the bank strictly prefers to lend to a firm with $s_0 = H$ if it chooses to acquire information, and is indifferent otherwise. Assuming that a high signal is always observed is a modeling device that ensures that after information is acquired, there is screening of loans in equilibrium; that is, by acquiring information the bank can always improve the expected quality of the issued loans.

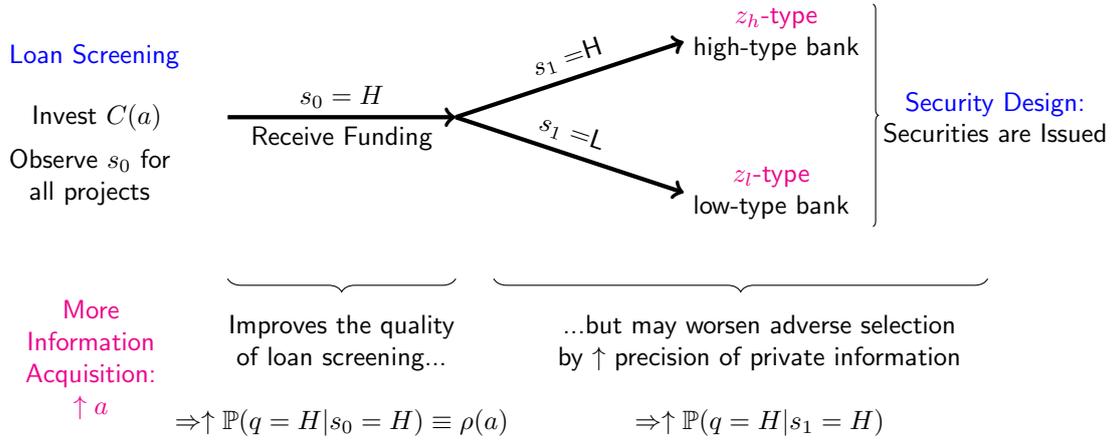


Figure 1: Information Acquisition, Lending, and Securitization

the issued loan, given the initial screening, defined as $\rho_h(a)$:

$$\rho(a) \equiv \mathbb{P}_a(q = H | s_0 = H) = \frac{a\pi_H}{a\pi_H + (1-a)(1-\pi_H)} \quad (1)$$

$$\rho_h(a) \equiv \mathbb{P}_a(s_1 = H | s_0 = H) = \tau(a)\rho(a) + (1-\tau(a))(1-\rho(a)) \quad (2)$$

Finally, to ensure that there are gains to acquiring information, I assume that parameters are such that there always exists an $\tilde{a} \in (\frac{1}{2}, 1]$ s.t. $\rho(\tilde{a})\mathbb{E}_H[X] + (1-\rho(\tilde{a}))\mathbb{E}_L[X] - C(\tilde{a}) > \theta$.

Bank Types. The bank arrives to $t = 1$ with private information about its loan quality, given by the signals s_0 and s_1 and the hidden-action a . Let $z \in \{z_h, z_l\}$ denote the bank's type in secondary markets, where $z_h \equiv \{s_0 = H, s_1 = H\}$ and $z_l \equiv \{s_0 = H, s_1 = L\}$ denote the high-type bank (more likely to hold a high quality loan) and the low-type bank (more likely to hold a low quality loan) respectively.¹⁶ It is important to note that heterogeneity across bank types is only due to different s_1 signals (H vs. L), as illustrated in Figure 1. This has two important implications. First, in equilibrium there is only one level of information acquisition, a^* , and $s_0 = H$ for the issued loan, since there is no bank heterogeneity in $t = 0$. Second, the distribution of types is endogenous since the likelihood of receiving H vs. L signal is only a function of the chosen level of information,

¹⁶Even though a could also be part of the bank's type, since in equilibrium it is unique and inferred by the market, it simplifies the problem to keep track of a and z separately, even though they are both the bank's private information.

a^* .¹⁷ Finally, the bank's private valuation of a given security F is denoted as $\mathbb{E}_a[F(X)|z]$ for $z \in \{z_l, z_h\}$, where $\mathbb{E}_a[\cdot|z]$ is the expectation operator over cashflows X , conditional on private signals z and the precision of these signals a .

Secondary Markets. At $t = 1$, to exploit gains from trade ($\theta > 1$), the bank can issue securities with payoffs (only) contingent on the realization of loan cashflows. Thus, a security F is given by some function $F : \mathbb{X} \rightarrow \mathbb{R}$ and its payoffs is denoted as $F(X)$. In addition, as is standard in the security design literature, I assume that the bank and the investors have limited-liability: (LL) $0 \leq F(x) \leq x$, and I restrict attention to securities with payoffs that are weakly monotone in underlying cashflows: (WM) $F(x)$ is weakly increasing for all $x \in \mathbb{X}$.¹⁸ Let $\Delta \equiv \{F : \mathbb{X} \rightarrow \mathbb{R} \text{ s.t. (LL) and (WM) hold}\}$ denote the set of feasible securities a bank can issue in secondary markets, and if the bank issues more than one security, where $\tilde{F}(X) \equiv \sum_i F_i(X)$, then it must be that $\tilde{F} \in \Delta$ as well.

I solve a screening problem in secondary markets, where uninformed investors post prices for feasible securities $F \in \Delta$ given their beliefs about information acquisition levels, a , and bank's type, z . Given this, the z -type bank chooses which securities to issue from the market offered menu. Therefore, the bank faces an inverse demand function $p : \Delta \rightarrow \mathbb{R}$ where $p(F)$ is the market price for security F that is determined in equilibrium by the investors' zero-profit condition.

Timing of the Game. At $t = 0$ the bank invests in information, observes signal s_0 and makes its lending decisions. At $t = 1$, when in need of funds and having received signal s_1 , the bank issues feasible securities backed by its loan cashflows to investors. At $t = 2$, loan cashflows are realized and contracts are executed. The timing of the game is presented in Figure 2.

2.2 First-Best

I begin by characterizing the first-best of this economy as a useful benchmark for the remainder of the paper. I do so by assuming that information acquisition " a " is observable, and received signals are public information. I solve the problem by backwards induction. In $t = 1$, the bank needs to choose which security to issue. Let $F \in \Delta$ be the

¹⁷For example, if $a = \frac{1}{2}$, signal s_1 contains no information, and thus there is no heterogeneity across banks.

¹⁸These restrictions are assumed in Nachman and Noe (1994), DeMarzo and Duffie (1999), Biais and Mariotti (2005), among others. Innes (1990) discusses the implications of restricting attention to contracts that are monotonic on realized returns in environments with moral hazard.

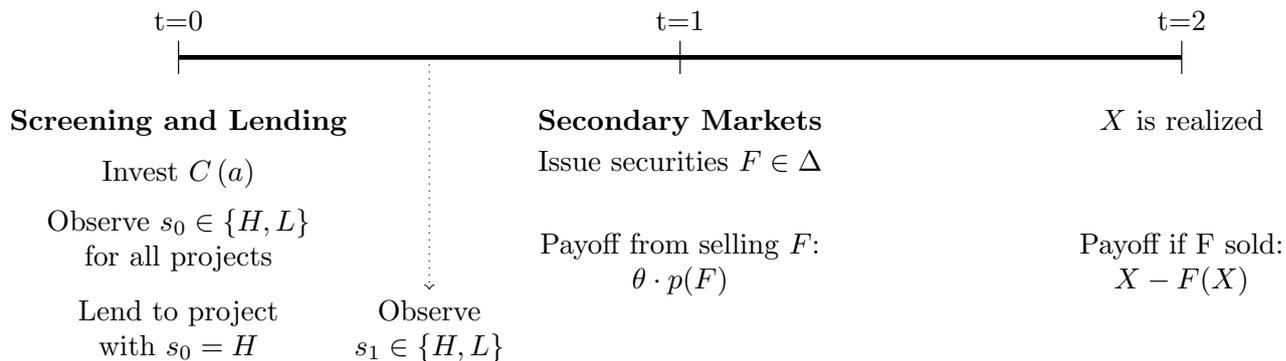


Figure 2: Timeline of the Model

security issued by the bank, and let $p(F) \in \mathbb{R}^+$ be the price the market offers for this security. The value of the z -type bank in $t = 1$ is given by:

$$\theta p(F) + \mathbb{E}_a [X - F(X)|z] = (\theta - 1) \mathbb{E}_a [F(X)|z] + \mathbb{E}_a [X|z]$$

where the last equality holds because the market values any security F as the bank, and the competitive investors price securities at its expected value; that is, $p(F) = \mathbb{E}_a[F(X)|z]$. It is straightforward that the bank chooses to issue a full claim to its loan cashflows, $F_{FI}^*(X) = X$, since it is the issuance that maximizes the gains from trade. From now on, I will refer to security $F(X) = X$ as equity. In $t = 1$, given that all claims are sold in the intermediate period, the bank chooses how much information to acquire to maximize the value of banking in $t = 0$:

$$a_{FB}^* = \arg \max_{a \in [\frac{1}{2}, 1)} \theta [\rho(a) \mathbb{E}_H [X] + (1 - \rho(a)) \mathbb{E}_L [X]] - C(a)$$

When choosing how much information to acquire, the bank is fully exposed to the cashflows of its loans and the market fully compensates it for investing in information. It will be useful to keep this benchmark in mind: in the first-best, gains from trade and from information acquisition are maximized when the bank issues a claim to all of its cashflows and when the market fully compensates the bank for its investment in information.

3 Markets for Securitized Assets: No Commitment

In this section, I study the scenario where securities are designed and priced *after*

loan origination, at $t = 1$. This implicitly assumes that the bank has *no commitment* to securities designed and priced at $t = 0$.¹⁹ I use the results from this section to answer two main questions that are at the heart of the discussion on how to optimally regulate securitization. First, how does information acquisition affect the design of securities sold in secondary markets and the levels securitization in these markets? And second, how does the design of securities affect incentives to acquire information and originate high quality loans in the first place? In Section 4, I study the optimal mechanism that maximizes ex-ante efficiency to characterize the inefficiencies that arise due to the lack of commitment in this framework.

In what follows, I define the value of the bank in the interim period, $t = 1$, and in the initial period, $t = 0$ for the case where the bank chooses to acquire information and make a loan. Later this value will be compared with the value of storing, and will determine whether the bank invests in information and lends or stores at the risk-free. Let p_h, p_l and F_h, F_l denote the funds raised and cashflows sold in secondary markets by type $z \in \{z_h, z_l\}$ respectively.²⁰ Therefore, at $t = 1$, the value of the z -type bank that acquired information with precision a is given by:

$$V_1(a, z, p_z, F_z) \equiv \theta p_z + \mathbb{E}_a [X - F_z(X)|z] \quad (3)$$

Consistent with this, the value of the bank in $t = 0$ is $V_0(a, p_l, p_h, F_l, F_h)$ defined as:

$$\rho_h(a) \{ \theta p_h + \mathbb{E}_a [X - F_h(X)|z_h] \} + (1 - \rho_h(a)) \{ \theta p_l + \mathbb{E}_a [X - F_l(X)|z_l] \} - C(a) \quad (4)$$

where the unit cost of investing in a project is incorporated into $C(a)$. Finally, let a^e denote the market (investors') belief about the hidden action taken by the bank. I focus on pure strategy equilibria in which market beliefs are degenerate at some level $a^e \in [\frac{1}{2}, 1)$, which will imply a unique choice of information acquisition as a response.²¹ The problem is solved by backwards induction. At $t = 1$, for a given level of information acquisition a and market beliefs a^e , the z -type bank designs and issues feasible securities

¹⁹In practice, originators can choose which loans to securitize and which ones to keep on balance sheet. This lack of commitment is capturing the fact that ex-ante optimal contracts with the market are not renegotiation proof in this environment, there are ex-post gains from deviating from the pre-designed security.

²⁰To simplify on notation, let $F_h \equiv F_{z_h}$ and idem for z_l . Note that sold cashflows denoted by F_z can potentially be sold through the issuance of more than one security in secondary markets. Consistent with this, p_z are the total funds raised in secondary markets. This clarification is important, since I will show that some bank types issue more than one security in equilibrium.

²¹For $C(a)$ convex enough, there is a unique level of a implemented in equilibrium for a given a^e .

in secondary markets to raise funds. At $t = 0$, given the secondary markets optimal strategies (including off-equilibrium strategies), the bank chooses how much information to acquire. In what follows, I define the equilibrium with information acquisition of this economy.

Definition 1. *An equilibrium with information acquisition is given by $\{a^e, a^*, p_l^*, p_h^*, F_l^*, F_h^*\} \in [\frac{1}{2}, 1)^2 \times \mathbb{R}_+^2 \times \Delta^2$ satisfying the following conditions:*

1. *Given a, a^e , $\{p_l(a^e), p_h(a^e), F_l(a, a^e), F_h(a, a^e)\}$ are equilibrium outcomes in secondary markets.*
2. *Given a^e , $a^*(a^e) = \arg \max_{a \in [\frac{1}{2}, 1]} V_0(a, p_l(a^e), p_h(a^e), F_l(a, a^e), F_h(a, a^e))$, from (4).*
3. *$a^e = a^* = a^*(a^*)$, and $p_l^* = p_l(a^*)$, $p_h^* = p_h(a^*)$, $F_l^* = F_l(a^*, a^*)$, $F_h^* = F_h(a^*, a^*)$*

An equilibrium with information acquisition exists if $V_0(a^*, p_l^*, p_h^*, F_l^*, F_h^*) \geq \theta$, that is, when the value of investing in information and in risky projects is at least as high as the value of storing, given by θ . When this condition does not hold, the bank chooses to store its endowment and does not invest in information nor it extends credit to risky projects. I assume that when there is no information acquisition nor lending in equilibrium, market beliefs are given by the level of information acquisition in the equilibrium with information acquisition, i.e. $a^e = a^*$. The remainder of this section focuses on characterizing the equilibrium with information acquisition, and is organized as follows. First, I solve for the equilibrium outcome in secondary markets. Second, I solve for the optimal level of investment in information chosen by the bank in $t = 0$, given the previously obtained secondary market equilibrium outcomes. Finally, I discuss how results from the model are able to rationalize key features of markets for asset-backed securities, such as the tranching of underlying cashflows and the observed fall in lending standards in the years leading to the crisis.

3.1 $t=1$. Equilibrium in Secondary Markets

The bank arrives to secondary markets with a chosen level of information precision, $a \in [\frac{1}{2}, 1)$, which is a bank's hidden action, and private signals $z \in \{z_l, z_h\}$. Both the hidden action and the signals determine the bank's valuation of its loan cashflows.

Conditional cashflow distributions are given by:

$$f_a(X|z_i) \equiv \pi_i(a) g_H(X) + (1 - \pi_i(a)) g_L(X), \quad i = \{l, h\} \quad (5)$$

$$\text{where } \pi_h(a) = P(q = H|z = z_h) = \frac{\tau(a)\rho(a)}{\tau(a)\rho(a) + (1 - \tau(a))(1 - \rho(a))} \quad (6)$$

$$\pi_l(a) = P(q = H|z = z_l) = \frac{(1 - \tau(a))\rho(a)}{(1 - \tau(a))\rho(a) + \tau(a)(1 - \rho(a))} \quad (7)$$

All computed using Bayes Rule. Note that $\pi'_h(a) \geq \pi'_l(a) \geq 0$ for all $a \in [\frac{1}{2}, 1)$ and $\pi_H \in [0, 1]$. That is, information acquisition increases the likelihood of having high cashflows, specially for the z_h -type bank. For the remainder of the paper, let $\tau(a) = 0.5 + \tau(a - 0.5)$, where $\tau \in [0, 1]$ reflects the sensitivity of the second signal (of private information), to the investment in information done at the screening stage.²² Note that $\frac{\partial \pi'_h(a)}{\partial \tau} \geq 0$ and $\frac{\partial \pi'_l(a)}{\partial \tau} \leq 0$; that is, increases in τ make cashflows of the z_h -type bank more responsive to changes in a , and cashflows of the z_l type bank less responsive to a . In the extreme case of $\tau = 1$, where both signals are equally precise, $\pi_l(a) = \pi_H$ and does not depend on a . These comparative statics are important, since the sensitivity of cashflows to the quality of information will affect how different retention levels implement different levels of information acquisition in equilibrium.

A. Strategies

Rather than defining investors' strategies, I model the buyer side of the market as a menu of prices and securities $\{p(F), F\}_{F \in \Delta}$ offered to the bank. This menu needs to satisfy two conditions: (i) *Zero Profits*: investors make zero profits in expectation, and (ii) *No Deals*: there are no profitable deviations for an investor; that is, by offering a price different than the one on the menu for a given security, an investor cannot expect to make profits.²³ In the remainder of the paper, I use the terms investors and the market interchangeably. The strategy of a z -type bank that acquired information a is to choose which securities to issue given the market posted prices.

²²Working with a linear approximation to $\tau(a)$ will not have a qualitative impact on the results presented in this paper, but it will be useful to characterize certain dynamics with respect to changes in τ . Thus, this assumption is at no loss, and done to ease the exposition of results.

²³This approach is a useful modeling device to summarize an environment where two or more uninformed, risk-neutral, deep-pockets investors compete by posting prices for all securities. The "No Deals" condition is taken from Daley and Green (2012), and can be also be interpreted as a No Entry condition. This "No Deals" condition needs to be imposed in environments with asymmetric information to ensure there are no profitable deviations for the buyers.

B. Market Beliefs

Investors enter secondary markets with belief a^e about the bank's hidden-action. In addition, they need to form beliefs about the bank's type z . I impose a "No Transparency" assumption that prevents the market from enforcing retention levels, and thus screening bank quality is not possible in equilibrium.²⁴ Gorton and Pennachi (1995) discuss the commitment to retain a given fraction when selling a loan. They argue that "... no participation contract requires that the bank selling the loan maintain a fraction, so this contract feature would also appear to be implicit and would need to be enforced by market, rather than legal, means." This assumption is therefore motivated by behavior in these markets, where enforcement of retention not only requires investors to monitor that the issuer retains the promised fraction until maturity, but also that they are not hedging their exposure to this retention by acquiring other financial assets. I discuss the implications of the No Transparency assumption in detail in the end of this section, where I solve the model under Transparency.

Assumption 1. [No Transparency] *The bank cannot commit to retain cashflows. Or equivalently, balance sheet information is not verifiable and markets are anonymous.*

Under the *No Transparency* assumption, an investor forms her beliefs about bank type per security sold since it cannot condition on the set of securities the bank is issuing in secondary markets. More formally, this implies that market beliefs about the bank's type are given by some function $\mu : \Delta \rightarrow [0, 1]$, where $\mu(F)$ denotes the probability of a bank being z_h -type if it chooses to sell security F . Therefore, the market valuation for a given security $F \in \Delta$ is denoted by $\mathbb{E}_{a^e, \mu}[F(X)]$, and it is given by:

$$\mathbb{E}_{a^e, \mu}[F(X)] \equiv \mu(F) \mathbb{E}_{a^e}[F(X)|z_h] + (1 - \mu(F))\mathbb{E}_{a^e}[F(X)|z_l] \quad (8)$$

C. Equilibrium

I assume that the bank wants to minimize the number of markets it issues in; that is, the bank prefers to issue one security than to issue several securities when both strategies

²⁴In principle, if retention was enforceable, the market could screen the bank's type. Separating equilibria in this environment is obtained in DeMarzo and Duffie (1999), Biais and Mariotti (2005), DeMarzo (2005), among others. The idea is that the cost of retaining cashflows (i.e. of not selling them) is lower for banks with good assets than for those with bad assets, and this can be used to separate them: those with good assets retain a fraction of their cashflows while those with bad assets reveal their type to be able to sell all of their cashflows. This is not possible under the No Transparency Assumption.

have the same payoff. I rationalize this by imposing an infinitesimal cost of issuing a positive claim ($F(x) > 0$ in a set of positive measure), $c > 0$.²⁵ Given this, I can assume without loss that the bank chooses to issue at most N securities, where N can be arbitrarily large. The equilibrium notion in secondary markets is defined as follows:

Definition 2. *Given any level of information acquisition, a , and market beliefs a^e , an equilibrium in secondary markets is given by a market menu $\{F, p(F)\}_{F \in \Delta}$, bank z -type strategy $\sigma(z) = \{F^1(z), \dots, F^N(z)\}$, and belief function $\mu : \Delta \rightarrow [0, 1]$, satisfying the following conditions:*

1. Bank's Optimality. *Given the market posted menu $\{p(F), F\}_{F \in \Delta}$, z -type bank chooses F^1, \dots, F^N to maximize its value at $t = 1$:*

$$\sum_{n=1}^N \{\theta p(F^n) - \mathbb{E}_a[F^n(X)|z]\} - c\tilde{N} \quad (9)$$

subject to $\sum_{n=1}^N F^n(X) \leq X$, and where \tilde{N} is the number of issued securities.

2. Belief Consistency. *$\mu(F) = \mathbb{P}_{a^e}(z = z_h | \text{Issue } F)$ are derived from $\sigma(z)$ using Bayes rule w.p.*
3. Zero Profit Condition. *$p(F) = \mathbb{E}_{a^e, \mu}[F(X)]$ for all $F \in \Delta$.*
4. No Deals. *For all $F \in \Delta$, it does not exist alternative pricing \tilde{p} such that by offering to buy F at price \tilde{p} , an investor expects to make profits.*

The following Lemma presents the first important result of this section, which states that under the No Transparency assumption the high-type bank cannot be separated from the one with the bad loan, eliminating the possibility of screening bank quality. As a result, the issuance chosen by the high-type bank is always mimicked by the low-type bank, and thus the high-type bank faces a lemon's problem in secondary markets. Full proofs are presented in the Appendix.

Lemma 1. [No Separation] *Under the No Transparency Assumption, fully separating equilibria in secondary markets do not exist. In particular, in any equilibrium in secondary markets the z_l -type bank mimics the issuance of the z_h -type bank.*

²⁵This assumption prevents multiplicity of equilibria arising from the fact that the bank in equilibrium might be indifferent between issuing a given security or any partition of the cashflows underlying that security; and thus simply eliminates a multiplicity of payoff-equivalent equilibria.

The main idea behind the proof is that in any separating equilibrium $\{p_l, p_h, F_l, F_h\}$, there is a profitable deviation for an investor. Note that in any separating equilibrium, the z_l -type bank is identified and thus $p(F_l) = \mathbb{E}_{a^e} [F_l(X)|z_l]$ by the zero-profit condition. Given this, consider the following deviation. An investor offers to buy security F' with cashflows $F'(X) = X - F_h(X)$ at price $p(F') = \mathbb{E}_{a^e} [F'(X)|z_l] - \epsilon$, $\epsilon > 0$, where F_h is the security issued by z_h -type bank in the separating equilibrium. For ϵ small enough, this offer attracts the low-type bank, that now benefits from issuing a claim to all of its cashflows by issuing: F_h at price $p(F_h) > \mathbb{E}_{a^e} [F_h(X)|z_l]$ to extract rents from the high-type bank, and further exploits remaining gains from trade by issuing F' at $p(F')$. Since $\epsilon > 0$, the investor makes profits. Lemma 1 implies that there is pooling in the market for the securities issued by the z_h -type bank. The following proposition characterizes the security design in secondary markets.

Proposition 1. [*Security Design*] *Under the No Transparency Assumption, in any equilibrium in secondary markets,*

1. *The z_h -type bank issues one security, given by standard debt $F_D(X) \equiv \min\{d, X\}$, where debt level d is chosen to maximize the value of the z_h -type bank in $t = 1$:*

$$d(a^e, a) = \arg \max_d \theta \cdot \mathbb{E}_{a^e, \mu} [\min\{d, X\}] - \mathbb{E}_a [\min\{d, X\} | z_h] \quad (10)$$

2. *The z_l -type bank issues **two** securities: 1) standard debt F_D , and 2) and junior tranche $F_J(X) \equiv \max\{X - d, 0\}$.*
3. *The market price for these securities:*

$$p(F_D) = \rho_h(a^e) \mathbb{E}_{a^e} [\min\{d, X\} | z_h] + (1 - \rho_h(a^e)) \mathbb{E}_{a^e} [\min\{d, X\} | z_l] \quad (11)$$

$$p(F_J) = \mathbb{E}_{a^e} [\min\{0, X - d\} | z_l] \quad (12)$$

Four important results are presented in Proposition 1. First, standard debt is always sold in secondary markets. Second, debt levels are chosen to maximize the value of the z_h -type bank. Third, the z_l -type bank tranches its cashflows into senior (standard debt) and junior (remaining cashflows) tranches that are sold separately in secondary markets, while the high-type bank only issues the senior tranche and retains its junior tranche. Finally, prices in secondary markets are such that the low-type bank is subsidized by the

high-type bank in the market for the senior tranches and it receives a fair value for its junior tranche.

Optimality of Standard Debt. Under the No Transparency assumption, the high quality bank faces a lemons problem as the one described in Akerlof (1970) when it participates in secondary markets, since the low quality bank always mimics its issuance. That is, there is pooling in the market where the high-type banks sell. For any given security, the lemon's discount faced by the high-type bank is given by the difference between its private valuation and the market valuation. Standard debt is the optimal security design because it allows the high-type bank to raise funds at the minimum retention cost by minimizing the region where disagreement about the likelihood of cashflows might arise. Thus, standard debt maximizes the gains from trade by minimizing the lemon's discount since it is the design that is least informationally sensitive in the set of feasible securities. In contrast to papers on security design that obtain a separating equilibrium, the reason why high types choose to retain in this framework is not to signal underlying quality, but because the lemon's discount is prohibitively high for the remaining cashflows.

Tranching. The low-type bank tranches underlying cashflows into a senior tranche –i.e. standard debt– and a junior tranche –i.e. remaining cashflows,– and sells both securities separately. It does so to receive an implicit subsidy in the market for the senior tranche and rip remaining gains from trade by issuing its junior tranche simultaneously. This result strongly relies on the No Transparency assumption, since the low-type bank can issue its junior tranche without being identified in the market for the senior tranche.

Optimal Debt Levels. Debt levels are chosen to maximize the value of the high-type bank at $t = 1$. Figure 3 plots (a) the payoff of the high-type bank at $t = 1$ as a function of different debt levels issued in secondary markets, and (b) optimal debt levels, both as a function of different equilibrium levels of information acquisition. Simulations are done to ease the exposition of results since qualitative results do not depend on specific functional forms nor parameters (specified at the bottom of each Figure). In the Appendix, I show that highlighted properties hold for general distributions and parameters. As we can see from Figure 3, optimal debt levels are non-monotonic on the equilibrium level of information precision a^* . For a given funding need θ , debt levels are maximized when asymmetric information is low. This occurs when information precision is low, and thus private information is not too valuable (see $a = 0.5$ case), and when information precision is high, and thus the quality of initial loan screening is sufficiently high to make private information not valuable (see $a = 1$ case). The following Lemma characterizes optimal

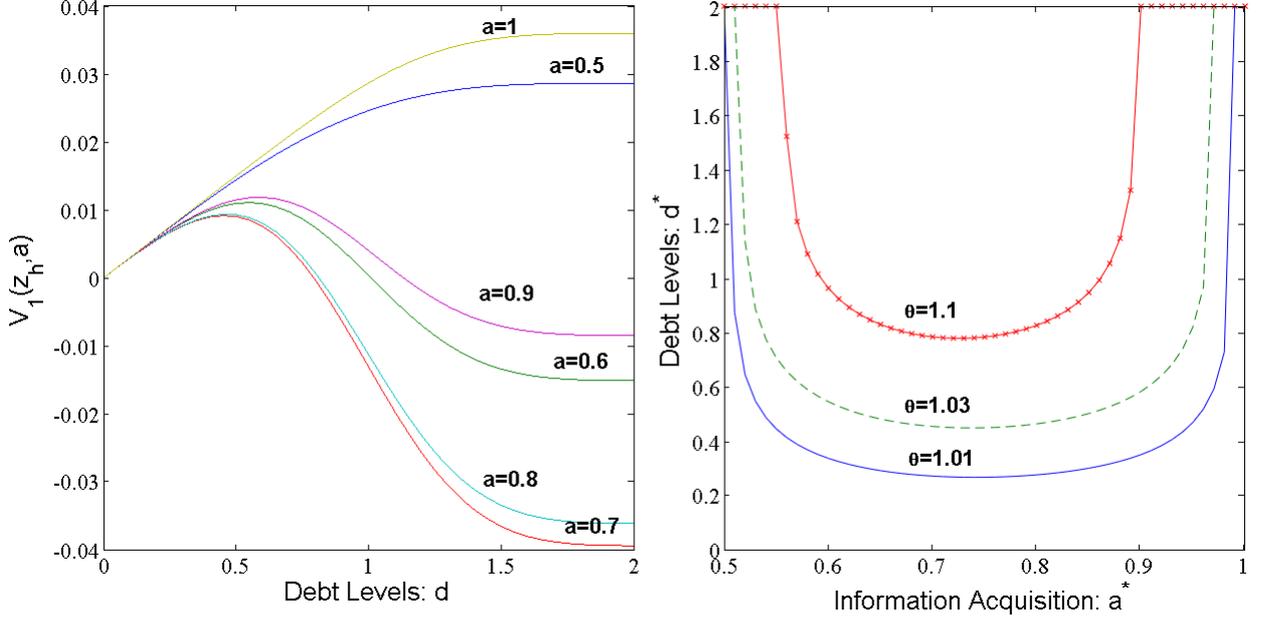


Figure 3: Debt Levels

$\theta = 1.03$, $\pi_H = 0.5$, the distribution of X is given by a truncated normal in $[0, 2]$ with $\mathbb{E}_H[X] = 1.2$, $\mathbb{E}_L[X] = 0.7$, $V_G[X] = V_B[X] = 0.2$ respectively for good and bad projects.

debt levels for given equilibrium levels of information acquisition.

Lemma 2. *Let a^* be the equilibrium level of information acquisition. Then, in any equilibrium where $\theta\rho(a^*) - \pi_h(a^*) < 0$ holds, optimal debt levels $d(a^*)$ are given by the solution to:*

$$\underbrace{[\theta\rho(a^*) - \pi_h(a^*)][G_L(d) - G_H(d)]}_{\text{Mg Cost due to Lemon's Discount}} + \underbrace{(\theta - 1)[1 - G_L(d)]}_{\text{Mg. Gains from Trade}} = 0 \quad (13)$$

Otherwise, both z -type banks issue equity; that is, $F_D = X$.

Debt levels are continuous, differentiable, and convex in the equilibrium level of information acquisition, a^* , and increasing in funding needs, θ . The high-type bank chooses to retain some of its cashflows when $\theta\rho(a^*) - \pi_h(a^*) < 0$. Note that $\rho(a^*)$ is the probability the market assigns to loan cashflows being high quality, while $\pi_h(a^*)$ is the probability the z_h -type assigns to this event. We know that $\rho(a^*) \leq \pi_h(a^*)$, with strict inequality when $a^* \in (\frac{1}{2}, 1)$.²⁶ When funding needs are high enough to compensate for the low prob-

²⁶Since $\rho(a) = \mathbb{P}(q = G|s_0 = G)$ while $\pi(a) = \mathbb{P}(q = G|s_0 = G, s_1 = G)$.

ability the market assigns to high cashflows, z_h -type bank issues equity. Otherwise, it optimally chooses to retain cashflows (i.e. its junior tranche). In the Appendix, issuance in secondary markets is also characterized for off-equilibrium scenarios with $a \neq a^e$.

Existence of Equilibrium. I have shown that in any equilibrium with information acquisition, the high-type bank issues standard debt in secondary markets at average valuations, and the low-type bank issues both standard debt at average valuations and its remaining cashflows at low valuations, where optimal debt levels are given by Lemma 2. Given this, I show that an equilibrium in secondary markets always exists. For example, for $\mu(F) = 0$ for all $F \in \Delta \neq F_D$ and $a^e = a^*$, there are no profitable deviations for the bank in secondary markets or in $t = 0$. By construction, there are no profitable deviations to investors. An equilibrium can also be supported with less stringent off-equilibrium beliefs (see Appendix).

3.2 $t=0$. Choosing Optimal Levels of Information Acquisition

I proceed to find the optimal level of information acquisition and the determination of market beliefs, given secondary market equilibrium outcomes. At $t = 0$, the bank chooses how much information to acquire to maximize V_0 given by (4). The following proposition characterizes optimal levels of investment in information, and completes the characterization of equilibrium allocations.

Proposition 2. *In any equilibrium with information acquisition:*

1. *Optimal investment in information, a^* , is given by the solution to:*

$$\begin{aligned} \rho_h(a^*) \pi'_h(a^*) \{ \mathbb{E}_H[\max\{X - d(a^*), 0\}] - \mathbb{E}_L[\max\{X - d(a^*), 0\}] \} + \\ \rho'_h(a^*) \{ \mathbb{E}[\max\{X - d(a^*), 0\} | z_h] - \theta \mathbb{E}[\max\{X - d(a^*), 0\} | z_l] \} = C'(a^*) \end{aligned} \quad (14)$$

2. *Optimal debt level is given by $d^* = d(a^*)$, where $d(a^*)$ is given by (13).*

Since the bank's information acquisition choice is a hidden-action, by choosing more or less information, the bank cannot directly affect investor's beliefs, and thus market transfers for a given security. In addition, by the envelope condition, we need not worry about how changes in a affect tomorrow's payoffs through changes in the design of issued securities. As a result, the bank has two motives to acquire information: (i) to improve

the quality of the cashflows that it expects to retain, and (ii) to affect the probability of being a z_h -type bank in secondary markets.

Retention. By investing in information the bank can increase the quality of the tranches that it expects to retain. This motive for information acquisition is well understood, and is the rationale behind proposed regulation for securitizers in the U.S. and Europe. How much a bank expects to retain in unregulated markets, however, is determined solely by the trade-off between gains from trade, measured by θ , and the level of asymmetric information between the bank and the market. Retention of cashflows is expected in equilibrium when the level of adverse selection is relatively large and thus the high-type bank is not willing to issue a full claim to its cashflows ex-post.

Secondary Market Payoffs. For a given retention level, the differential payoff between z_h and z_l types in $t = 1$, which strongly depends on secondary market outcomes, also affects incentives for information acquisition. The higher the benefits associated with being a high-type bank ex-post –i.e. higher payoff of the z_h -type bank relative to the z_l -type bank,– the higher the incentives to acquire information to screen loans ex-ante. Note that the z_h -type bank is not fully compensated in secondary markets: it implicitly subsidizes the z_l -type bank in the market for debt, and it loses access to the market for its junior tranche, where the lemon’s discount is prohibitively high. Thus, transfers across different bank types in secondary markets *do* affect ex-ante efficiency by affecting incentives to screen loans.

The Value of Adverse Selection. Both of these motives are positive only when the bank expects to retain cashflows in secondary markets, which only occurs when the level of asymmetric information is sufficiently high. Therefore, with lack of commitment, the presence of adverse selection in secondary markets is essential to sustain an equilibrium with information acquisition and loan screening.

3.3 Multiplicity of Equilibria

I have described the equilibrium outcomes in secondary markets for given choice of information acquisition, a and market beliefs a^e , and the resulting choice of information acquisition and loan screening ex-ante. To characterize the equilibria of this economy, I impose the equilibrium condition $a = a^e$. The following proposition establishes that when the precision of private information, given by s_1 , is increasing in the precision of the quality of loan screening, given by s_0 , multiple equilibria may arise.

Proposition 3. *When $\tau'(a) > 0$, there are at most three equilibria:*

1. *Storage Equilibrium. If $a^e = \frac{1}{2}$, the bank's best response is no information acquisition: $a^B = \frac{1}{2}$ and equity issuance ex-post: $d_h^B = d_l^B = \infty$. In this scenario, the bank chooses to store.*
2. *Low Information Acquisition Equilibrium: with information acquisition $a^L > \frac{1}{2}$ and retention of cashflows of the z_h -type: $d_h^L < \infty, d_l^L = \infty$. For a_L small enough, storage may also dominate.*
3. *High Information Acquisition Equilibrium: with information acquisition $a^H > a^L$ and retention of cashflows given by $d_h^H < d_h^L$.*

The model therefore predicts that depending on market sentiment, the economy can move from high-quality lending with high ex-post retention, to low-quality lending with high ex-post trading and low retention, to no lending at all. This result is fully dependent on the non-monotonicity of debt issuance in secondary markets to the initial choice of information acquisition and loan screening presented in Figure 3. First, there is always an equilibrium with no information acquisition, no loan screening, and ex-post equity issuance. When unscreened projects have negative NPV, as assumed in this model, this equilibrium is dominated by the bank's choice of storing its endowment, and thus never arises. It's important to note, however, that if projects had positive NPV even when unscreened, we could observe markets with no loan screening and high trading volume in secondary markets. I make the negative NPV assumption to motivate the idea that under some market beliefs, lending to the risky sector would collapse and storage preferred. In addition to the Storage Equilibrium, the Low-High Equilibria arise for a broad range of parameter values, more specifically, arise when there are positive gains from information acquisition (gains from trade not too large, for example).

Figure 4 describes the underlying reasons for multiplicity, by showing the marginal costs and benefits of increasing equilibrium levels of information acquisition given by the right-hand and left-hand side of equation 2. Gains from information acquisition tend to be increasing in the level of cashflows retained by the high-type bank. High retention levels are more likely for intermediate levels of information acquisition, and decrease for extreme low and high levels where adverse selection is small. Therefore, as the figure depicts, the marginal benefit of implementing higher information acquisition is non-monotonic, it is zero in an interval around the extremes (where retention ex-post is

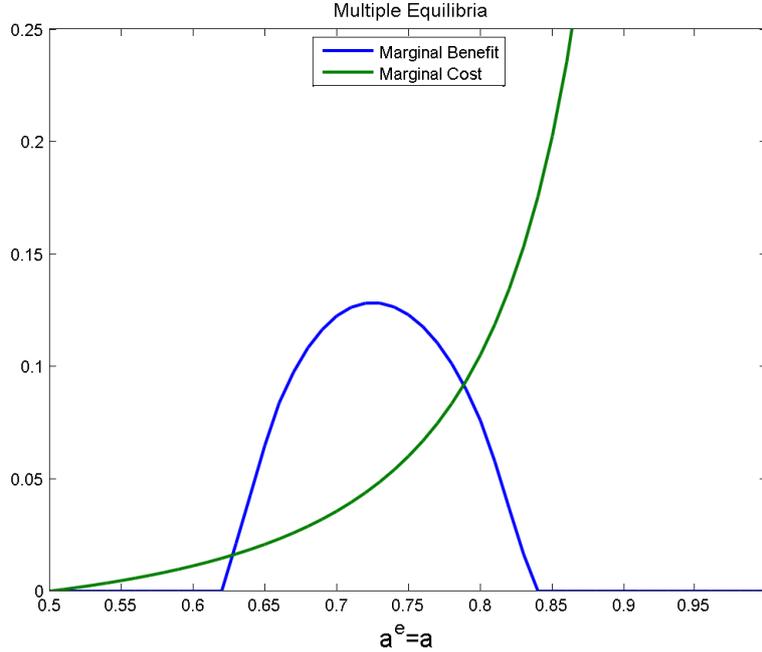


Figure 4: **Multiple Equilibria**

The distribution of X is given by a truncated normal in $[0, 2]$ with $\mathbb{E}_H[X] = 1.2$, $\mathbb{E}_L[X] = 0.7$, $V_G[X] = V_B[X] = 0.2$ respectively for good and bad projects, $\pi_H = 0.5$, $C(a) = -0.02 \frac{(0.5-a)^2}{(1-a)}$, and $\theta = 1.09$.

zero), and then increasing for low levels and decreasing for high levels of a^* . As we can see, the three equilibria arise for parameter values that promote retention in secondary markets and incentivize information acquisition, such as lower gains from trade θ , higher asymmetric information in secondary markets τ , or lower costs of information acquisition.

3.4 Comparative Statics

I have fully characterized equilibrium outcomes when securities are designed and priced in secondary markets, after loan issuance. The environment is stylized, but rich enough to generate several predictions and new insights. For this section, I will focus on the High-Information Equilibrium to describe the comparative statics of the model. Figure 5 shows optimal information acquisition and debt levels as a function of gains from trade, θ , and of costs of information acquisition, χ , where $C(a) = -\chi \frac{(0.5-a)^2}{(1-a)}$. As gains from trade in secondary markets increase, the bank optimally chooses to increase securitization. As a result, information acquisition falls and the quality of the originated loan

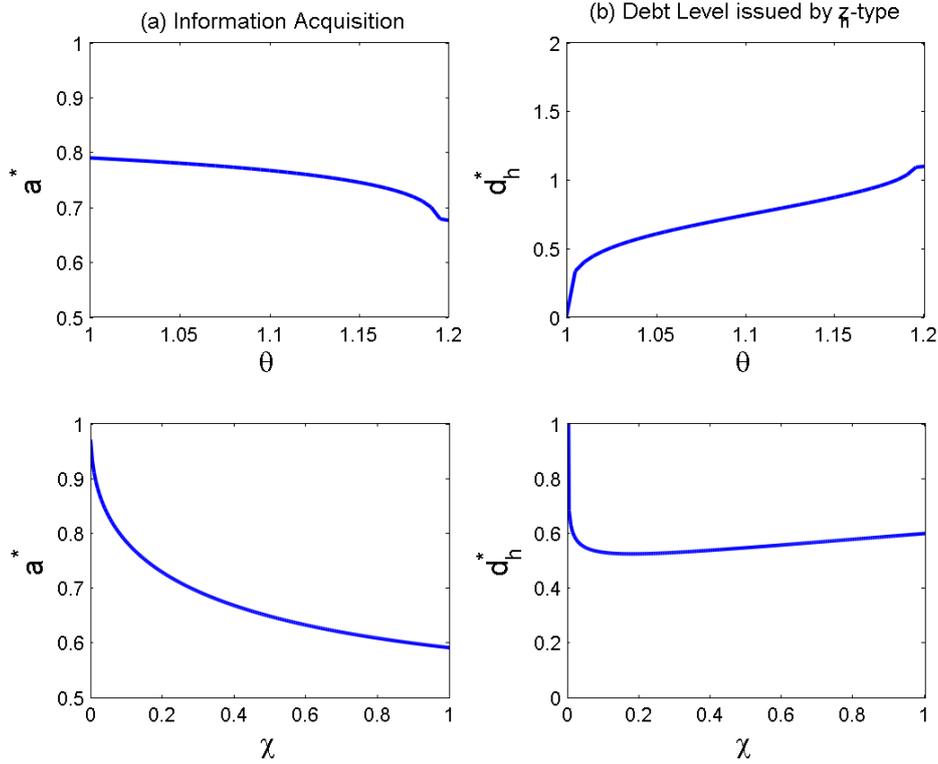


Figure 5: **Comparative Statics**

The distribution of X is given by a truncated normal in $[0, 2]$ with $\mathbb{E}_H[X] = 1.2$, $\mathbb{E}_L[X] = 0.7$, $V_G[X] = V_B[X] = 0.2$ respectively for good and bad projects, $\pi_H = 0.5$, $\tau(a) = a$ and $C(a) = -\chi \frac{(0.5-a)^2}{(1-a)}$. Panels (a) and (b) are computed for $\chi = 0.1$, and (c) and (d) for $\theta = 1.03$.

is worsened. This prediction is consistent with what was observed in the decade leading to the crisis: where a rapid increase in securitization was accompanied by a decrease in the quality of originated loans.²⁷ On the bottom panel, we can see that as the costs of information acquisition, χ , increase, the bank has less incentives to acquire information. Most importantly, this seems to be reinforced by lower retention of cashflows ex-post, where lower a levels are allowing the high-type bank to issue more, since the quality of its private information is lower.

I now address the two main questions asked at the beginning of this section. First, how does information acquisition affect the design of securities sold in secondary markets and the levels of securitization in these markets? Standard debt is the optimal design for

²⁷Jaffee et al. (2009), Dell’Ariccia, Igan and Laeven (2008), Mian and Sufi (2009), Bernd and Gupta (2008), provide empirical evidence of this fact.

all levels of information acquisition. Debt levels, however, are shown to be non-monotonic on the precision of information acquired in equilibrium. In particular, improving initial loan screening does not always increase securitization levels (See Figure 3). This result relies on the dual effect of information acquisition, and predicts that securitization is maximized for low and high levels of information precision. This result suggests that loans for which the bank acquires too little or too much information at the origination stage should have higher securitization levels.

Second, how does the design of securities sold in secondary markets affect incentives of the bank to acquire information and originate high quality loans in the first place? There are two aspects of secondary markets that affect the bank's decision to acquire information. First, to have a relevant level of information acquisition the bank has to expect to retain some of cashflows ex-post. In the absence of commitment, this only occurs when adverse selection in secondary markets is severe enough to have the high-type bank not off-loading its entire loan. Consistent with this, larger expected retention levels generate higher levels of information acquisition. The second aspect is related to the payoff received in the market for the securities sold: standard debt and junior tranche. Ex-ante, by acquiring information, the bank can affect the likelihood of showing up in secondary markets with a good loan. Thus, the differential payoff between the high-type bank and the low-type bank in secondary market matters. As this relative payoff increases, incentives for information acquisition improve; this relative payoff, however, is non-monotonic in retention levels. In the numerical simulations, however, the latter force is always dominated by the retention of cashflows motive.

3.5 The Case of Transparency

I will now characterize equilibrium outcomes when the No Transparency Assumption is removed. A Transparency Assumption is imposed instead: markets are not anonymous, and investors can observe all the securities a bank is issuing in secondary markets. In this situation, it is at no loss to assume that each bank type issues only one security. This problem is presented in DeMarzo (2005), where he finds that there is a unique equilibrium satisfying the Intuitive Criterion of Cho and Kreps (1987), that the equilibrium is separating, and that the optimal security design is a debt contract, with the face value of the debt given by incentive compatibility constraints.

Equilibrium in Secondary Markets. Following DeMarzo (2005), when investors are able to screen loan quality through retention, the optimal security design in secondary

markets is as follows. The low-type bank issues a full claim to its loan, and the high-type bank issues standard debt with debt level given by the incentive compatibility constraint of the low type:

$$(\theta - 1)E_a[X|z_l] \geq \theta E_a[\min\{d, X\}|z_h] - E_a[\min\{d, X\}|z_l]$$

Investors will price securities at its expected value. Note that there is still a cost associated with being a high-type bank in secondary markets, since retention is costly.

Choice of Information Acquisition. Relative to the equilibrium outcomes described under No Transparency, in this case debt levels issued by the high-type bank may differ, and transfers to each bank type will also differ. This will have quantitative, but not qualitative effects. That is, whether banks retain more or less, and how the surplus is split in secondary markets will affect ex-ante incentives to acquire information. This suggests that it is essential to understand which assumption better applies to securitization.

4 The Optimal Mechanism: Commitment

In this section, I characterize the optimal mechanism that maximizes ex-ante efficiency. The results presented here will motivate the policy interventions proposed in Section 4.2.

I focus on direct revelation mechanisms that stipulate a transfer and a security to be issued as a function of the reported bank-type. Let $\{p_l, F_l\}$ and $\{p_h, F_h\}$ denote the transfer and the security assigned to the reported type \hat{z}_l and \hat{z}_h respectively.²⁸

Definition 3. *The optimal mechanism is given by $\{a^*, p_l, p_h, F_l, F_h\} \in [\frac{1}{2}, 1] \times \mathbb{R}_+^2 \times \Delta^2$ chosen to maximize the value of the bank in $t = 0$:*

$$\rho_h(a^*)[\theta p_h + \mathbb{E}_{a^*}[X - F_h(X)|z_h]] + (1 - \rho_h(a^*))[\theta p_l + \mathbb{E}_{a^*}[X - F_l(X)|z_l]] - C(a^*)$$

subject to:

1. *The incentive compatibility constraints:*

$$\theta p_l - \mathbb{E}_{a^*}[F_l(X)|z_l] \geq \theta p_h - \mathbb{E}_{a^*}[F_h(X)|z_h] \tag{15}$$

$$\theta p_h - \mathbb{E}_{a^*}[F_h(X)|z_h] \geq \theta p_l - \mathbb{E}_{a^*}[F_l(X)|z_l] \tag{16}$$

²⁸By the Revelation Principle, we know that for any Bayesian-Nash equilibrium there exists a direct mechanism that is payoff-equivalent and where truthful revelation is an equilibrium.

2. *Zero-Profit Condition:*

$$\rho_h(a^*) [\mathbb{E}_{a^*} [F_h(X)|z_h] - p_h] + (1 - \rho_h(a^*)) [\mathbb{E}_{a^*} [F_l(X)|z_l] - p_l] = 0 \quad (17)$$

3. *The incentive compatibility constraint for information acquisition:*

$$a^* = \arg \max_{a \in [\frac{1}{2}, 1]} \rho_h(a) [\theta p_h + \mathbb{E}_a [X - F_h(X)|z_h]] + (1 - \rho_h(a)) [\theta p_l + \mathbb{E}_a [X - F_l(X)|z_l]] - C(a) \quad (18)$$

This problem is similar to the one presented in Biais and Mariotti (2005). They study optimal mechanism design in the presence of adverse selection, where an issuer with private information about asset quality has to issue a security to uninformed competitive liquidity providers. The main difference between their framework and mine is that in their setup, the quality of underlying assets and of the private information held by the issuer are exogenously determined, while in this problem both elements are dependent on information acquisition, which is a bank's hidden action. Therefore, the problem internalizes the effect that different securities and transfers have on incentives to acquire information, on the quality of issued loans and on the resulting issuance levels in secondary markets. The following proposition characterizes the optimal security design in the presence of commitment.

Proposition 4. *In the optimal mechanism,*

1. *The z_h -type bank issues standard debt with debt level d_h : $F_h(X) = \min\{d_h, X\}$.*
2. *The z_l -type bank issues standard debt with debt level $d_l \geq d_h$: $F_l(X) = \min\{d_l, X\}$.*
3. *Binding incentive compatibility constraint of the low-type and zero-profit imply:*

$$p_h = \{ \rho_h(a) \mathbb{E} [F_h(X)|z_h] + (1 - \rho_h(a)) \mathbb{E} [F_l(X)|z_l] \} - (1 - \rho_h(a)) \frac{1}{\theta} [\mathbb{E} [F_l(X)|z_l] - \mathbb{E} [F_h(X)|z_l]]$$

$$p_l = \{ \rho_h(a) \mathbb{E} [F_h(X)|z_h] + (1 - \rho_h(a)) \mathbb{E} [F_l(X)|z_l] \} + \rho_h(a) \frac{1}{\theta} [\mathbb{E} [F_l(X)|z_l] - \mathbb{E} [F_h(X)|z_l]]$$

The proposition states that both the low-type and the high-type bank issue standard debt, but the high type bank's debt levels are lower, that is, it retains more cashflows than the low-type. Standard debt is optimal because i) given a level of information acquisition, a , standard debt minimizes the required retention necessary to implement it, and this is good because retention of cashflows is costly –forgo gains from trade;– and ii) it relaxes incentive compatibility constraints. As in the ex-post security design

case, standard debt allows the bank to raise funds by loading on cashflows for which there is less disagreement, and thus less adverse selection in secondary markets. In addition, when securities are designed ex-ante they incorporate the impact on information acquisition, and thus standard debt is also preferable because it exposes the bank to the most informationally sensitive cashflows, improving incentives for information acquisition.

In this economy, demanding the same retention levels for all bank types may be inefficient: it reduces gains from trade and may reduce incentives for loan screening by making harder for high-types to separate ex-post. There are two forces behind the differential retention requirements. First, cashflows of the high-type banks are more sensitive to information acquisition levels than those of low-type banks. The assumption that $\tau \in [0.5, 1]$ states that the precision of the first signal, used for loan screening, is more responsive to investment in information than the second signal. As a result, the cashflows of the low-type bank are less dependent on the quality of loan screening; the second low signal can at most offset the information contained on the first high signal. Second, it is more costly for the low-type bank to retain cashflows than for the high-type, and an incentive compatible mechanism requires that retention levels cannot be higher for low-type banks. Due to this, imposing higher retention levels to high-type banks increases the differential payoff associated with being a high vs. a low type bank in secondary markets.

It remains to show how debt levels are determined. Let $a(\cdot, \cdot) : \mathbb{R}^+ \times \mathbb{R}^+ \rightarrow [0.5, 1]$ determine information acquisition as a function of debt levels $\{d_h, d_l\}$, given by the incentive compatibility of investment in information (IC_a). Using the first-order approach:

$$\begin{aligned} & \phi_h(a^*) (\mathbb{E}_H[X - \min\{d_h, X\}] - \mathbb{E}_L[X - \min\{d_h, X\}]) + \dots \\ & \phi_l(a^*) (\mathbb{E}_H[X - \min\{d_l, X\}] - \mathbb{E}_L[X - \min\{d_l, X\}]) - C'(a^*) = 0 \end{aligned} \quad (19)$$

where $\phi_h(a) \equiv \rho'_h(a)(\pi_h(a) - \pi_l(a)) + \rho_h(a)\pi'_h(a)$ and $\phi_l(a) \equiv (1 - \rho_h(a))\pi'_l(a)$. Function $a(\cdot, \cdot)$ is continuous, differentiable, and decreasing in both debt levels d due to the MLRP. The following Proposition concludes the characterization of the optimal mechanism.

Proposition 5. *In the optimal mechanism, optimal debt levels d_h^*, d_l^* are given by:*

$$\underbrace{\frac{\partial}{\partial a} [\rho_h(a) p_h + (1 - \rho_h(a)) p_l] \frac{\partial a(d_l, d_h)}{\partial d_h}}_{\text{Marginal Cost of } \uparrow d_h} + \underbrace{\frac{\theta - 1}{\theta} \rho_h(a) (1 - F(d_h | z_h))}_{\text{Marginal Gain from } \uparrow d_h} \Big|_{a=a(d_l, d_h)} - \underbrace{\lambda}_{(IC_l)} \geq 0$$

$$\underbrace{\frac{\partial}{\partial a} [\rho_h(a) p_h + (1 - \rho_h(a)) p_l] \frac{\partial a(d_l, d_h)}{\partial d_l}}_{\text{Marginal Cost of } \uparrow d_l} + \underbrace{\frac{\theta - 1}{\theta} (1 - \rho_h(a)) (1 - F(d_l | z_l))}_{\text{Marginal Gain from } \uparrow d_l} \Big|_{a=a(d_l, d_h)} - \underbrace{\lambda}_{(IC_l)} \geq 0$$

where $\lambda(d_l - d_h) = 0$. and optimal investment in information is given by $a^* = a(d_h^*, d_l^*)$.

By committing to lower debt levels ex-ante, the bank can commit to a certain level of information acquisition, pinning down market beliefs. In particular, lower debt levels imply higher market beliefs, which are translated into higher ex-post transfers. These are the first terms of the equations of Proposition (5), and they reflect the costs associated with increasing the debt levels for the high (d_h) and the low-type (d_l) respectively. The interpretation of the second term is straightforward: gains from trade are increased by increasing debt levels. Debt levels are therefore chosen to optimally trade-off the gains from trade with the gains from information acquisition. Finally, since an incentive compatible mechanism requires $d_h \leq d_l$, the multiplier is positive $\lambda > 0$ when the constraint binds.

4.1 Discussion

There are two key differences between the allocations obtained in the optimal mechanism and those found in Section 3, where securities were designed and priced *after* loan issuance. First, in the optimal mechanism, the design of securities internalizes its effect on the equilibrium level of information acquisition. Although standard debt continues to be the optimal design, gains from trade may now be sacrificed to implement more information acquisition and better loan screening and vice-versa. Second, because in the optimal mechanism the market Zero Profit condition holds in expectation, there is room to exploit type-contingent transfers. In particular, I have shown that it is optimal to transfer all surplus to the high-type bank subject incentive compatibility constraints. These transfers improve the bank's incentives for information acquisition for any given retention level.

Figure 6 plots equilibrium debt levels and information acquisition for the optimal mechanism (commitment case) and the ex-post security design (no commitment) cases,

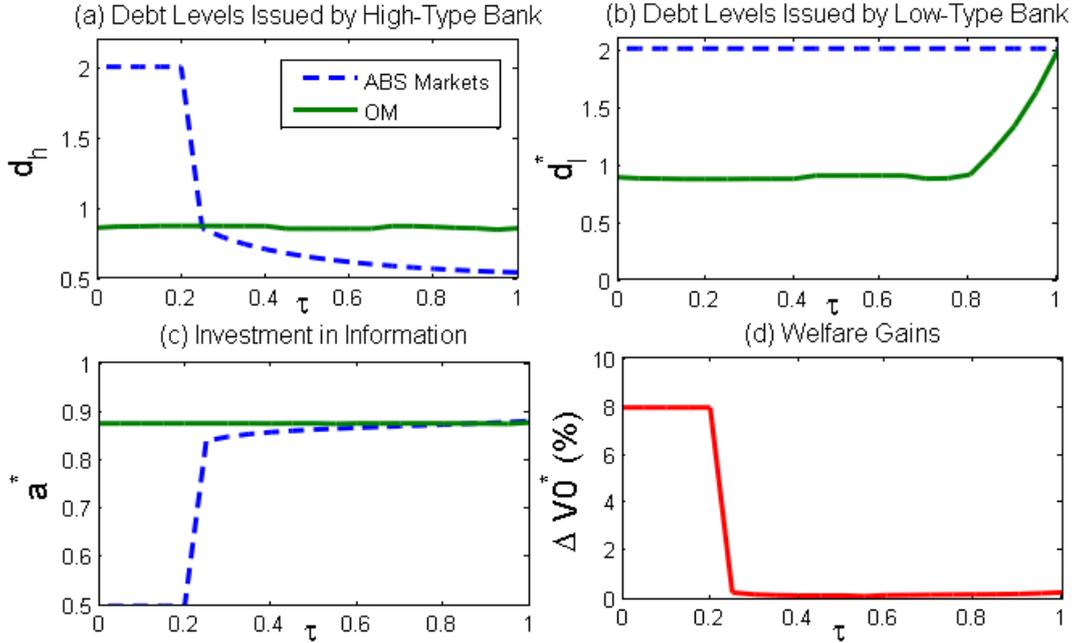


Figure 6: **Markets vs. Optimal Mechanism.**

The distribution of X is given by a truncated normal in $[0, 2]$ with $\mathbb{E}_H[X] = 1.2$, $\mathbb{E}_L[X] = 0.7$, $V_H[X] = V_L[X] = 0.2$ respectively for good and bad projects, $\pi_H = 0.5$, $\theta = 1.03$, and information costs are given by $C(a) = \chi(a - 0.5)^2 / (1 - a)$ for $\chi = 0.1$, $\tau(a) = 0.5 + \tau(a - 0.5)$

as a function of the sensitivity of the precision of private information to the quality of loan screening, captured by τ . The top panels plot debt levels issued by the high and low-type bank, while the bottom panel plots the equilibrium level of information acquisition, and the percentage gain in ex-ante welfare from implementing the optimal mechanism allocations. One of the insights of the paper is that the presence of adverse selection in secondary markets alleviates the problem of incentives for loan origination. When the quality of private information is low relative to the quality of screening (low τ), there is too much issuance in secondary markets and inefficiently low levels of information acquisition and loan screening. In particular, when $\tau = 0$, the *Bad Equilibrium* is the only possible equilibrium with no loan screening, and no retention of cashflows. In this case, the bank prefers to store. On the other hand, when adverse selection levels are high (higher τ), the high type-bank naturally chooses to retain cashflows, and thus the gains from implementing the optimal mechanism are much smaller. Therefore, gains from implementing the optimal mechanism are much larger for markets that exhibit high securitization levels. It is also important to note that, while the mechanism requires banks with low-quality

loans to retain less cashflows than those with high-quality loans, relative to what they would do in the market, the optimal mechanism is imposing “binding” retention levels to low-type banks, that would otherwise issue a full claim to their cashflows.

4.2 Policy Implications: Regulating Securitization

In this section I show that a simple tax scheme can implement the optimal mechanism and therefore improve ex-ante efficiency when market participants lack commitment. The policy prescriptions presented in this section are only necessary when there are no commitment tools available to the bank and to the market.

Proposition 6. [Implementation] *The Optimal Mechanism allocations can be decentralized with a tax scheme $\{\Gamma(F), \gamma(F)\}_{F \in \Delta}$ of lump-sum and marginal taxes respectively.*

In the Appendix, the proposition is proved by constructing a tax scheme that implements the optimal mechanism in decentralized markets. A question that arises when thinking about the implementation of the optimal mechanism is whether the No Transparency assumption should also hold for regulators. If we believe regulators have an advantage in monitoring retention levels, then it is easy to see that by imposing retention levels in different markets, and making transfers across markets the optimal mechanism should be easily implemented. Instead, I will continue to assume that retention cannot be enforced. In this scenario, the implementation becomes more complex. The regulator has two policy tools: lump-sum transfers on participation in different markets, and marginal taxes on issuance (debt) levels. The key finding is that when retention cannot be enforced, to deter the bad-type bank from issuing all of its cashflows certain markets for junior tranches need to be “closed.” This can be attained with lump-sum taxes that absorb all of the surplus generated by issuing in that market. In addition, marginal taxes on debt levels implement the desired level of issuance of the high-type bank. Due to the No Transparency, the low-type bank will mimic this issuance, and will issue remaining mezzanine tranches up to the optimal retention level of the optimal mechanism. The low-type is prevented from issuing more by high-participation taxes in the markets for more junior tranches.

In the optimal mechanism all available surplus is transferred ex-post to the high-type bank subject to incentive compatibility constraints, while markets pay the expected valuation of each security. Therefore, it is also necessary to make transfers across different

markets. In particular, a regulator would want to tax the participation in the market for mezzanine tranches and subsidize the issuance of senior tranches. The take-away from this implementation is that in the absence of tools to enforce retention, certain markets need to be "closed." This can be done directly, or by imposing high participation taxes. In addition, conditional on implementing the desired retention levels, there are gains from making transfers across markets that allow the high-type to be compensated by the illiquidity associated with holding a better loan.

Regulators in the US and in Europe are in the process of implementing risk retention rules for all issuers of asset-backed securities. The rules demand all securitizers to retain at least 5 percent of a risk exposure to the cashflows underlying the issued securities, with some exceptions in place. This intervention is usually referred to as the "Skin in the Game" rule and is suggested in the Dodd-Frank Act in the US, and by the EU Capital Requirements Directive (CRD) in Europe. These rules intent to deal with the misalignment of interest between loan originators and investors, believed to have contributed to the financial crash of 2008. The model presented in this paper is able to rationalize the demand of retention levels as a way to give incentives to improve loan screening standards. However, the model suggests that demanding the same retention levels to all issuers is, in general, inefficient. In particular, retention levels should be larger for issuers that claim to have good assets underlying their securities. Requesting the same retention for issuers that claim to have bad assets underlying makes it harder for high-type banks to separate themselves ex-post, reducing ex-ante incentives to screen loans. Furthermore, the model suggests that incentives are better provided when securitizers retain the first-lost piece (junior tranche) of the underlying assets, while the proposed regulation allows issuers to freely choose to which cashflows to be exposed to.²⁹

In addition, the model suggests that there are gains from subsidizing the issuance of senior tranches by taxing the issuance of junior ones. This type of policy is relatively easy to implement, but it has not been discussed in policy circles. Due to the presence of adverse selection in markets for securitized assets is introduced, transfers across issuers with different quality underlying affect incentives for loan screening, conditional on a retention level. Thus, the model suggests that regulators should not only focus on retention levels for securitizers but also on the way the market compensates good vs. bad issuers.

Finally, regulation on disclosure requirements and originators due diligence is also

²⁹Vertical slice, horizontal slice, originator's share, random selection of assets, or even exposure to assets that have the same underlying characteristics as the one backing the issued ABS.

being implemented. First, it is required that all information regarding the retention and risk exposure levels of originators/sponsors is made available to investors. Second, investors and potential investors need to have access to all material that is relevant to be able to assess the credit quality and performance of the assets underlying the issued securities, and all information that is necessary to perform stress-tests on the values of cashflows and collateral. It stands to reason that this type of regulation is beneficial if possible to fully implement. Giving easy access to all the information required to evaluate underlying cashflows would solve both the moral hazard and the adverse selection problem; retention of underlying cashflows would not be necessary. All policies that address the problem of asymmetric information between originators and investors are, in the environment described in this paper, welfare improving.

5 Conclusions

In this paper, I have proposed a parsimonious framework to study the role of securitization. The model incorporates some of the key features of this market, and it exploits the tension between incentives to acquire information to screen loans and liquidity in markets for securitized loans. Loan issuers acquire private information about borrower quality, and while this information is beneficial ex-ante when used to screen loans, it becomes detrimental ex-post as it hinders gains from trade/securitization. I have highlighted two inefficiencies introduced by the presence of securitization. First, the design of securities does not internalize its impact on the originator's incentives to screen good quality loans. Second, markets distort the originator's incentives by implicitly subsidizing issuers with bad loans backing their securities at the expense of those with good loans (lemon's problem). In the optimal mechanism, these problems are addressed by committing to the design of securities ex-ante and by the appropriate design of transfers across markets for different seniority tranches.

I show that the optimal mechanism can be decentralized with simple tax scheme when market participants lack commitment. In particular, subsidies to participation in the market for senior tranches, together with taxes for participation in the market for the junior tranches are beneficial since they improve incentives for information acquisition at no retention cost. This policy compensates banks with good loans for being mimicked by those with bad loans in secondary markets. These transfers together with policies that attain the desired retention levels implement second-best levels of information acquisition,

loan screening, and securitization. In particular, gains from policy intervention are larger in markets with high securitization levels.

The results of this paper shed light on the costs and benefits of policy proposals for securitization. The “Skin in the Game” rule requires issuers of asset-backed securities to retain a fraction of the underlying assets. My model rationalizes this type of intervention as a means to give incentives to improve loan screening only in markets with liquid secondary markets. The model further suggests that banks that claim to have good quality loans underlying their issuance should be required to retain more than those that claim to have bad quality loans. As a result, policies that demand the same retention levels of all issuers may impose excessive costs by hindering trade in secondary markets.

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6 Appendix

Markets for ABS: The No Commitment Case

Equilibrium in Secondary Markets and Security Design

Let I be the finite set of investors in the economy that compete by posting prices for feasible securities, and let $\{F, p\}$ denote the market where security F is bought at price p by at least one investor.

Lemma 1. *[Zero Profit Condition] In any equilibrium, investors must earn zero expected profits in each market.*

Proof. Assume not. Investor j is making positive profits in market $\{F, p_j\}$, and thus $p_j < \mathbb{E}_{\mu, a^e}[F(X)]$ and $p_i \leq p_j, \forall i \in I$ where p_i is the price other investors offer for security F . Let $\Pi > 0$ denote the investors aggregate profits in this market a note that one investor in I must be making no more than Π/I . Consider the deviation of this investor to open market $\{F, p_j - \epsilon\}, \epsilon > 0$. This market will attract the bank that was issuing in $\{F, p_j\}$. Since ϵ can be chosen to be arbitrarily low, this deviation yields the investor almost Π profits. Then, we must have $\Pi \leq 0$ in each market. Because investors cannot incur a loss in any equilibrium (it can always earn zero by posting price zero), all investors in fact earn zero profits. \square

Lemma 2. *[No Separation] Under the No Transparency Assumption, separating equilibria in secondary markets do not exist.*

Proof. Assume there is a separating equilibrium. Since $c > 0$, only two securities are issued in equilibrium. Let F_z be a security issued by the z -type bank in this equilibrium. Separation implies that $\mu(F_{z_h}) = 1$ and $\mu(F_{z_l}) = 0$. By the Zero-Profit Condition, the payoff to type z_l is given by $\theta p_{z_l} - \mathbb{E}[F_{z_l}(X)|z_l] = (\theta - 1) \mathbb{E}[F_{z_l}(X)|z_l]$. Investor j has a profitable deviation: to offer to buy security $H(X) = [F_{z_l}(X) - F_{z_h}(X)]^+$, at price $p = \mathbb{E}[H|z_l] - \epsilon$ for $\epsilon > 0$. By the incentive compatibility constraint, in any separating equilibrium $H(x) > 0$ on a set of positive measure. This market will attract the z_l -type bank, that will now issue $\{F_{z_h}, p(F_{z_h})\}$, and remaining cashflows $H = [F_{z_l} - F_{z_h}]^+$ at p , since for ϵ small enough this strategy generates a higher payoff: $\theta\{\mathbb{E}[F_{z_h}(X)|z_h] + \mathbb{E}[H(X)|z_l] - \epsilon\} - \mathbb{E}[F_{z_h}(X) + H(X)|z_l] > (\theta - 1) \mathbb{E}[F_{z_l}(X)|z_l]$. Then, investor j attracts the z_l -type bank, does not participate in any other market, and makes profits. Contradiction. \square

Lemma 3. *In any equilibrium in secondary markets,*

1. The z_h -type bank issues one security, $F_h \in \Delta$,
2. Market beliefs are given by $\mu(F_h) = \rho_h(a^e) < 1$.

Proof. (i) Assume that the z_h -type bank is issuing N securities: $F^1, F^2, \dots, F^N > 0$. By feasibility, it must be that $\sum_{n=1}^N F^n(x) \leq x, \forall x$, and investors make zero profits. By Lemma 1, market beliefs for these securities must be given by the unconditional probability assigned to being a z_h -type bank, i.e. $\mu(F^1) = \dots = \mu(F^N) = \rho_h(a^e)$ (No Separation). Consider the following deviation for an investor j . Post price $p(F_h) = \mathbb{E}_{a^e, \mu}[F_h(X)] - \epsilon$ for security $F_h(X) \equiv \sum_{n=1}^N F^n(X)$, where $c > \epsilon > 0$ and $\mu(F_h) = \rho_h(a^e)$. The z_h -type bank strictly prefers to issue F_h since $c > \epsilon$. (ii) Note that this is a profitable deviation for investor j for $\epsilon > 0$. Note that the z_l -type bank also prefers to issue F_h to avoid paying multiple $c > 0$, and thus $\mu(F_h) = \rho_h(a^e)$ in equilibrium. \square

Lemma 4. *Let $F_h \in \Delta$ be the security issued by z_h -type bank in equilibrium. In any equilibrium in secondary markets,*

1. Junior tranches $F_J(X) \equiv X - F_h(X)$ are sold by the z_l -type bank,
2. Market beliefs are given by $\mu(F_J) = 0$

Proof. (i) Let security F_J be defined as $F_J(X) \equiv X - F_h(X)$. When $F_h(X) = X$ the Lemma is trivial. Let $F_h(X) \neq X$. By Lemma 1, the z_l -type bank issues F_h as well. The lowest price an investor will post for the remaining cashflows is $p_J = E[F_J(X)|z_l]$. Since there are positive gains from trade, the low type bank will always issue F_J : $(\theta - 1)E[F_J(X)|z_l] > 0$. (ii) By construction only the z_l -type bank issues F_J , $\mu F_J = 0$. \square

For the following proofs, let

$$\Pi_{z_h}(a, a^e, F) \equiv \theta \mathbb{E}_{a^e, \mu}[F(X)] - \mathbb{E}_a[X - F(X)|z_h] \quad (20)$$

denote the value of banking for the z_h -type bank with information acquisition a , and market beliefs a^e .

Lemma 5. *Assume there exists $F^* \in \Delta$, s.t. $\Pi_{z_h}(a, a^e, F^*) = \sup_{F \in \Delta} \Pi_{z_h}(a, a^e, F)$. Then, in any equilibrium in secondary markets, for given information acquisition a and market beliefs a^e , the z_h -type bank issues security $F_h \in \arg \sup_{F \in \Delta} \Pi_{z_h}(a, a^e, F)$.*

Proof. Assume the z_h -type is issuing $F_h \in \Delta$ with $\Pi_{z_h}(a, a^e, F_h) < \Pi_{z_h}(a, a^e, F^*)$. By previous Lemmas: $\mu(F_h) = \rho(a^e)$ and the security is priced by the zero-profit condition. Consider the following deviation for an investor j : offer price $p(F^*) = \mathbb{E}_{a^e, \mu}[F^*(X)] - \frac{\epsilon}{\theta}$, $\epsilon > 0$, for security F^* , with $\mu(F^*) = \rho_h(a^e)$. This attracts the z_h -type bank, since $\theta \mathbb{E}_{a^e, \mu}[F^*(X)] - \mathbb{E}_a[F^*(X)|z_h] - \epsilon > \theta \mathbb{E}_{a^e, \mu}[F_{z_h}(X)] - \mathbb{E}_a[F_{z_h}(X)|z_h]$ for ϵ small enough and the investor makes profits. Contradiction. \square

Lemma 6. *In any equilibrium in secondary markets, the z_h -type bank issues standard debt. In particular, $F^* \in \arg \sup_{F \in \Delta} \Pi_{z_h}(a, a^e, F)$ exists, it is unique, and it is given by $F^*(X) = \min\{d(a, a^e), X\}$ where*

$$d(a, a^e) \in \arg \max_d \theta \mathbb{E}_{a^e, \mu}[\min\{d, X\}] - \mathbb{E}_a[\min\{d, X\}|z_h] \quad (21)$$

Proof. We are interested in finding $F_h \in \arg \sup_{F \in \Delta} \theta \mathbb{E}_{a^e, \mu}[F(X)] - \mathbb{E}_a[F(X)|z_h]$. By the law of iterated expectations, market valuation of security F can be written as

$$\begin{aligned} \mathbb{E}_{a^e, \mu}[F(X)] &= \rho_h(a^e) \mathbb{E}_{a^e}[F(X)|z_h] + (1 - \rho_h(a^e)) \mathbb{E}_{a^e}[F(X)|z_l] = \rho(a^e) [\mathbb{E}_H[F(X)] - \mathbb{E}_L[F(X)]] + \mathbb{E}_L[F(X)] \\ \mathbb{E}_a[F(X)|z_h] &= \pi_h(a) [\mathbb{E}_H[F(X)] - \mathbb{E}_L[F(X)]] + \mathbb{E}_L[F(X)] \end{aligned}$$

With this, the problem can be re-written as follows:

$$\max_{F \in \Delta} (\theta \rho(a^e) - \pi_h(a)) [\mathbb{E}_H[F(X)] - \mathbb{E}_L[F(X)]] + (\theta - 1) \mathbb{E}_L[F(X)]$$

For $\theta \rho(a^e) \geq \pi_h(a)$, the value of the z_h -type bank is increasing in the cashflows of F , and thus $F_h^*(X) = X$. In this case, we say the bank issues standard debt with $d = \infty$. For $\theta \rho(a^e) < \pi_h(a)$, the z_h -type faces adverse selection since it values cashflows more than the market. Let G be any feasible security, and let $g \equiv \mathbb{E}_a[G(X)|z_h]$ and $g_m \equiv \mathbb{E}_{a^e, \mu}[G(X)]$, denote the private and the market valuations respectively. Now consider a standard debt security $F_D(X) = \min\{d, X\}$. Let $f \equiv \mathbb{E}_a[\min\{d, X\}|z_h]$ and $f_m \equiv \mathbb{E}_{a^e, \mu}[\min\{d, X\}]$. Given the continuity of f_m on d , pick d so that $g_m = f_m = \mathbb{E}_{a^e, \mu}[\min\{d, X\}]$. Let $H = G - F$ where $\mathbb{E}_{a^e, \mu}[H(X)] = 0$ by construction. Given the monotonicity of G , and the fact that $G(x) \leq x$, $\exists x^*$ s.t. $H(x) > 0$ iff $x > x^*$. By FOSD due to $\rho(a^e) < \pi_h(a)$, $\mathbb{E}_a[H(X)|z_h] > \mathbb{E}_{a^e, \mu}[H(X)] = 0$. Thus, $g = f + h > f$, and then $\Pi_{z_h}(a, a^e, G) < \Pi_{z_h}(a, a^e, F)$. Because G was arbitrary, the optimal security preferred by the z_h -type is standard debt. Debt level d is chosen to $\max_d \theta \mathbb{E}_{a^e, \mu}[\min(d, X)] - \mathbb{E}_a[\min(d, X)|z_h]$, where the solution to this exists and is unique (where $d = \infty$ is an admissible solution). \square

Thus, investors post price $p(F_D) = \mathbb{E}_{a^e, \mu}[\min\{d(a^e, a^e), X\}]$ for debt level given by

$d(a^e, a^e)$ as defined in previous Lemma, since they cannot observe a . In what follows, to characterize equilibrium debt levels, I may impose the equilibrium condition $a = a^e = a^*$.

Lemma 7. *Let a^* be the equilibrium level of information acquisition. When $\tau'(a) > 0$, for any $\theta > 1$, $\exists \underline{a}(\theta), \bar{a}(\theta) \in [\frac{1}{2}, 1]$ s.t. $\forall a \in [\frac{1}{2}; \underline{a}(\theta)] \cup [\bar{a}(\theta), 1]$ equity is the only security issued in secondary markets. Moreover, $\underline{a}(\theta)$ ($\bar{a}(\theta)$) is increasing (decreasing) in funding needs θ .*

Proof. By Lemma 6, equity is issued when $\theta\rho(a) \geq \pi_h(a)$. i) Existence of $\underline{a}(\theta)$. For $a = \frac{1}{2}$, both signals are uninformative, and thus $\rho(a) = \pi_h(a) = \pi_H$; the constraint is satisfied since $\theta > 1$. Using continuity and monotonicity of the RHS on a , the inequality must hold in an interval close to $a = \frac{1}{2}$, given by $[\frac{1}{2}; \underline{a}(\theta)]$. To see that the threshold is increasing, note that higher θ makes the constraint less binding. ii) Existence of $\bar{a}(\theta)$. Note that for $a = 1$, both signals are fully informative, and thus the initial screening excludes all bad firms, i.e. $\rho(1) = 1$, and thus the constraint is again satisfied for any $\theta > 1$. Again by continuity and monotonicity of the RHS on a , the constraint must hold for an interval close to $a = 1$, denoted by $[\bar{a}(\theta), 1]$. To see that $\bar{a}(\theta)$ is decreasing in θ , note that the constraint is again less binding for higher θ . By Lemma 1, the z_l -type also issues equity. \square

Lemma 8. *For any beliefs, a^e , function $d(\cdot, a^e) : [\frac{1}{2}, 1] \rightarrow \mathbb{R}^+$ is decreasing, continuous and differentiable.*

Proof. Function $d(\cdot, a^e)$ arises from FOC:

$$\frac{\pi_h(a) - \theta\rho(a^e)}{\theta - 1} = \frac{1}{\frac{1-G_H(d)}{1-G_L(d)} - 1} \quad (22)$$

- i) The RHS is continuous, differentiable, and decreasing in d . This follows from the MLRP, that implies a hazard rate ordering and thus $\frac{1-G_H(X)}{1-G_L(X)}$ is increasing in X , the continuity and differentiability are given by the continuity and differentiability of the cumulative distributions.
- ii) The LHS is continuous, differentiable, and increasing in a . This follows from $\pi_h(a)$ being continuous, differentiable, and increasing in a . Therefore, there exists an implicit function $d(a, a^e)$ that is continuous, differentiable, and decreasing in a . \square

Proposition 1. *Let a^* denote the equilibrium level of information acquisition. Under the No Transparency Assumption, in any equilibrium in secondary markets:*

1. The z_h -type bank issues standard debt $F_D^* = \min \{d(a^*, a^*), X\}$ where $d(a^*, a^*)$ is given by (22), at price $p_D^* = \mathbb{E}_{a^*, \mu} [\min \{d(a^*, a^*), X\}]$.
2. The z_l -type bank issues standard debt F_D and junior tranche $F_J^*(X) = X - F_D^*(X)$ at prices p_D^* and $p_J^* = \mathbb{E}_{a^*} [X - \min \{d(a^*, a^*), X\} | z_l]$.

Off-Equilibrium Beliefs and Existence of an Equilibrium in Secondary Markets. It is left to determine how to price the securities not issued in equilibrium. The following beliefs support an equilibrium in secondary markets. For all $G \in \Delta$ different than standard debt, $\mu(G) = 0$. Now, we are left with a set:

$$\Delta_D = \{F \in \Delta : \exists d \in \mathbb{R}^+ \text{ s.t. } F(X) = \min \{d, X\}\}$$

Then, for $G \equiv \min \{d, X\} \in \Delta_D$ s.t. $d \leq d(a^*, a^*)$, $\mu(G) = \rho_h(a^e)$ and $\mu(G) = 0$ otherwise. That is, securities different than debt and debt securities with higher debt levels than the ones issued by the high-type in equilibrium are assigned low valuations; debt securities with lower debt levels than the one issued by the z_h -type in equilibrium are evaluated at average valuations. Note that for given a^e , the market posts the described menu, and by construction there are no profitable deviations for the market. The bank chooses which security to issue, given the posted menu, and thus there is no room for signaling, the bank has access to the whole set of securities in Δ and issues the one that maximizes the value of banking in $t = 0$.

Given this off-equilibrium beliefs, I characterize the optimal security design in secondary markets when agents deviate from the equilibrium level of information acquisition a^* , since this will be important when the bank chooses ex-ante how much information to acquire. Let $a^* = a^e$ be the equilibrium level of information acquisition and assume that the bank has deviated to $a \neq a^*$.

(A) Let $a > a^e$. We have that $\pi_h(a) - \theta\rho(a^e) > \pi_h(a^*) - \theta\rho(a^*)$, and thus the high-type bank faces an even stronger adverse selection problem in secondary markets. Everything else equal, debt continues to be the optimal security design since the same arguments apply. In addition, from Lemma 8, we know the z_h -type bank would like to issue a lower debt level, and thus $d(a, a^*) < d(a^*, a^*)$. Since there are no change in beliefs for issuing lower debt levels than in equilibrium, the FOC that determined $d(a, a^*)$ continues to be valid, and the bank therefore maximizes its interim value by issuing $\min \{d(a, a^e), X\}$ at average valuations and retaining the rest. As for the z_l -type bank, his optimal strategy is

still to issue $F_D^*(X) = \min \{d(a^*, a^*), X\}$ at average valuations and $F_J^*(X) = X - F_D^*(X)$ at low valuations. It is straightforward that deviating with the z_h -type bank to a lower debt issuance would reduce its interim value. Therefore, increasing a implies a lower debt issuance in secondary markets for the high-type bank.

(B) Let $a < a^e$. We have that $\pi_h(a) - \theta\rho(a^e) < \pi_h(a^*) - \theta\rho(a^*)$, and thus the z_h -type bank faces “less” adverse selection in secondary markets. Due to the presence of adverse selection, debt continues to be the optimal design. From Lemma 8, the high-type bank would want to increase its debt issuance. However, for $d > d(a^*, a^*)$, off-equilibrium beliefs are given by $\mu = 0$, and thus the FOC no longer applies. Given the No Transparency assumption, it is easy to see that the z_h -type bank would prefer to issue $F_D^* = \min \{d(a^*, a^*)\}$ at average valuations, and if there are still gains from issuing cashflows at low valuation, extra cashflows will be issued. That is, equilibrium tranche F_D^* continues to be issued at average valuation, and in addition the high-type bank may issue mezzanine tranche $F_M = \min \{\bar{d} - d(a^*, a^*), 0\}$ where

$$\bar{d} = \arg \max_d \theta E_{a^*} [\min \{d, X - F_D^*(X)\} | z_l] - \theta E_a [\min \{d, X - F_D^*(X)\} | z_h]$$

If $\bar{d} = 0$, then the high-type bank does not issue additional tranches. As argued before, the low type has no incentives to deviate from its optimal secondary market strategy. Therefore, decreasing a may or may not affect the secondary market equilibrium outcomes (the discrete jump in beliefs and thus valuations generates an inaction region where the high type bank does not change its strategy). In principle, large deviations to lower a levels may justify the issuance of new tranches at low valuation. In the extreme case of deviating to $a = 0.5$, for example, it is easy to see that now both bank types will issue F_D^* and F_J^* ; on the other hand, deviating to $a = a^* - \epsilon$ for $\epsilon > 0$ small would not change outcomes since $\bar{d} = 0$; thus, the high-type would issue F_D^* and retain remaining cashflows while low-type would issue both F_D^* and F_J^* .

Choice of Information Acquisition

Given the previously constructed equilibrium outcome in secondary markets, I now focus on the choice of information acquisition done by the bank in $t = 0$, where the bank cannot affect market beliefs a^e . Given the off-equilibrium strategies previously defined, the bank’s expected utility in $t = 0$ is given by:

$$\begin{aligned}
V_0(a, a^e) &\equiv \rho_h(a) [\theta p(F_D(a, a^e)) + \mathbb{E}_a[X - F_D(a, a^e)(X) | z_h]] \mathbb{I}_{\{d(a, a^e) \leq d(a^e, a^e)\}} + \dots \\
&\quad \rho_h(a) [\theta p(F_D^*) + \mathbb{E}_a[X - F_D^*(X) | z_h]] + \dots \\
&\quad \rho_h(a) \max_d \{\theta E_{a^*}[\min\{d, X - F_D^*(X)\} | z_l] - \theta E_a[\min\{d, X - F_D^*(X)\} | z_h]\} \mathbb{I}_{\{d(a, a^e) > d(a^e, a^e)\}} + \dots \\
&\quad (1 - \rho_h(a)) [\theta p(F_D^*) + p(F_J^*)] - C(a)
\end{aligned}$$

where $F^* = F(a^e, a^e)$ is used to save on notation. Note that we can use the Envelope Condition to abstract from the impact a has on the choice of security $F(a, a^e)$ ex-post, since securities are chosen ex-post to maximize the value of the bank in $t = 1$. By taking FOC and imposing the equilibrium condition $a = a^e$ we obtain:

$$\begin{aligned}
\rho_h(a) \frac{\partial \mathbb{E}_a[X - F_D(a, a) | z_h]}{\partial a} + \rho'_h(a) \{\theta p(F_D(a, a)) + \mathbb{E}_a[X - F_D(a, a) | z_h] - \theta(p(F_D(a, a)) + p(F_J(a, a)))\} &= C'(a) \\
\rho_h(a) \frac{\partial \mathbb{E}_a[\max\{X - d(a, a), 0\} | z_h]}{\partial a} + \rho'_h(a) \{\mathbb{E}_a[\max\{X - d(a, a), 0\} | z_h] - \theta \mathbb{E}_a[\max\{X - d(a, a), 0\} | z_l]\} &= C'(a)
\end{aligned}$$

For a given a^e , there exists a cost function convex enough so that $V_0(a, a^e)$ is concave. In other words, for a given a^e , the $SOC < 0$ for convex enough costs. Therefore, I focus on cases for which the cost of information acquisition is such that for a given a^e there exists a unique level of information acquisition a as a result. To see this, note that the SOC at the optimum ($a = a^e$) can be made negative for $C''(\cdot)$ large enough:

$$\begin{aligned}
\rho'_h(a) \frac{\partial \mathbb{E}_a[X - F_D(a, a) | z_h]}{\partial a} + \rho_h(a) \frac{\partial^2 \mathbb{E}_a[X - F_D(a, a) | z_h]}{\partial a^2} + \dots \\
+ \rho''_h(a) \{\theta p(F_D(a, a)) + \mathbb{E}_a[X - F_D(a, a) | z_h] - \theta(p(F_D(a, a)) + p(F_J(a, a)))\} - C''(a) < 0
\end{aligned}$$

Equilibria With Information Acquisition. In what follows, I characterize the equilibria with information acquisition of this economy, that requires $a = a^e$. For an equilibrium with information acquisition to exist, the value to the bank in such equilibrium should be larger than that of storage. For this characterization, let $\tau(a) = 0.5 + \tau(a - 0.5)$. The linear approximation is done for simplicity, what will be important is the sensitivity of private information to the information acquisition done at loan screening: $\tau'(a)$.

Proposition 2. *When $\tau > 0$, at most three equilibria can arise.*

Proof. To show this, it suffices to characterize the first order condition for information acquisition

tion in equilibrium:

$$\begin{aligned} & \rho_h(a) \pi'_H(a) [\mathbb{E}_H[\max\{X - d(a, a), 0\}] - \mathbb{E}_L[\max\{X - d(a, a), 0\}]] + \dots \\ & \rho'_h(a) \{\mathbb{E}_a[\max\{X - d(a, a), 0\} | z_h] - \theta \mathbb{E}_a[\max\{X - d(a, a), 0\} | z_l]\} = C'(a) \end{aligned}$$

First, for any a^e , the SOC is satisfied. By assumption, $C'(a)$ is increasing in a , with $\lim_{a \rightarrow 1} C'(a) = \infty$ and $\lim_{a \rightarrow \frac{1}{2}} C'(a) = 0$. Let $LHS(a)$ denote the left-hand side of the previous equation. The non-monotonicity of debt levels on equilibrium levels of information acquisition, that only arises for $\tau > 0$, will result in a non-monotonicity of the $LHS(a)$ with respect to a :

(a) There exists $\underline{a} > \frac{1}{2}$ such that $LHS(a) = 0$ for all $a \in [\frac{1}{2}, \underline{a}]$. From Lemma 7, there exists an interval to the right of $a = \frac{1}{2}$ where $d(a, a) = \infty$ (where the high type bank issues equity). Therefore, it is straightforward that when retention of cashflows $\max\{X - d, 0\}$ is zero, the marginal benefit of acquiring information is also zero: $LHS(a) = 0$, $\forall a \in [\frac{1}{2}, \underline{a}]$. Since $C'(\frac{1}{2}) = 0$, there always exists an equilibrium with no information acquisition where $a_B = \frac{1}{2}$, $d_B = \infty$. I call this the Bad Equilibrium.

(b) For a broad range of parameter values, the $LHS(a)$ will be positive for $a \in (\underline{a}, \bar{a})$ when $\underline{a} < \bar{a}$. Given the continuity and differentiability of the LHS with respect to a , there exists $a_M \in (\underline{a}, \bar{a})$ such that $LHS'(a) \geq 0$ for a positive measure of $a \in (\underline{a}, a_M)$ and $LHS'(a) \leq 0$ for a positive measure of $a \in (a_M, \bar{a})$. Therefore, we have two options. Either $LHS(a) \neq C'(a)$ for all $a > \frac{1}{2}$, in which case there is no equilibrium with information acquisition, or $LHS(a) = C'(a)$ for two different levels of information acquisition a_L, a_H , with $\frac{1}{2} < a_L < a_H < 1$. The point a_L is given by the crossing point where the LHS line crosses $C'(a)$ from below, and the second one when it crosses it from above. Note that $a_L = a_H$ for the unique case in which the marginal cost is tangential to the LHS curve. Therefore, there are two possible equilibria with information acquisition, that arise for a broad range of parameter values. The Low Information Acquisition Equilibrium, with $a_L, d_L = d(a_L, a_L) < \infty$ and the High Information Acquisition Equilibrium with $a_H, d_H = d(a_H, a_H) < \infty$. Since $a_H > a_L$, it must be that $d_H < d_L$. This is because conditional on a retention level, higher market beliefs reduce incentives for information acquisition, so to implement a higher level of information acquisition, $a_H > a_L$, with higher market beliefs, $a_H > a_L$, it has to be that the high type bank is retaining more cashflows in secondary markets in that equilibrium; that is, $d_H < d_L$. So the Low equilibrium features high levels of trade and low quality of loan screening, while the High Equilibrium features lower trade levels and higher levels of information acquisition. □

The Optimal Mechanism: The Case of Commitment.

The following Lemmas fully characterize the truth-revelation mechanism $\{F_h, F_l, p_h, p_l, a^*\}$ that maximizes ex-ante efficiency.

Lemma 9. *In any optimal mechanism, the z_l -type bank issues standard debt, $F_l = \min\{d_l, X\}$.*

Proof. Plugging in the binding zero-profit condition, the problem can be re-written as follows:

$$\max (\theta - 1) \{ \rho_h(a^*) E[F_h(X) | z_h] + (1 - \rho_h(a^*)) E[F_l(X) | z_l] \} + E[X] - C(a^*)$$

$$\theta p_h - E[F_h(X) | z_l] \leq \theta p_l - E[F_l(X) | z_l] \quad (IC_l)$$

$$\theta p_l - E[F_l(X) | z_h] \leq \theta p_h - E[F_h(X) | z_h] \quad (IC_h)$$

$$\phi_h(a^*) [E_H[X - F_h(X)] - E_L[X - F_h(X)]] + \phi_l(a^*) [E_H[X - F_l(X)] - E_L[X - F_l(X)]] - C'(a^*) = 0 \quad (IC_a)$$

$$p_l - \frac{\rho_h(a^*)}{1 - \rho_h(a^*)} (\mathbb{E}[F_h(X) | z_h] - p_h) + \mathbb{E}[F_l(X) | z_l] = 0 \quad (PC_{Inv})$$

Let $\{p_l^*, p_h^*, F_h^*, F_l^*, a^*\}$ be an optimal mechanism where $F_l^* = G$ is an arbitrary $G \in \Delta$, with cashflows $v(X)$, different than standard debt. Let $D_l(X) = \min\{d_l, X\}$ and choose d_l so that the $E[\min\{d_l, X\} | z_l] = E[G(X) | z_l]$. Let $H(x) \equiv G(x) - D_l(x)$, and let $h(z) = E_{a^*}[H(X) | z]$. By construction, $h(z_l) = 0$. Since $v(x) \leq x$, $H(x) > 0 \iff x \geq x^*$ for some $x^* \in \mathbb{X}$, and thus $h(z_h) > h(z_l) = 0$, which implies that:

$$E_H[G(X) - D_l(X)] > E_L[G(X) - D_l(X)]$$

$$E_H[X - D_l(X) - [X - G(X)]] > E_L[X - D_l(X) - [X - G(X)]]$$

$$E_H[X - D_l(X)] - E_L[X - D_l(X)] > E_H[X - G(X)] - E_L[X - G(X)]$$

Now, from the (IC_a) , we know that security D_l implements a weakly higher level of information acquisition, since $\phi_l(a^*) \geq 0$ for any a^* . Thus, pick new feasible security $D'_l = \min\{d'_l, X\}$, and choose d'_l so that:

$$E_H[X - D'_l(X)] - E_L[X - D'_l(X)] = E_H[X - G(X)] - E_L[X - G(X)]$$

and thus security D'_l implements the same level of information acquisition a^* . Due to the MLRP, it must be that $d'_l > d_l$. Now, from (PC_{Inv}) , if we leave p_h constant, the new p'_l satisfies $\theta p'_l - E[D'_l(X) | z_l] > \theta p_l - E[F_l(X) | z_l]$, and thus the (IC_l) is relaxed. Also note that $\theta p'_l - E[D'_l(X) | z_h] < \theta p_l - E[F_l(X) | z_h]$ since $\Delta p_l = E[D'_l(X) | z_l] - E[F_l(X) | z_l] < E[D'_l(X) | z_h] - E[F_l(X) | z_h]$, and thus the (IC_h) is relaxed. Finally, since $E[D'_l(X) | z_l] >$

$E[F_l(X) | z_l]$, mechanism $\{p'_l, p_h^*, F_h^*, D'_l, a^*\}$ attains higher welfare. Contradiction. Since G was an arbitrary feasible security, it must be that $F_l = \min\{d_l, \infty\}$ for some $d_l \in [0, \infty]$. \square

Corollary 1. *In any optimal mechanism, when $\phi_l(a^*) = 0$, the z_l -type bank issues equity, i.e. $F_l(X) = X$.*

Proof. Note from the previous proof that when $\phi_l(a^*) = 0$, increasing debt level d_l relaxes all of the constraints and increases welfare. Therefore, in the optimal mechanism, $d_l = \infty$. \square

Lemma 10. *In any optimal mechanism, the z_h -type bank issues standard debt, $F_h(X) = \min\{d_h, X\}$.*

Proof. Assume not. Then, there exists an optimal mechanism $\{p_l^*, p_h^*, F_l^*, F_h^*, a^*\}$ where $F_h^* = G$ is an arbitrary $G \in \Delta$, with cashflows $v(X)$, different than standard debt. Let $D_h(X) = \min\{d, X\}$ and choose d_h so that $\mathbb{E}[G(X) | z_h] = \mathbb{E}[D_h(X) | z_h]$. Let $H(X) = G(X) - D_h(X)$. Note that since $v(X) \leq X$, $H(x) > 0$ iff $x \geq x^*$ for some $x^* \in \mathbb{X}$. Therefore, given the MLRP,

$$\begin{aligned} \mathbb{E}_H[H(X)] - \mathbb{E}_L[H(X)] &> 0 \\ \mathbb{E}_H[G(X)] - \mathbb{E}_L[G(X)] &> \mathbb{E}_H[D_h(X)] - \mathbb{E}_L[D_h(X)] \\ \mathbb{E}_H[X - G(X)] - \mathbb{E}_L[X - G(X)] &< \mathbb{E}_H[X - D_h(X)] - \mathbb{E}_L[X - D_h(X)] \end{aligned}$$

And thus, standard debt $D_h = \min\{d_h, X\}$ implements a higher level of information acquisition since $\phi_h(a^*) > 0$. Thus, pick security $D'_h = \min\{d'_h, X\}$, where d'_h is chosen so that:

$$E_H[X - \min\{d'_h, X\}] - E_L[X - \min\{d'_h, X\}] = E_H[X - G(X)] - E_L[X - G(X)]$$

so that security D'_h implements the same level of information acquisition a^* . Due to the MLRP, it must be that $d'_h > d_h$. Now choose transfers p'_l and p'_h to make the (IC_l) and (PC_{Inv}) bind, and note that $E[\min\{d'_h, X\} | z_h] > E[\min\{d_h, X\} | z_h] = E[G(X) | z_h]$. By the previous Lemma, we know that $F_l = \min\{d_l, X\}$ for some debt level $d_l \in [0, \infty]$. Case A. If $d'_h \leq d_l$, then the (IC_h) is also satisfied, and mechanism $\{p'_l, p'_h, F_l^*, D'_h, a^*\}$ attains higher welfare. Contradiction. Case B. If $d'_h > d_l$, (IC_h) could be violated. For this case, choose securities $D'_h = D'_l = \min\{d, X\}$, and choose debt level d so that:

$$(\phi_h(a^*) + \phi_l(a^*)) [E_H[X - \min\{d, X\}] - E_L[X - \min\{d, X\}]] - C'(a^*) = 0$$

the same level of information acquisition a^* is implemented. The term $E_H[X - \min\{d, X\}] - E_L[X - \min\{d, X\}]$ is decreasing and continuous in d , which implies that $d_h < d < d'_h$ and $d_l < d$:

$$\phi_h(a^*)[E_H[X - \min\{d_l, X\}] - E_L[X - \min\{d_l, X\}]] + \phi_l(a^*)[E_H[X - \min\{d'_h, X\}] - E_L[X - \min\{d'_h, X\}]] - C'(a^*) = 0$$

with $\phi_h(a^*) > 0, \phi_h(a^*) \geq 0$. Choose transfers p'_l, p'_h to make (IC_l) and (PC_{Inv}) bind, and note that the (IC_h) is satisfied. Finally, since $E[\min\{d, X\} | z_l] > E[\min\{d_l, X\} | z_l]$ and $E[\min\{d, X\} | z_h] > E[\min\{d_h, X\} | z_h] = E[G(X) | z_h]$, mechanism $\{p'_l, p'_h, D'_l, D'_h, a^*\}$ implements the same level of information acquisition and attains higher welfare. Contradiction. Since G was chosen arbitrarily from the set of feasible securities Δ , it must be that in the optimal mechanism, $F_h^* = \min\{d_h, X\}$ for some optimal debt level $d_h \in [0, \infty]$. □

Lemma 11. *The z_l -type bank issues standard debt with $d_h \leq d_l < \infty$.*

Proof. We know that both bank types will issue standard debt. Combining the (IC_l) and (IC_h) , we obtain the following condition:

$$\begin{aligned} \mathbb{E}[\min\{d_l, X\} | z_h] - \mathbb{E}[\min\{d_h, X\} | z_h] &\geq \theta(p_l - p_h) \geq \mathbb{E}[\min\{d_l, X\} | z_l] - \mathbb{E}[\min\{d_h, X\} | z_l] \\ \Rightarrow \mathbb{E}[\min\{d_l, X\} | z_h] - \mathbb{E}[\min\{d_l, X\} | z_l] &\geq \mathbb{E}[\min\{d_h, X\} | z_h] - \mathbb{E}[\min\{d_h, X\} | z_l] \end{aligned}$$

which requires $d_l \geq d_l$ since

$$\frac{\partial}{\partial d} [\mathbb{E}[\min\{d, X\} | z_h] - \mathbb{E}[\min\{d, X\} | z_l]] = \int_d^\infty [f(x|z_h) - f(x|z_l)] dx > 0$$

□

Lemma 12. *In any optimal mechanism, the incentive compatibility for the z_l -type bank binds; that is, $\theta p_l - \mathbb{E}_a[F_l(X) | z_l] = \theta p_h - \mathbb{E}_a[F_h(X) | z_l]$.*

Proof. Assume it does not. Then, there exists an optimal mechanism $\{p_h^*, p_l^*, F_h^*, F_l^*, a^*\}$ s.t.

$$\theta p_l^* - \mathbb{E}_{a^*}[F_l^*(X) | z_l] > \theta p_h^* - \mathbb{E}_{a^*}[F_h^*(X) | z_l]$$

This mechanism maximizes the bank's ex-ante utility, which given the investors zero profit condition is given by:

$$V_0^* = (\theta - 1) [\rho(a^*) E_{a^*}[F_h^*(X) | z_h] + (1 - \rho(a^*)) E_{a^*}[F_l^*(X) | z_l]] + E_{a^*}[X] - C(a^*)$$

Define new transfers:

$$\begin{aligned} p'_l &= p_l^* - \epsilon \left(\frac{1 - \rho(a^*)}{\rho(a^*)} \right) & p'_h &= p_h + \epsilon \left(\frac{1 - \rho(a^*)}{\rho(a^*)} \right) \\ & \Rightarrow p'_h - p'_l &= p_h^* - p_l^* &+ 2\epsilon \left(\frac{1 - \rho(a^*)}{\rho(a^*)} \right) \end{aligned}$$

where $\epsilon > 0$. If the (IC_l) is slack, $d_l > d_h$ (if both bank types issue the same security, truth-telling requires $p_l = p_h$, and (IC_l) binds). Plugging in the new transfers into the (IC_a) constraint, we get:

$$\begin{aligned} & \rho'(a^*) \left\{ \theta(p_h^* - p_l^*) + 2\theta\epsilon \left(\frac{1 - \rho(a^*)}{\rho(a^*)} \right) + E_{a^*}[X - F_h^*(X) | z_h] - E_{a^*}[X - F_l^*(X) | z_l] \right\} + \\ & \rho(a^*) \pi'_h(a^*) [E_H[X - F_h^*(X)] - E_L[X - F_h^*(X)]] + (1 - \rho(a^*)) \pi'_l(a^*) [E_H[X - F_l^*(X)] - E_L[X - F_l^*(X)]] - C(a^*) > 0 \end{aligned}$$

Define a new security $F_h^\epsilon(\cdot) = \min\{d_h + \epsilon, X\}$ and choose $\epsilon > 0$ small to not violate the (IC_l) , i.e. $d_h + \epsilon < d_l$ and find ϵ so that the FOC wrt a is not affected:

$$\begin{aligned} & \rho'(a^*) \left\{ \theta \left(p_h - p_l + 2\epsilon \left(\frac{1 - \rho(a^*)}{\rho(a^*)} \right) \right) + E_{a^*}[X - F_h^\epsilon(X) | z_h] - E_{a^*}[X - F_l^*(X) | z_l] \right\} + \\ & \rho(a^*) \pi'_h(a^*) [E_H[X - F_h^\epsilon(X)] - E_L[X - F_h^\epsilon(X)]] + (1 - \rho(a^*)) \pi'_l(a^*) [E_H[X - F_l^*(X)] - E_L[X - F_l^*(X)]] - C(a^*) = 0 \end{aligned}$$

It is straightforward that the LHS is increasing and continuous on ϵ and decreasing and continuous on $\epsilon > 0$, since $E_H[\min\{d, X\}] - E_L[\min\{d, X\}]$ is increasing in d (as shown in the previous Lemma). Thus $\exists \epsilon > 0$ that allows to implement the same level of information acquisition for security F_h^ϵ . Therefore, mechanism $\{p'_h, p'_l, F_h^\epsilon, F_l, a^*\}$ implements the same levels of information acquisition as the optimal one. In addition, we know that $E[F_h^\epsilon(X) | z_h] > E[F_h(X) | z_h]$. Finally, take the extra funds raised in the market: $\phi \equiv \rho(\tilde{a}) \{E[F_h^\epsilon(X) | z_h] - E[F_h(X) | z_h]\}$ and split them evenly to both bank types: $p''_h = p'_h + \frac{\phi}{2}$ and $p''_l = p'_l + \frac{\phi}{2}$. This transfer does not distort incentives, the zero-profit condition continues to bind, and thus mechanism $\{p''_h, p''_l, F_h^\epsilon, F_l, a^*\}$ attains higher welfare. Contradiction. \square

Using the results from the previous Lemmas, the optimal mechanism is given by the solution to the following simplified problem:

$$\max_{\{p_l, p_h, d_l, d_h, a^*\}} \rho_h(a^*) \{\theta p_h + \mathbb{E}[X - \min\{d_h, X\} | z_h]\} + (1 - \rho_h(a^*)) \{\theta p_l + \mathbb{E}[X - \min\{d_l, X\} | z_l]\} - C(a^*)$$

$$\mathbb{E}[\min \{d_l, X\} | z_h] - \mathbb{E}[\min \{d_l, X\} | z_l] \geq \mathbb{E}[\min \{d_h, X\} | z_h] - \mathbb{E}[\min \{d_h, X\} | z_l]$$

$$p_l = p_h + \frac{1}{\theta} \{\mathbb{E}[\min \{d_l, X\} - \min \{d_h, X\} | z_l]\}$$

$$\phi_h(a^*) [E_H[X - \min \{d_h, X\}] - E_L[X - \min \{d_h, X\}]] + \phi_l(a^*) [E_H[X - \min \{d_l, X\}] - E_L[X - \min \{d_l, X\}]] - C'(a^*) = 0$$

$$\rho_h(a^*) [\mathbb{E}[\min \{d_h, X\} | z_h] - p_h] + (1 - \rho_h(a^*)) [\mathbb{E}[\min \{d_l, X\} | z_l] - p_l] = 0$$

where $\phi_h(a) \equiv \rho'_h(a) [\pi_h(a) - \pi_l(a)] + \rho_h(a) \pi'_h(a) > 0$ and $\phi_l(a) \equiv (1 - \rho_h(a)) \pi'_l(a) \geq 0$ for $\tau \in [0, 1]$. Transfers $\{p_l^*, p_h^*\}$ will be given by the binding zero-profits and the incentive compatibility constraint of the z_l -type bank. Therefore, the problem can be re-written as:

$$\max_{\{p_l, p_h, d_l, d_h, a^*\}} (\theta - 1) \{\rho_h(a^*) \mathbb{E}_{a^*}[\min \{d_h, X\} | z_h] + (1 - \rho_h(a^*)) \mathbb{E}_{a^*}[\min \{d_l, X\} | z_l] + \mathbb{E}[X] - C(a^*)\}$$

subject to:

$$0 \leq \mathbb{E}[\min \{d_l, X\} | z_h] - \mathbb{E}[\min \{d_l, X\} | z_l] - \{\mathbb{E}[\min \{d_h, X\} | z_h] - \mathbb{E}[\min \{d_h, X\} | z_l]\}$$

$$0 = \phi_h(a^*) [E_H[X - \min \{d_h, X\}] - E_L[X - \min \{d_h, X\}]] + \phi_l(a^*) [E_H[X - \min \{d_l, X\}] - E_L[X - \min \{d_l, X\}]] - C'(a^*)$$

$$p_h^* = \rho_h(a^*) \mathbb{E}[\min \{d_h, X\} | z_h] + (1 - \rho_h(a^*)) \mathbb{E}[\min \{d_l, X\} | z_l] - \frac{1 - \rho_h(a^*)}{\theta} \{\mathbb{E}[\min \{d_l, X\} - \min \{d_h, X\} | z_l]\}$$

$$p_l^* = \rho_h(a^*) \mathbb{E}[\min \{d_h, X\} | z_h] + (1 - \rho_h(a^*)) \mathbb{E}[\min \{d_l, X\} | z_l] + \frac{\rho_h(a^*)}{\theta} \{\mathbb{E}[\min \{d_l, X\} - \min \{d_h, X\} | z_l]\}$$

Lemma 13. Let $a(\cdot, \cdot) : [0, \infty)^2 \rightarrow [\frac{1}{2}, 1]$ be the function given by the (IC_a) constraint. In the optimal mechanism, optimal debt levels d_l and d_h are unique and given by:

$$\frac{\partial}{\partial a} [\rho_h(a) p_h + (1 - \rho_h(a)) p_l] \frac{\partial a(d_l, d_h)}{\partial d_h} \Big|_{a=a(d_l, d_h)} + \frac{\theta - 1}{\theta} \rho_h(a(d_l, d_h)) (1 - F(d_h | z_h)) - \lambda = 0 \quad (23)$$

$$\frac{\partial}{\partial a} [\rho_h(a) p_h + (1 - \rho_h(a)) p_l] \frac{\partial a(d_l, d_h)}{\partial d_l} \Big|_{a=a(d_l, d_h)} + \frac{\theta - 1}{\theta} (1 - \rho_h(a(d_l, d_h))) (1 - F(d_l | z_l)) + \lambda = 0 \quad (24)$$

Proof. The FOC for debt levels are given by:

$$(d_h) \quad \left\{ \frac{\partial V_0(a, a)}{\partial a} \frac{\partial a(d_l, d_h)}{\partial d_h} + (\theta - 1) \rho_h(a) (1 - F(d_h | z_h)) \right\} \Big|_{a=a(d_l, d_h)} - \lambda = 0$$

$$(d_l) \quad \left\{ \frac{\partial V_0(a, a)}{\partial a} \frac{\partial a(d_l, d_h)}{\partial d_l} + (\theta - 1) (1 - \rho_h(a^*)) (1 - F(d_l | z_l)) \right\} \Big|_{a=a(d_l, d_h)} + \lambda = 0$$

using the (IC_a) , we can eliminate the impact a has directly on ex-ante welfare, all that remains is the impact through market transfers that is not internalized by the bank ex-ante. We get:

$$\frac{\partial}{\partial a^*} [\rho_h(a) p_h + (1 - \rho_h(a)) p_l] \frac{\partial a^*}{\partial d_h} + \frac{\theta - 1}{\theta} \rho_h(a^*) (1 - F(d_h | z_h)) - \lambda = 0$$

$$\frac{\partial}{\partial a^*} [\rho_h(a) p_h + (1 - \rho_h(a)) p_l] \frac{\partial a^*}{\partial d_l} + \frac{\theta-1}{\theta} (1 - \rho_h(a^*)) (1 - F(d_l|z_l)) + \lambda = 0$$

First-Term. Let $a(d_l, d_h)$ be the implicit function given by the (IC_a) constraint with:

$$\frac{\partial a(d_l, d_h)}{\partial d_h} = \frac{\phi_h(a^*) [F_L(d_l) - F_H(d_l)]}{\phi_h'(a^*) [E_H[X - \min\{d_l, X\}] - E_L[X - \min\{d_l, X\}]] + \phi_l'(a^*) [E_H[X - \min\{d_h, X\}] - E_L[X - \min\{d_h, X\}]] - C''(a^*)} \leq 0$$

$$\frac{\partial a(d_l, d_h)}{\partial d_l} = \frac{\phi_l(a^*) [F_L(d_h) - F_H(d_h)]}{\phi_h'(a^*) [E_H[X - \min\{d_l, X\}] - E_L[X - \min\{d_l, X\}]] + \phi_l'(a^*) [E_H[X - \min\{d_h, X\}] - E_L[X - \min\{d_h, X\}]] - C''(a^*)} \leq 0$$

where the short-hand $a^* = a(d_l, d_h)$ is used to save on notation. This is because at the optimum, the denominator is negative ($SOC < 0$), and due to the MLRP the numerator is positive. In addition, from the zero-profit condition, we can see that conditional on a given security, $\frac{\partial}{\partial a} [\rho_h(a) p_h + (1 - \rho_h(a)) p_l] \geq 0$:

$$\begin{aligned} \frac{\partial}{\partial a} [\rho_h(a) p_h + (1 - \rho_h(a)) p_l] = & \\ & \rho_h'(a) [E[\min\{d_h, X\} | z_h] - E[\min\{d_l, X\} | z_l]] + \\ & \rho_h(a) \pi_H'(a) [E_H[\min\{d_h, X\}] - E_L[\min\{d_h, X\}]] + \\ & (1 - \rho_h(a)) \pi_L'(a) [E_H[\min\{d_l, X\}] - E_L[\min\{d_l, X\}]] \end{aligned}$$

In addition, due to the MLRP we know that $\frac{\partial a(d_l, d_h)}{\partial d_k} < 0$ for $k = \{l, h\}$ and that it is decreasing in d_k (the numerator is decreasing, and note that at the optimum, $C''(\cdot)$ is steeper than the $MgBenefit'$ and thus the denominator is increasing in d_k). Therefore, the first term $\frac{\partial}{\partial a} [\rho_h(a) p_h + (1 - \rho_h(a)) p_l] \frac{\partial a(d_l, d_h)}{\partial d_k} |_{a=a(d_l, d_h)}$ is negative and decreasing in $d_k, k = \{l, h\}$.

Second Term. It is straightforward that $\frac{\theta-1}{\theta} \rho_h(a(d_l, d_h)) (1 - F(d_h|z_h))$ is positive and decreasing in d_h , and thus there is a unique d_h that satisfies the FOC. As for $ST(d_l, d_h) \equiv \frac{\theta-1}{\theta} (1 - \rho_h(a(d_l, d_h))) (1 - F(d_l|z_l))$, it is also positive, continuous in d_l with $\lim_{d_l \rightarrow 0} ST(d_l, d_h) > 0$ and $\lim_{d_l \rightarrow \infty} ST(d_l, d_h) = 0$. Therefore, there is also a unique d_l at which the FOC is zero.

Third Term. λ is the multiplier for the (IC_h) constraint and $\lambda(d_l - d_h) = 0$ and $\lambda > 0$ when $d_l = d_h$. We obtain therefore a unique solution $\{d_l^*, d_h^*, a(d_l^*, d_h^*)\}$. \square

Lemma 14. *When $\tau(a) = a$, the level of information acquisition a^* that can be implemented by any optimal mechanism only depends on the security issued by the z_h -type bank, F_h .*

Proof. By previous Lemmas, we know that the (IC_l) binds in equilibrium. The (IC_a) determines the implementable level of information acquisition, a^* , which is given by the following

FOC:

$$\begin{aligned} & \rho'_h(a^*)\{\theta(p_h - p_l) + \mathbb{E}[X - F_h(X) | z_h] - \mathbb{E}[X - F_l(X) | z_l]\} - C'(a^*) + \dots \\ & \rho_h(a^*)\pi'_h(a^*)\{\mathbb{E}_H[X - F_h(X)] - \mathbb{E}_L[X - F_h(X)]\} = 0 \end{aligned}$$

Using the binding (IC_l), $\theta p_l - \mathbb{E}[F_l(X) | z_l] = \theta p_h - \mathbb{E}[F_h(X) | z_l]$, and the fact that $\pi_l(a) = \pi_H$ when $\tau(a) = 1$ we get:

$$\begin{aligned} & \rho'_h(a)\{\theta p_h - \mathbb{E}[F_h | z_l] + \mathbb{E}[F_h | z_l] + \mathbb{E}[X - F_h | z_h] - [\theta p_l + \mathbb{E}[X - F_l | z_l]]\} - C'(a) + \dots \\ & \dots + \rho_h(a)\pi'_h(a)\{\mathbb{E}_H[X - F_h] - \mathbb{E}_L[X - F_h]\} = 0 \\ \rho'_h(a)(\pi_h(a) - \pi_H)\{\mathbb{E}_H[X - F_h] - \mathbb{E}_L[X - F_h]\} - C'(a) + \rho_h(a)\pi'_h(a)\{\mathbb{E}_H[X - F_h] - \mathbb{E}_L[X - F_h]\} &= 0 \\ & \rho'(a)\{\mathbb{E}_H[X - F_h] - \mathbb{E}_L[X - F_h]\} = C'(a) \end{aligned}$$

since $\rho'(a) = \rho'_h(a)(\pi_h(a) - \pi_H) + \rho_h(a)\pi'_h(a)$. Thus, a^* is only a function of F_h . \square

The main intuition behind the previous result is as follows. When $\tau(a) = a$, both signals are symmetric, and therefore $f(X|s_0 = H, s_1 = L) = f(X)$, meaning that investment in information does not affect the distribution of cashflows for the bad-type bank, and thus retention of cashflows in those states of the world does not provide incentives for information acquisition. This case is particularly interesting because it suggests that there are scenarios in which retention of cashflows for the provision of incentives may not be necessary for those holding low quality loans.

Policy Implications

Proposition 3. *[Implementation.] The Optimal Mechanism can be decentralized by implementing a tax scheme $\{\Gamma(F), \gamma(F)\}_{F \in \Delta}$ of lump-sum and marginal taxes respectively.*

Proof. The proof is by construction. I will construct a tax-scheme that implements the OM allocations in decentralized markets. Let $\{\Gamma(F), \gamma(F)\}_{F \in \Delta}$ be the lump-sum transfers and marginal taxes associated with issuing security F in the market. Note that the implementation of such a policy would pin down market beliefs at $a^e = a^{om}$, where the latter is the level of information acquisition implemented with the optimal mechanism. I conjecture this, and later verify that the policy uniquely implements $a = a_{om}$.

(High-Type Optimal Debt Levels) Let γ be a marginal tax on debt-level issuance, chosen so that the in equilibrium high-types optimally choose to retain the desired levels of retention, i.e. issue debt with d_h^{om} :

$$\max_d \theta \{E_{a^{pm}, \mu}[\min\{d, X\}] - \gamma d\} - E_{a^{pm}}[\min\{d, X\} | z_h]$$

$$\theta \int_d^\infty \rho_h(a) g_H(X) + (1 - \rho_h(a)) g_L(X) dX - \theta \gamma - \int_d^\infty \pi_h(a) g_H(X) + (1 - \pi_h(a)) g_L(X) dX = 0$$

$$\int_d^\infty (\theta \rho_h(a) - \pi_h(a)) (g_H(X) - g_L(X)) + (\theta - 1) g_L(X) dX - \theta \gamma = 0$$

Therefore,

$$\gamma^* = \frac{1}{\theta} [(\theta \rho_h(a^{om}) - \pi_h(a^{om})) (G_H(d_h^{om}) - G_L(d_h^{om})) + (\theta - 1) G_L(d_h^{om})]$$

(Low-Type Junior Tranches) The low-type banks will mimic the issuance of high-type banks, and thus issue standard debt with debt level d_h^{om} . In the optimal mechanism, however, it may be desirable to allow the low-type banks to off-load remaining cashflows: $\min\{X - d_h^{om}, d_l^{om} - d_h^{om}, 0\}$, which can be interpreted as a junior or mezzanine tranche. Low-type banks are always willing to issue cashflows in the market at any price valuation. Therefore, the only way to implement the issuance of only the mezzanine tranche, it to charge lump-sum transfers for the issuance of more junior tranches. Therefore, for any security issuing cashflows that intersect with $\max\{d_l^{om}, X\}$, there is a lump-sum tax given by:

$$\Gamma(F) = \theta E[X|z_h] - E[X|z_l], \quad \gamma(F) = 0, \quad \forall F \text{ s.t. } \exists x \text{ s.t. } F(x) > \min\{d_l^{om}, x\}$$

Note that the lump-sum tax is the highest possible gain a bank can make by participating in the market. In other words, the regulator is preventing the issuance of the equity tranches by imposing such a high participation tax.

(Preventing Deviations) Now we need to ensure that the high type bank does not deviate to alternative securities to avoid the marginal tax on debt. Let

$$\Delta_D = \{F \in \Delta : F(x) = \min\{d, h(x)\}, \text{ for some } d \in \mathbb{R}^+, h'(\cdot) > 0\}$$

be the set of feasible securities that are debt-type. Therefore, to prevent issuance of any other type of security, policy makers can tax issuance of any security different than debt-type securities with a lump-sum tax that absorbs all the surplus generated by the transaction.

$$\Gamma(F) = \theta E[X|z_h] - E[X|z_l], \quad \gamma(F) = 0, \quad \forall F \notin \Delta_D$$

Given these taxes, in equilibrium, high-type banks would choose to issue debt with debt levels chosen to maximize interim value: d_h^{om} ; and low type banks will mimic this issuance, and in addition issue as much cashflows as possible, that is, they will issue the mezzanine tranche: $F_M \equiv \min\{d_l^{om}, X - \min\{d_h^{om}, X\}\}$. Note that when no retention is desired for the low type bank ($d_l^{om} \rightarrow \infty$), it issues the full junior tranche: $\max\{X - d_h^{om}, 0\}$. There are no incentives for the low-type to deviate to issue more cashflows since the lump sum transfers are effective

closing those markets. These transfers are also closing the markets for any security that is not debt-like as defined in Δ_D . Given this, the market will price securities with the zero profit condition:

$$\begin{aligned} p(\min\{d_h^{om}, X\}) &= \rho_h(a^{om}) E_{a^{om}}[\min\{d_h^{om}, X\} | z_h] + (1 - \rho(a^{om})) E_{a^{om}}[\min\{d_h^{om}, X\} | z_l] \\ p(\min\{d_l^{om}, X - \min\{d_h^{om}, X\}\}) &= E_{a^{om}}[\min\{d_l^{om}, X - \min\{d_h^{om}, X\}\} | z_l] \end{aligned}$$

(Transfers Across Markets) I have also shown that imposing the desired retention levels is not enough to implement the optimal mechanism, since transfers across bank types matter. Therefore, the following lump-sum transfers should be implemented for securities $F \in \Delta_D$:

$$\Gamma(\min\{d, h(X)\}) = (E_{a^{om}, \mu}[\min\{d, h(X)\}] - \gamma d_h^{om}) - p_h^{om} > 0 \quad \forall d \leq d_h^{om}$$

$$\Gamma(\min\{d, h(X)\}) = (E[\min\{d, h(X)\} | z_l] - \gamma d_l^{om}) - p_l^{om} < 0 \quad \forall d > d_h^{om}$$

where p_h^{om} and p_l^{om} are the transfers made to each type in the optimal mechanism. Note that since this transfers, given the optimal mechanism securities, do not violate (IC) constraints, imposing this transfers will not make the low-type deviate, it will continue to issue the mezzanine tranche. Therefore,

Lump-Sum Tax: $\Gamma(F)$	Marginal Tax: $\gamma(F)$	Set
$\theta E[X z_h] - E[X z_l]$	0	$F \notin \Delta_D$
$(E_{a^{om}, \mu}[\min\{d_h^{om}, h(X)\}] - \gamma d_h^{om}) - p_h^{om}$	γ^*	$F \in \Delta_D, d \leq d_h^{om}$
$(E[\min\{d_l^{om}, h(X)\} z_l] - \gamma d_l^{om}) - p_l^{om}$	γ^*	$F \in \Delta_D, d_h^{om} < d \leq d_l^{om}$
$\theta E[X z_h] - E[X z_l]$	0	$F \in \Delta_D, d_l^{om} < d$

It is easy to check that given this transfer structure, high-type banks will sell cashflows $E[\min\{d_h^{om}, X\}]$ (their FOC holds) while low type banks will sell cashflows $E[\min\{d_l^{om}, X\}]$ (sell as much as possible). In exchange, they will raise funds p_h^{om} and p_l^{om} by construction. Therefore, by FOC for information acquisition, (IC_a), this policy implements a^{om} when market beliefs are a_{om} . Therefore, the conjecture is verified. \square