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# Are there too many safe securities? Securitization and the incentives for information production

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## Abstract

We present a model that helps explain several past collapses of securitization markets. Originators issue too many informationally insensitive securities in good times, blunting investor incentives to become informed. The resulting scarcity of informed investors exacerbates market collapses in bad times. Inefficiency arises because informed investors are a public good from the perspective of originators. All originators benefit from the presence of additional informed investors in bad times, but each originator minimizes his reliance on costly informed capital in good times by issuing safe securities. Our model suggests regulations that limit the issuance of safe securities in good times.

# 1    Introduction

Many accounts of the rise of securitization argue that tranching – manufacturing claims with different degrees of seniority – helps economize on information production costs.[1] Without tranching, many investors would have incentives to produce information about asset cash flows. While information production helps allocate capital efficiently, duplicating it across many investors may be inefficient.

Tranching cash flows into senior and junior securities helps minimize such duplication. Informationally insensitive senior securities (i.e., AAA-rated senior tranches) are nearly riskless, so investors can hold them without expending significant resources on information acquisition. Information production can then be carried out by a handful of specialized investors who hold informationally sensitive junior securities (equity tranches), and duplication is minimized.

However, as noted by Gorton (2008a,b), economizing on information production costs in good times may set the stage for market collapses in bad times, when the scope for adverse selection rises dramatically. Indeed, while the recent financial crisis provides the most prominent example, markets for near-riskless securities have suffered numerous shutdowns in the last 40 years as we discuss below. This suggests that instability could be a general characteristic of such markets, not just a one-time problem associated with the recent subprime mortgage crisis. The critical question is whether such crashes are inefficient. Since bad states are rare, the benefits of economizing on information production in good times could outweigh the costs of collapse in bad times.

We present a model in which inefficient collapses occur because securitization blunts investor incentives to build the "information production infrastructure" necessary to analyze securitization cash flows. For an investment fund to produce information about a securitization, it must have databases of historical loan performance, Monte Carlo models to simulate asset cash flows, and highly trained analysts. This infrastructure is costly to build and has limited value when most securities are informationally insensitive. Privately optimal securitization can produce an inefficiently high amount of informationally insensitive securities in good times, resulting in inefficiently low levels of information infrastructure, which exacerbates collapses in bad times.

In our model, originators wish to finance positive NPV loan pools using securitization. Specifically, each originator raises financing by issuing a combination of debt and equity backed by his loan pool in the primary market. Prior to this financing decision, investors can make an irreversible decision to build information production infrastructure. Investors who choose not to build infrastructure (the "uninformed") may face adverse selection when they trade with

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[1]See, for example, Gorton and Pennacchi (1990), Duffie and DeMarzo (1999), DeMarzo (2005), Gorton (2008a,b), Dang, Gorton, and Holmstrom (2010).

investors who do build infrastructure (the "informed") in the secondary market. However, the uninformed require a lower return on capital than the informed, who in equilibrium must recoup their up-front costs of building infrastructure. In equilibrium, uninformed investors will purchase informationally insensitive debt in the primary market, while informed investors will purchase informationally sensitive equity.

In normal times, the difference between good and bad loan pools is relatively small, so the scope for adverse selection is low. Thus, originators can create large amounts of informationally insensitive debt and finance their loan pools primarily by issuing this debt to uninformed investors. In bad times, however, the payoffs on bad pools fall and the scope for adverse selection increases. This significantly reduces the amount of informationally insensitive debt that can be created. Even though the average loan pool is still positive NPV, the amount of funding originators can raise from uninformed investors drops dramatically. Thus, issuance collapses because it is constrained by the limited amount of informed capital already in place, and loan pools may go unfunded.

In contrast to much of the previous work on security design and adverse selection, the private market outcome can be inefficient in our model because of a financing friction: the full surplus associated with loan pools cannot be pledged to informed investors. This friction, which can be motivated by moral hazard considerations, creates a wedge between the social and private returns to becoming informed.

A social planner can overcome the financing friction and increase total surplus by regulating originator capital structure decisions to increase the issuance of risky securities. Two types of interventions can accomplish this goal. First, limiting the issuance of informationally insensitive debt in good times would raise the demand for informed capital to purchase equity in the primary market, increasing the returns to being informed. This would induce more investors to become informed ex ante and alleviate underfunding in bad times. Alternatively, constraining originators to issue riskier debt in good times would raise the adverse selection profits available to informed investors trading in the secondary market, again increasing the incentives to become informed ex ante. Both types of regulation are effectively "in-kind" subsidies to informed investors: originators sacrifice a small portion of their profits in good times to encourage more investors to become informed. The small sacrifice in good times is more than offset by the gains in bad times, so regulation raises expected originator surplus.

By contrast, in the private market equilibrium, each originator takes the information production infrastructure of investors as fixed. Thus, originators find it privately optimal to tilt their security issuance towards informationally insensitive debt in normal times, economizing on his use of costly informed capital. The decisions of originators collectively reduce the supply of informationally sensitive securities that informed investors can buy in the primary market

or trade in the secondary market. This lowers the returns to informed investors in good times, which in turn dulls incentives to become informed ex ante and exacerbates the underfunding problem in bad times. Put simply, individually rational decisions by originators in good times blunt investors' incentives to become informed, creating an under-informed investor base that proves socially costly in rare, bad states.

Why is the private market unable to overcome the financing friction on its own? The answer lies in two commitment problems. First, originators cannot commit to limiting their use of informationally insensitive debt in good times. Before it is known whether times will be good or bad, originators recognize that they would benefit from additional information infrastructure if the bad state occurs. From this ex ante perspective, originators would like to commit to issuing securities that encourage investors to become informed. However, once the good state is realized, originators maximize their profits by issuing large amounts of informationally insensitive debt. Anticipating originator behavior, investors limit their up-front investment in information infrastructure.

The second commitment problem is that informed investors cannot commit funding to particular originators in bad times. An individual originator who issued informationally sensitive securities in good times would induce investors to build additional information infrastructure ex ante. However, that particular originator would not necessarily receive funding from informed investors in bad times. Thus, infrastructure is a public good from the perspective of originators: it has diffuse costs in good times and concentrated (rival and non-excludable) benefits in bad times. As a result, it is optimal for originators to avoid the higher costs of issuing informationally sensitive securities to informed investors in good times. Inefficient underfunding of loan pools in bad times can arise if either commitment problem exists.

The assumption that information infrastructure is fixed in the short-term is crucial. Neither commitment problem would exist if investors could make state-contingent infrastructure decisions. The assumption that infrastructure is fixed in the short-run can be motivated in two ways. First, financial capital may be slow-moving, so it might take time for informed investors to raise capital in bad times. Second, it takes time and resources to build new analytical capabilities, so uninformed investors cannot easily become informed in bad times.

In addition to showing that capital structure regulation in good times can improve welfare, we develop a number of other results. First, we quantify the size of the welfare gains from capital structure regulation. Second, we allow the planner to use ex post debt guarantees funded by distortionary taxes to increase the amount of informationally insensitive debt that can be issued in bad times. We characterize conditions under which the optimal intervention involves a combination of ex ante debt limits and ex post debt guarantees. Third, we show that the mechanism generating collapses in our model is more likely to play a role in securitization

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markets than in markets for long-term corporate debt.

The mechanism in our model is not the fire-sales channel of Diamond and Rajan (2009), Shleifer and Vishny (2010), and Stein (2010). Specifically, the collapse of the primary market for securitizations is not due to attractive investment opportunities in the secondary market or anticipation of such opportunities in the future. Instead, it is driven by a "buyers' strike" among the uninformed investors upon whom the primary market normally relies. These uninformed investors simply move to the sidelines in bad times because they fear adverse selection and lack the infrastructure necessary to produce information about asset cash flows.

Thus, unlike fire-sales models, where the capital structure decisions of *leveraged investors* may create externalities, in our model the capital structure decisions of *originators* themselves are the problem. As a result, our model has distinct policy implications. In particular, it suggests that it may be desirable to regulate the capital structures of securitization trusts by limiting the amount of AAA-rated debt that can be issued in good times.

Our paper builds on the security design and optimal capital structure literature, including Myers and Majluf (1984), Gorton and Pennacchi (1990), Duffie and DeMarzo (1999), Bolton and Freixas (2000), DeMarzo (2005), Dang, Gorton, and Holmstrom (2010), and Chelma and Hennessy (2010). Most work in this tradition takes investor composition as given and focuses on minimizing the costs of adverse selection, while we consider the effects of security design on the ex ante information infrastructure decisions of investors. In this regard, our work is also related to the literature on endogenous participation, including Grossman and Stiglitz (1980), Merton (1987) Allen and Gale (1994), and Boot and Thakor (1997).

Moreover, in previous work informed investors provide benefits by improving the real investment decisions of firms. In contrast, we highlight a novel benefit of informed investors: they are a robust source of capital capable of analyzing investment opportunities and financing positive NPV projects even in bad times. In our model the privately optimal capital structure decisions of issuers may result in an inefficient shortage of information infrastructure.

This also distinguishes our paper from the recent work of Coval, Jurek, and Stafford (2009a,b) and Gennaioli, Shleifer, and Vishny (2011), who argue that neglected risks explain the collapse of securitization markets in recent years. In contrast, we emphasize how financial innovations that create near-riskless securities encourage investors to rationally choose to be uninformed. Our results suggest that learning from prior mistakes will not necessarily eliminate the instabilities associated with near-riskless securities.

The paper is organized as follows. In section 2, we present the baseline model, solving for the private market equilibrium and the social planner's solution. Section 3 explores a number of extensions to baseline model. Section 4 discusses the distinctive empirical implications of our model and examines its policy implications. Section 5 concludes.

# 2  Baseline Model

We now present the baseline model. Section 2.1 describes the setup and discusses our key modeling assumption that information production infrastructure is fixed in the short run. In Section 2.2, we solve for the private market equilibrium. Section 2.3 derives the planner's solution, which involves increasing the amount of informationally sensitive securities issued in good times, and explains the forces that generate the inefficiency of the private market outcome. Section 2.4 considers optimal interventions when the planner can both limit the issuance of safe securities in good times and guarantee debt in bad times.

## 2.1  Setup

The model has 4 periods ($t = 0, 1, 2, 3$) and three types of risk-neutral agents: originators, investors, and market makers. There is a continuum of measure 1 of originators. Each is endowed with the opportunity to originate a pool of loans at time 1, but has no capital. Originating a loan pool requires \$1 of financing. To raise this financing, originators tranche the cash flows from their pools into senior debt claims and junior equity claims. They then attempt to raise \$1 by selling some or all of these claims to investors, retaining the rights to any residual cash flows.

Loan pool payoffs are realized at time 3 and depend on the state of the macroeconomy and the type of the individual pool. At time 1, when loan pools are originated, originators and all investors know the state of the macroeconomy but not the types of individual loan pools. The state of the macroeconomy is either high or low, denoted by $S \in \{H, L\}$, and the high state occurs with probability $\Pr[S = H] = p$. Individual pools are either good or bad, denoted by $Q \in \{G, B\}$, and the fraction of good pools is $\Pr[Q = G] = \theta$ in both states. Good pools pay $v^G > 1$ regardless of the state. By contrast, bad pools pay $v_H^B < 1$ in the high state $H$ and $v_L^B < v_H^B$ in the low state $L$.

The only difference between the high state and the low state is that bad pools have worse payoffs in the low state. This increases the scope for adverse selection in the low state. Let $V_S = \theta v^G + (1 - \theta) v_S^B$ denote the expected value of the average loan pool in state $S$. We assume that $V_H > V_L > 1$ so that funding loan pools is positive NPV even in the low state. Note that this assumption means that information has no *direct* social value in the model. Information production does not affect the *quality* of the projects undertaken. Since funding loan pools is positive NPV in both states of the world, zero information production would be the best outcome, a point emphasized by Dang, Gorton, and Holmstrom (2010). However, information production has indirect social value in the model: the presence of informed capital increases the *quantity* of projects that can be financed in bad times. This setup allows us to

emphasize the indirect "market robustness" value of informed capital even in a world where it has no direct social value. Increasing the amount of informed capital in the market can increase total originator surplus through this market robustness channel.

There is a continuum of investors. At the beginning of the game, investors are identical, and each is endowed with $1 of capital. At time 0, before the state of the macroeconomy is known, each investor may make an irreversible decision to become informed by paying cost $c$ to build information production infrastructure. In return for paying this cost, informed investors will learn the types of individual loan pools at time 2. The number of informed investors is a proxy for the total information production infrastructure in the market. The key assumption is that investors choose an infrastructure at time 0 and that these choices cannot be conditioned on the realization of the state of the macroeconomy $S$ at time 1. This captures the idea that capital and information infrastructure are fixed in the short run.

The assumption that infrastructure is fixed at time 1 also affects the returns informed investors are able to earn. When originators sell claims backed by their loan pools at time 1, they face a fixed number of informed investors. Therefore, as discussed further below, the relative scarcity of informed investors is a key determinant of the profits the informed earn in the primary issuance market.

At time 2, after loan pools have been originated and sold to investors, the types of individual pools are learned by informed investors. By contrast, uninformed investors do not learn the types of individual pools until time 3. After loan pool types are revealed to the informed, fraction $\ell$ of both informed and uninformed investors are hit by liquidity shocks. These liquidity shocks force investors to trade, raising the possibility of adverse selection at time 2, which in turn impacts the prices that investors are willing to pay at time 1.

Investors hit by liquidity shocks must sell their securities. In addition, informed investors may, in the aggregate, sell short $M$ units of debt per loan pool originated. Uninformed investors have no private information and therefore will not sell securities short in equilibrium. Short selling of debt by informed investors in the secondary market opens the door for adverse selection at time 2. Investors sell their securities to the third group of agents in the model, uninformed market makers. We assume these market makers have enough capital to buy all securities investors wish to sell at time 2. Prices in the secondary market will be pinned down by market makers' zero-profit condition.

Figure 1 summarizes the timing of the game. At time 0 investors may choose to become informed. At time 1 the state of the macroeconomy is revealed to everyone. Originators then originate loan pools and sell claims backed by those cash flows to investors. At time 2, the types of individual loan pools are revealed to informed investors. Some investors are then hit by liquidity shocks and sell securities to market makers. At time 3, payoffs are realized.

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**Time t = 0** | **Time t = 1** | **Time t = 2** | **Time t = 3**

Investors may pay cost c to become informed

The state of the macroeconomy S is revealed to all actors

Informed investors learn individual pool types Q

Pool payoffs v are realized

$Q = G$    $v = v^G$

$\theta$

$S = H$

$p$

$Q = B$    $v = v^B_H$

$1\text{-}\theta$

$Q = G$    $v = v^G$

$\theta$

$1\text{-}p$

$S = L$

$Q = B$    $v = v^B_L$

$1\text{-}\theta$

Loan pools are originated, tranched, and sold to investors

Some investors are hit by liquidity shocks and forced to sell
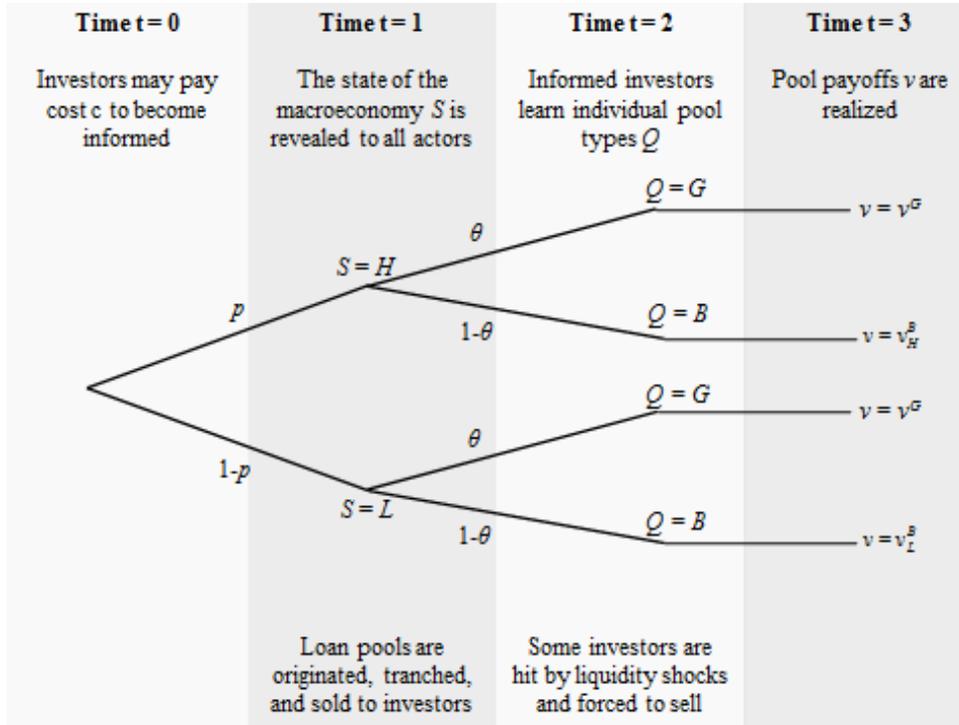
Figure 1: Structure of the Game.

### 2.1.1   What is Information Production Infrastructure?

Information production infrastructure in the model can be thought of as market-specific information technology or human capital. As pointed out by Brunnermeier and Oehmke (2009a) and Arora et al. (2009), analysis of securitizations is computationally complex. For an investment fund to produce information about specific securitizations, it must have a variety of databases and analytical tools, as well as a stock of human capital (i.e., analysts) familiar with these tools. For example, during the recent boom, investors analyzing securitizations relied on Monte Carlo methods using Gaussian copula functions. These tools required significant computational power, as well as substantial expertise to build and use.

The assumption that information infrastructure is fixed in the short run is critical to our results and captures two complementary ideas. First, capital may be slow-moving following market shocks due to a variety of frictions (Duffie 2010). Specifically, it may take time to reallocate capital from delegated investors lacking information infrastructure to those with the necessary infrastructure. Informed investors may need several months to raise new funds, a significant amount of time for primary markets to be constrained.

Second, even in the absence of slow-moving capital, information infrastructure may require time to build. Once an investment fund decides to build additional analytical capacity, it could

take several months for that capacity to come online. Indeed, the American Securitization Forum (2008) recognized that this time-to-build problem was exacerbating the shutdown of the securitization market in late 2008, reporting that "The market faces significant challenges in developing new investors... Sources of new funds that could potentially be invested ... will need to find mechanisms to access the capabilities and infrastructure necessary to manage securitized products."

## 2.2 Private Market Equilibrium

We now construct the private market equilibrium. We start by considering the outcome of the secondary market trading game at time 2. We then fold this back into the prices that investors are willing to pay for securities at time 1. Taking these prices as given, we then consider the time 1 capital structure decisions of originators (i.e., the mix of debt and equity they use to finance loan pools). Finally, we consider the time 0 decisions of investors to become informed.

### 2.2.1 Adverse Selection in the Time 2 Trading Game

Suppose we are in state $S$ at time 2 and that originators have chosen to issue debt of face value $d_S$ at time 1. Furthermore, suppose that at the chosen value of $d_S$ informed investors choose to buy equity claims and uninformed investors choose to buy debt claims. In the Appendix we verify that this is indeed the case in equilibrium.

For simplicity, suppose that there are separate market makers for debt and equity. Both are uninformed and will set prices to make zero profits. First consider the secondary market for debt. Fraction $\ell$ of uninformed investors will be hit by liquidity shocks and be forced to sell their debt, which will be of average quality. In addition, all informed investors will short sell debt backed by bad pools, generating adverse selection in the market.[2]

We assume that informed investors can, in the aggregate, sell short $M$ units of debt per loan pool originated. A large $M$ indicates fewer impediments to short-selling. The market maker will set the time 2 price of debt, $P_2[D; d_S]$, so that his profits from forced sellers exactly offset his losses to informed short sellers:

$$\underbrace{\ell \left( \theta \min \left\{ v^G, d_S \right\} + (1 - \theta) \min \left\{ v_S^B, d_S \right\} - P_2[d_S; D] \right)}_{\text{Profit from forced sales by the uninformed}} = \underbrace{M \left( P_2[d_S; D] - \min \left\{ v_S^B, d_S \right\} \right)}_{\text{Loss to informed}}.$$

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[2]We make the standard assumption that market makers cannot identify investors as informed or uninformed and therefore cannot discriminate between forced sales and informed short sales.

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This implies that

$$P_2\left[D; d_S\right] = \underbrace{\theta \min\left\{v^G, d_S\right\} + (1-\theta) \min\left\{v_S^B, d_S\right\}}_{\text{Expected value}} - \underbrace{\theta \frac{M}{M+\ell}\left(\min\left\{v^G, d_S\right\} - \min\left\{v_S^B, d_S\right\}\right)}_{\text{Adverse selection discount}},$$

so risky debt $(d_S > v_S^B)$ trades at a discount to its expected value in the secondary market.

Next consider the secondary market for equity. Informed investors who are hit by liquidity shocks are forced to sell their equity, regardless of the quality of the pool backing it. In addition, all investors not hit by liquidity shocks will opportunistically sell their bad pools. For simplicity, we assume that informed investors are not able to borrow any additional equity to sell short, since all of the equity in bad pools is already being sold at time 2.[3] Thus, the market maker sets the time 2 price of equity, $P_2\left[E; d_S\right]$, such that

$$\overbrace{\ell\left(\theta \max\left\{v^G - d_S, 0\right\} + (1-\theta) \max\left\{v_S^B - d_S, 0\right\} - P_2\left[d_S; E\right]\right)}^{\text{Profit from forced sales}}$$
$$= \underbrace{(1-\ell)(1-\theta)\left(P_2\left[d_S; E\right] - \max\left\{v_S^B - d_S, 0\right\}\right)}_{\text{Loss from opportunistic sales}},$$

which implies that

$$P_2\left[d_S; E\right] = \overbrace{\theta \max\left\{v^G - d_S, 0\right\} + (1-\theta) \max\left\{v_S^B - d_S, 0\right\}}^{\text{Expected value}}$$
$$\underbrace{-\theta \frac{(1-\ell)(1-\theta)}{(1-\ell)(1-\theta) + \ell}\left(\max\left\{v^G - d_S, 0\right\} - \max\left\{v_S^B - d_S, 0\right\}\right)}_{\text{Adverse selection discount}}.$$

Thus, both debt and equity trade at an adverse selection discount at time 2 due to opportunistic trading by informed investors.

### 2.2.2 Security Prices and Capital Structure Decisions at Time 1

Next consider the prices that informed and uninformed investors are willing to pay for securities at time 1. Recall that at time 1, the state of the macroeconomy is known, but the types of individual loan pools are unknown. The uninformed anticipate that with probability $\ell$ they will be forced to sell at an unfavorable price at time 2. Therefore, they will charge an adverse

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[3]This assumption is not critical. We could treat debt and equity symmetrically, assuming that informed investors could short $M$ units of equity per loan pool originated. We would additionally need to assume that the right to short is contingent upon participating in the primary market to ensure that informed investors actually buy equity at issuance. As we will show below, the key is that adverse selection in the secondary market for equity only redistributes wealth between informed investors and nets out among them.

selection discount at time 1, and the price of debt claims at time 1 is

$$P[D; d_S] = \overbrace{\theta \min\left\{v^G, d_S\right\} + (1 - \theta) \min\left\{v_S^B, d_S\right\}}^{\text{Expected value}} - \overbrace{\theta \ell \frac{M}{M + \ell} \left(\min\left\{v^G, d_S\right\} - \min\left\{v_S^B, d_S\right\}\right)}^{\text{Expected loss from adverse selection when forced to sell}}$$

(1)

The adverse selection discount charged by the uninformed accrues to the informed due to their trading in the time 2 game. In other words, the discount simply compensates the uninformed for the expected wealth transfer to the informed in the secondary market at time 2.

While informed investors also suffer from adverse selection when hit by liquidity shocks, they benefit from their ability to adversely select others when they are not hit by liquidity shocks. The expected payoff to purchasing equity for informed investors is

$$\overbrace{\theta (1 - \ell) \max\left\{v^G - d_S, 0\right\}}^{\text{Good pool, no liquidity shock}} + \overbrace{\theta \ell P_2 \left[d_S; E\right]}^{\text{Good pool, forced sale}} + \overbrace{(1 - \theta) P_2 \left[d_S; E\right]}^{\text{Bad pool}}$$

$$= \theta \max\left\{v^G - d_S, 0\right\} + (1 - \theta) \max\left\{v_S^B - d_S, 0\right\}.$$

Since market makers make zero profits, adverse selection between informed investors simply transfers wealth between them and nets out in the aggregate. Thus, the expected payoff to purchasing equity for the informed is the fundamental value of the equity, and the informed do not need to charge an adverse selection discount at time 1.

However, since informed investors must recoup their up-front infrastructure costs $c$ in equilibrium, the number of investors who become informed must be small enough that they earn a positive return. Let the return earned per dollar invested in state $S$ be $r_S$. $r_S$ is taken as fixed by originators, but in equilibrium it will be determined by the relative scarcity of informed capital as described below. Thus, the price informed investors are willing to pay for equity claims at time 1 is given by

$$P[d_S; E] = \frac{\theta \max\left\{v^G - d_S, 0\right\} + (1 - \theta) \max\left\{v_S^B - d_S, 0\right\}}{1 + r_S}.$$

(2)

Thus, two opposing violations of the Modigliani-Miller (1958) theorem pin down an optimal capital structure. Debt suffers from an adverse selection discount, while originators perceive equity as expensive due to the higher rate of return required by informed investors.

Originators pick the face value of debt $d_S$ to maximize the value of the stake they retain
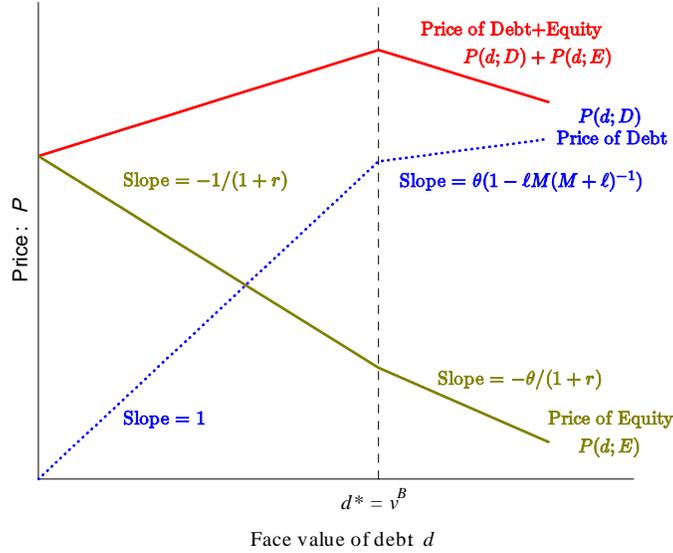
Figure 2: Originator Capital Structure Decisions.

in the loan pool.[4] Appendix B shows that originators' objective function can be written as

$$\max_{d_S} \ P\left[d_S; E\right] + P\left[d_S; D\right].$$

Figure 2 depicts this capital structure decision, plotting security prices as a function of $d_S$. The dotted blue line shows that the price of debt increases one-for-one with $d_S$ when $d_S < v_S^B$ because debt is risk-free in this range. When $d_S > v_S^B$, the debt is risky and its price increases at rate $\theta(1 - \ell M \left(M + \ell\right)^{-1})$, where $\theta$ reflects the debt's riskiness and $(1 - \ell M \left(M + \ell\right)^{-1})$ reflects the adverse selection discount charged by uninformed investors. The solid green line shows that the price of equity decreases with $d_S$, first at rate $-1/\left(1 + r_S\right)$ for $d_S < v_S^B$ and then at rate $-\theta/\left(1 + r_S\right)$ for $d_S > v_S^B$.

Since $1 > 1/\left(1 + r_S\right)$, the value of equity decreases more slowly than the value of debt increases when the debt is risk-free $(d_S < v_S^B)$. Thus, originators always want to issue as much risk-free debt as possible to economize on costly informed capital. Would originators want to set $d_S > v_S^B$ and sell risky debt to uninformed investors? If

$$\ell\frac{M}{M + \ell} > 1 - \frac{1}{1 + r_S}, \tag{3}$$

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[4]The assumption that originators choose simple capital structures consisting of debt and equity is without loss of generality. Originators want to issue as much informationally insensitive debt as possible to uninformed investors. Their payoffs are equivalent for any informationally sensitive security issued to informed investors and equity is the simplest such security to work with.

the adverse selection discount charged by the uninformed for risky debt outweighs the higher rate of return charged by the informed. This condition holds when $\ell$ and $M$ are sufficiently large or $r_S$ is sufficiently small.[5] When it holds, originators find it optimal to only issue risk-free debt, setting $d_S^* = v_S^B$. Note that $d_L^* = v_L^B < v_H^B = d_H^*$, so the originators' optimal capital structure involves more equity in the low state, when the scope for uninformed debt investors to be adversely selected is higher.

The optimality of risk-free, and thus adverse selection-free, debt is a result of our assumption that loan pool payoffs are binary (either $v^G$ or $v_S^B$). In Section 3 we develop a more general version of the model where pool payoffs are continuously distributed and show that originators find it optimal to issue debt that is somewhat risky.

### 2.2.3 Investor Decisions to Become Informed at Time $0$

Next we find the number of investors, $K$, who choose to become informed at time 0. To do so we first discuss how the return $r_S$ earned by informed investors in state $S$ is determined. The amount of equity financing originators attempt to raise from informed investors in state $S$ is $e_S = 1 - P[d_S; D]$. We will say that informed capital is "maximally scarce" when it is fully invested in equity so that $K \leq e_S$.

The fact that information infrastructure is fixed at time 1 means that the relative scarcity of informed investors determines the returns they are able to earn. When informed investors are relatively abundant, originators can effectively hold them up, capturing most of the value of loan pools. Conversely, when informed investors are relatively scarce, they can capture more value from originators.[6]

Formally, we write the return earned by the informed as a function of the supply and demand for informed capital: $r_S = r[K, e_S]$. In a "Walrasian" model of the interaction between originators and informed investors, $r[\cdot]$ takes a simple form. When informed investors are maximally scarce ($K \leq e_S$), they capture as much of the value of loan pools as possible. When they are not maximally scarce ($K > e_S$), they earn zero return.

In the main text, we will not use Walrasian model. Instead, we will assume that $r[\cdot]$ is smooth so that informed investors earn a positive return even when they are less than maximally scarce. As we show in Appendix A, this assumption can be micro-founded using a variant of the Rubinstein and Wolinsky (1985) bargaining model, in which originators must

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[5]Note that when $M = 1$ so that shorting is constrained by the physical supply of debt, this condition reduces to $\ell > r_S$.

[6]By contrast, there are an infinite number of uninformed investors in the primary market for debt and an infinite number of uninformed market makers in secondary markets. As a result, they are never scarce and always earn 0 return.

search for informed investors with whom they transact.[7] This assumption is solely for ex-positional simplicity. In Appendix A we also show that one obtains identical results if the Walrasian model is used.

The function $r\left[\cdot\right]$ determines the return earned by informed capital invested in equity. The following properties of the $r\left[\cdot\right]$ function will be used throughout the paper:

1. Returns exceed $c$ when it is maximally scarce: $r\left[K, e_S\right] > c$ when $K \le e_S$.

2. Informed capital earns a higher return when it is more scarce: $\partial r / \partial K < 0$ and $\partial \left(r\left[K, e_S\right] \cdot e_S\right) / \partial e_S > 0$ (i.e., total informed profit per pool, $r\left[K, e_S\right] \cdot e_S$, is increasing in the amount of equity originators attempt to raise).

3. The full surplus associated with loan pools cannot be pledged to informed investors even when they are maximally scarce. Specifically, $r_S \cdot e_S < \left(V_S - 1\right)$ where $V_S = \theta v^G + \left(1 - \theta\right) v_S^B$ is the value of the average loan pool in state $S$.

The first property is an assumption. The second and third properties are micro-founded in Appendix A. The first property states that it is possible for an informed investor to recoup her up-front infrastructure cost. The second property states that informed investors can extract more surplus from originators when informed capital is more scarce. This implies that the returns earned by informed investors are decreasing in the face value of debt.[8]

The third property is the key financing friction in the model. It drives a wedge between the private and social returns to informed capital, raising the possibility that the private market outcome may be inefficient. As shown in Appendix A, this property emerges naturally from the bargaining power of originators. Alternatively, it can be simply taken as an assumption motivated by moral hazard considerations outside the model. For instance, the originator may have to retain a stake in the loan pool to provide incentives for monitoring borrowers.

When informed capital is maximally scarce ($K \le e_S$), the number of pools that can be funded becomes constrained by the amount of informed capital available. Specifically, if capital is maximally scarce in state $S$ the number of projects that are funded is $N_S = K/e_S \le 1$. This is consistent with the decentralized/sequential market structure implicit in any search model. The originators who encounter informed investors early transact, while those who do not are shut out of the market.

We can now analyze investor decisions to become informed. Informed investors must earn an average return of $c$ to break even. Thus, the equilibrium number of investors who choose

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[7]See Duffie, Garleanu, and Pedersen (2005, 2007) for applications of such models to finance.

[8]To see this note that $\partial \left(r\left[K, e_S\right] \cdot e_S\right) / \partial d_S = - \left(\partial \left(r\left[K, e_S\right] \cdot e_S\right) / \partial e_S\right) \left(\partial P\left[d_S; D\right] / \partial d_S\right) < 0$.

to become informed $K^*$ satisfies the zero profit condition:

$$cK^* = p \cdot N_H \cdot \Pi_H \left[ K^*, d_H^* \right] + (1 - p) \cdot N_L \cdot \Pi_L \left[ K^*, d_L^* \right] \tag{4}$$

where $N_S = \min \left\{ 1, K^*/e_S^* \right\}$ is the number of loan pools originated in state $S$ and

$$\Pi_S \left[ K^*, d_S^* \right] = \underbrace{r \left[ K^*, 1 - P \left[ d_S^*; D \right] \right] \left( 1 - P \left[ d_S^*; D \right] \right)}_{\text{primary market scarcity profits}} + \underbrace{\frac{M}{M + \ell} \ell \theta \left( \min \left\{ v^G, d_S^* \right\} - \min \left\{ v_S^B, d_S^* \right\} \right)}_{\text{secondary market adverse selection profits}} \tag{5}$$

is the profit earned by informed investors in state $S$ per pool originated. Informed investors can (in expectation) earn profits from two sources: their scarcity in the primary market for equity at time 1 and their trading in the secondary market for debt at time 2. Recall that, in expectation, informed investors earn no adverse selection profits from trading in the secondary market for equity: sometimes they are hit by liquidity shocks and suffer losses due to adverse selection, while other times they are not hit by liquidity shocks and profit from their ability to opportunistically sell equity in bad pools.

We now find conditions under which $e_H^* < K^* < e_L^*$ (where $e_S^* = 1 - P \left[ d_S^*; D \right]$), so that there is enough informed capital to fund all loan pools in the high state but not enough to fund all loan pools in the low state. First, note that we must have $K^* > e_H^*$. Suppose the number of informed investors is $K \le e_H^*$. Since $e_H^* < e_L^*$, informed investors would be maximally scarce in both states, and they would earn a return greater than $c$ in both states of the world by the first property of $r \left[ \cdot \right]$. Thus, informed investors would earn positive profits and (4) would not be satisfied. More investors would choose to become informed so $K^* > e_H^*$.

Next suppose there are just enough informed investors to fund all loan pools in the low state ($K = e_L^* = 1 - P \left[ d_L^*; D \right]$). If

$$p \cdot \Pi_H \left[ 1 - P \left[ d_L^*; D \right], d_H^* \right] + (1 - p) \cdot \Pi_L \left[ 1 - P \left[ d_L^*; D \right], d_L^* \right] < c \left( 1 - P \left[ d_L^*; D \right] \right), \tag{6}$$

these informed investors do not earn enough to break even. Thus, assuming condition (6), we will have $e_H^* < K^* < e_L^*$.

These conditions simplify when condition (3) is satisfied, and originators choose to make the debt risk-free. Then $d_S^* = v_S^B$ and $e_S^* = 1 - v_B^S$, so there is no adverse selection in the secondary market for debt and the informed must fully recoup the costs of infrastructure by charging a scarcity premium in the primary market for equity. Condition (6) then reduces to

$$p \cdot r \left[ 1 - v_L^B, v_H^B \right] \frac{1 - v_H^B}{1 - v_L^B} + (1 - p) \cdot r \left[ 1 - v_L^B, v_L^B \right] < c,$$

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and the zero profit condition for informed investors is given by

$$cK^* = p \cdot r\left[K^*, 1 - v_H^B\right] \cdot \left(1 - v_H^B\right) + (1 - p) \cdot r\left[K^*, 1 - v_L^B\right] \cdot K^*.$$

Technically, we also need to assume $\theta v^G + (1 - \theta) v_L^B - \theta \ell M (M + \ell)^{-1} \left(v^G - v_L^B\right) < 1$, so originators who are unable to raise equity capital from informed investors cannot raise \$1 of financing using only debt capital from uninformed investors in the low state. This condition always holds if $\ell$ and/or $M$ are sufficiently large.

The private market equilibrium of interest is summarized by the following proposition.

**Proposition 1** *Suppose that conditions (3) and (6) are satisfied. Then the private market equilibrium is a triple $(K^*, d_H^*, d_L^*)$ such that: (i) originator capital structure decisions are optimal and $d_S^* = v_S^B$; (ii) the number of informed investors $K^*$ satisfies the zero-profit condition (4); and (iii) the number of loan pools originated is $N_H^* = 1$ in the high state and $N_L^* = K^*/\left(1 - d_L^*\right) < 1$ so that positive NPV loan pools go unfunded in the low state.*
**Proof.** *All proofs are presented in Appendix B.* ∎

When (3) is not satisfied, the adverse selection discount charged by the uninformed is small. In this case, originators choose to raise financing only from uninformed investors. When (6) is not satisfied, enough investors become fully informed to fund all loan pools in the low state.

### 2.2.4 Instability in the Private Market Equilibrium

The private market equilibrium we have constructed is unstable. Despite the fact that the average loan pool is positive NPV in the low state, it cannot be financed because uninformed investors are unwilling to provide funding. This instability is driven by the interaction of conditions (3) and (6). When condition (3) is satisfied, originators sell as much risk-free debt as possible in both states of the world to economize on costly informed capital. The amount of financing that can be raised from uninformed investors drops sharply in the low state, so there is strong demand for informed capital in the low state. The value of information production infrastructure in the model is that informed investors are a robust source of capital that can be relied upon in the low state.

However, when (6) is satisfied, the high-state returns earned by informed investors are modest since little informed capital is used in the high state. These modest returns blunt incentives to become informed at time 0. Thus, the number of informed investors is insufficient to finance all loan pools in the low state, and positive NPV loan pools go unfunded.

The nature of the private market equilibrium depends crucially on the fact that investor infrastructure decisions cannot be made state-contingent. To see this, suppose there were only

a single state of the world. Then investors would be able to perfectly forecast demand for informed capital and enough investors would become informed to fund all loan pools.[9]

**Why ignorance may not be bliss**  One might wonder whether a "ignorance-is-bliss" (i.e., $K = 0$) outcome, in the words of Dang, Gorton, and Holmstrom (2010), is possible in our setting. Since there is no direct social benefit of information production in our setting, a planner in our model would ideally want to prohibit all investors from building information infrastructure. However, in a more complicated model where informed investors also provide direct social benefits by improving the real investment decisions of firms (e.g., by screening out negative NPV projects) such a prohibition would be undesirable.

Furthermore, it would be difficult if not impossible to enforce such a prohibition. And if the planner cannot prevent investors from becoming informed, a $K = 0$ equilibrium is not sustainable in our model. The key assumption that drives this result is that positive NPV loans pools require risky external finance (i.e., $v_S^B < 1$). To see this, conjecture an equilibrium in which $K = 0$ and all investors are uninformed. Since originators must raise \$1 of external finance, at least $1 - v_S^B$ of it must be risky regardless of the form of the financing. As a result, adverse selection profits equal to $\ell M (M + \ell)^{-1} (1 - v_S^B)$ are available in state $S$. Mass $K$ of investors could become informed and earn a return on capital of

$$ K^{-1} \frac{M\ell}{M + \ell} \left[ p \left( 1 - v_H^B \right) + (1 - p) \left( 1 - v_L^B \right) \right] $$

which can be made larger than $c$ by taking $K$ small enough. Thus, some mass $K > 0$ of investors will always choose to become informed. As a result, the ignorance-is-bliss optimum cannot be sustained in our model.

## 2.3   The Planner's Problem: Regulating Capital Structure

Could a social planner increase total originator surplus by imposing ex ante restrictions on originator capital structure decisions in good times? Recall that $V_S = \theta v^G + (1 - \theta) v_S^B$ is the expected value of loan pools in state $S$. As shown in Appendix B, since all investors earn zero profits total surplus is the NPV of the loan pools funded in each state net of the costs of informed capital:

$$ pN_H (V_H - 1) + (1 - p) N_L (V_L - 1) - cK $$

where $N_S$ in the number of loan pools originated in state $S$. The planner picks $d_H$ and $K = K [d_H]$ is implicitly defined by the zero-profit condition of the informed (4). At the private

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[9]In this case, $K^*$ would satisfy $c = r \left[ K^*, v^B \right]$. Since $c < r \left[ 1 - v^B, v^B \right]$ by the first property of $r [\cdot]$ and $\partial r / \partial K < 0$ by the second property, $c = r \left[ K^*, v^B \right]$ implies $K^* > 1 - v^B$ so all pools would be funded.

market equilibrium we have $d_H = v_H^B$, $N_H = 1$, and $N_L = K[d_H]/(1 - v_L^B)$. Differentiating total surplus with respect to $d_H$ shows that the effect of altering $d_H$ consists of two parts:

$$\underbrace{\left( (1-p)\left( \frac{V_L - 1}{1 - v_L^B} \right) - c \right)}_{\text{social value of informed capital}} \frac{\partial K}{\partial d_H}.$$

The first part is the social return to informed capital net of its cost. An extra unit of informed capital has cost $c$. The benefit of having this extra unit of informed capital is that it is a robust source of funding in the low state. The low state occurs with probability $(1-p)$ and an additional unit of capital can finance $1/(1 - v_B^L)$ more loan pools, each of which generates $V_L - 1$ of surplus. When

$$(1-p)\left( \frac{V_L - 1}{1 - v_L^B} \right) > c \tag{7}$$

the social benefit of informed capital exceeds its cost. In this case, the planner would like to encourage more investors to become informed, either lowering $d_H$ if $\partial K/\partial d_H < 0$ or raising it if $\partial K/\partial d_H > 0$. In contrast, if condition (7) does not hold, the planner may want to alter $d_H$ to discourage investors from becoming informed.[10]

Since there are constant returns to loan pool origination, when condition (7) is met, the planner wants ensure that all loan pools are funded in the low state. How can she accomplish this? Two types of ex ante capital structure regulation could increase the number of informed investors. First, at time 0 the planner could announce a limit on the issuance of risk-free debt in the high state at time 1. Second, at time 0 the planner could announce that the face value of debt in the high state at time 1 must be higher than in the private market equilibrium, increasing the riskiness of the debt. Both interventions effectively allow the planner to subsidize information production by increasing the amount of informationally sensitive securities from which informed investors can profit in good times.

First consider interventions that limit the issuance of risk-free debt in the high state (i.e., lower $d_H$). Using the zero-profit condition of the informed (4), it can be shown that $\partial K/\partial d_H < 0$ for $d_H < v_H^B$. Intuitively, when $d_H < v_H^B$ the debt is risk-free so the informed earn no adverse selection profits in the secondary market. Reducing the amount of risk-free debt issued increases the demand for informed capital in the primary market. This increases the scarcity profits earned by the informed in the primary market and thus encourages more investors to become informed ex ante.

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[10]If (7) does not hold, the planner's ability to restrict informed capital may be limited. As we argue below, lowering $d_H$ (relative to the private market equilibrium) always increases the amount of informed capital, while raising $d_H$ may either increase or decrease it. Thus, if (7) does not hold, the planner either wants to raise $d_H$ if that would lower the amount of informed capital, or she simply accepts the private market outcome as the constrained efficient outcome.

By the first property of scarcity returns $r[\cdot]$, the planner can reduce $d_H$ enough that all loan pools are funded in the low state. Specifically, if the planner were to set $d_H^{**} = d_L^* = v_L^B$, at least $1 - v_L^B$ investors would become informed because in both states they would be maximally scarce and earn returns greater than $c$. The planner can do better and will set $d_H^{**}$ such that $d_L^* < d_H^{**} < d_H^*$ and $K^{**} = K[d_H^{**}] = 1 - v_L^B$ so that all loan pools are funded in the low state.[11] Note that while the planner would like more investors to become informed, it is inefficient for all investors to be informed. She does not set $d_H^{**} = 0$ because securitization has social value in the model, reducing the number of investors who pay the infrastructure cost $c$. However, from the planner's perspective, the private market skimps too much on these costs.

Next consider interventions that increase the riskiness of debt in the high state by raising its face value (i.e., raise $d_H$). For $v_H^B < d_H < v^G$, the sign of $\partial K / \partial d_H$ is ambiguous. Intuitively, once the planner perturbs $d_H$ so that the debt is slightly risky, the informed have two possible sources of profits: scarcity in the primary market for equity and adverse selection in the secondary market for debt. Raising $d_H$ lowers the demand for informed capital in the primary market for equity, reducing the scarcity profits. However, raising $d_H$ also increases the riskiness of the debt, increasing the adverse selection profits the informed can earn. The nature of primary market scarcity returns $r[\cdot]$ determines which effect dominates.

One can show that condition (3) is necessary, but not sufficient, for $\partial K / \partial d_H$ to be positive when $v_H^B < d_H < v^G$. When condition (3) holds, originators optimally choose to issue risk-free debt because the scope for adverse selection in the secondary market for debt is large relative to the scarcity profits of the informed in the primary market for equity. Thus, originators seeking to minimize their costs of financing choose to issue risk-free debt. But at such times the planner may be able to increase the profits of the informed by making the debt riskier and allowing them to earn adverse selection profits.

When the planner can encourage investors to become informed by raising $d_H$ to make the debt riskier, the fact that originators only need to raise \$1 is a constraint on such interventions. Specifically, the planner cannot force originators to raise more than \$1 of total financing. Thus, the planner can only raise $d_H$ to the point where the price of debt equals 1.[12] As shown in Appendix B, a sufficient, but not necessary, condition for the planner to be able to achieve

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[11] We also need to check that uninformed investors have a lower valuation for equity than informed investors at $d_H^{**}$. Note that this generally will be the case because condition (3) holds at the private market solution. The entry of informed capital offsets the increased demand for informed capital when we move from the private market solution to the planner's solution so $r[K^{**}, 1 - d_H^{**}]$ will be similar to $r[K^*, 1 - d_H^*]$.

[12] Recall that we assume that originators cannot raise the full \$1 of financing from debt in the low state. However, they may be able to raise a full \$1 in the high state since the scope for adverse selection is lower.

full funding of loan pools in the low state by making the debt riskier in good times is:

$$\underbrace{\frac{M\ell}{M\left(1-\ell\right)+\ell}\left(1-v_H^B\right)}_{\text{maximum adverse selection profits}} > c\left(1-v_L^B\right) \tag{8}$$

The left hand side of this expression gives the maximum achievable adverse selection profits for the informed in the high state, earned for the value of $d_H$ such that $P\left[d_H;D\right] = 1$. The right hand side is the cost of the information production infrastructure needed to fully fund all loan pools in the low state. Note that $v_H^B$ is likely to be relatively high since the scope for adverse selection should be low in good times. Thus, condition (8) may be relatively difficult to satisfy. Intuitively, the planner is trying to subsidize information production by creating more adverse selection, but it may be difficult to create enough adverse selection in good times to achieve the optimal subsidy level.

The planner's solutions are characterized in the following propositions.

**Proposition 2** *Suppose that conditions (3), (6), and (7) are satisfied. Then the planner can increase total surplus by limiting debt issuance in the high state. This solution is given by the triple $\left(K^{**}, d_H^{**}, d_L^{**}\right)$ such that: (i) $d_L^{**} = d_L^* = v_L^B$ and the planner limits debt in the high state: $d_H^{**} < d_H^*$; (ii) the number of informed investors is greater than in the private market outcome: $K^{**} = K\left[d_H^{**}\right] = 1 - d_L^{**} > K^*$; and (iii) the number of projects undertaken is $N_H^{**} = 1$ in the high state and $N_L^{**} = 1$ so that there is no underfunding in the low state.*

**Proposition 3** *The planner may also be able to increase total surplus by requiring the debt issued in the high state to be riskier. In particular, if condition (8) is satisfied, the planner can also achieve $K^{**} = 1 - d_L^{**} > K^*$, $N_H^{**} = 1$, and $N_L^{**} = 1$ by setting $d_H^{**} > d_H^*$.*

### 2.3.1 Roots of Private Market Inefficiency

Note that the planner's solution can only differ from the private market equilibrium if informed investors cannot capture the full surplus of loan pools in the low state. Intuitively, if informed investors can capture the full surplus in the low state and this covers the costs of information infrastructure, enough investors will become informed to ensure that all pools are financed in the low state.[13] As discussed above, there are a variety of ways to motivate the assumption that informed investors cannot capture the full surplus.

The *key contribution* of our paper is to formalize why originators and investors are unable to overcome this friction by themselves. The planner arrives at a different outcome because she

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[13] Formally, if $r = \left(V_L - 1\right)/\left(1 - v_L^B\right)$ when informed capital is maximally scarce, it is impossible to simultaneously satisfy conditions (6) and (7).

internalizes the externality that originators in the high state impose on originators in the low state. All costs of information production infrastructure are ultimately borne by originators. Some costs are borne directly through the scarcity profits earned by informed investors on the equity they purchase in the primary market at time 1. Others are borne indirectly through the adverse selection discount charged by uninformed investors, which accrues to informed investors as profits earned trading debt in the secondary market at time 2.

Individual originators maximize their profits by minimizing the total transfer to informed investors. Raising as much risk-free debt as possible from the uninformed enables an individual originator to economize on costly informed capital. Since each originator takes the number of informed investors as fixed, there are no costs offsetting this gain. In contrast, the planner recognizes that the use of risk-free debt in the high state affects the ex ante decisions of investors to become informed. Using more risk-free debt in the high state causes fewer investors to become informed and leads to greater underfunding in the low state. When condition (7) is met, the costs of underfunding in the low state outweigh the benefits of economizing on informed capital.

Policies limiting the issuance of safe securities raise the returns to informed investors and reduce originator profits in the high state, and thus represent an "in-kind" subsidy to informed investors. This subsidy can be achieved by either limiting the issuance of risk-free debt in the high state or by making all debt issued in the high state riskier. These are just two different ways of creating more informationally sensitive securities in normal times, which encourages more investors to build infrastructure. In the model, both interventions are equivalent to directly subsidizing the cost of becoming informed and financing this subsidy by taxing originators in the high state. In practice, direct subsidies are unlikely to be feasible because it would be quite difficult for a regulator to verify whether an investor has actually built the requisite information infrastructure in normal times. Thus, from a practical standpoint, the indirect policy of regulating originator capital structure decisions may be more effective than directly subsidizing infrastructure.

**Commitment Problems** Why is the private market unable to overcome the financing friction as the planner does? The answer lies in a pair of commitment problems. First, informed investors cannot commit capital to particular originators in the low state. This means that informed capital is a public good when the low state is realized. Second, originators cannot commit themselves to capital structures other than $d_S^*$ once the state $S$ is realized. Thus, once the high state is realized they will choose $d_H^*$ without taking into account its effect on the number of informed investors, $K$. In the presence of a financing friction, there may be underfunding in the low state if either commitment problem exists. Note that the assumption

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that infrastructure is fixed in the short run is key. If investors could make their infrastructure decisions state-contingent, there would be no need for commitment on the part of originators.

We isolate each commitment problem in turn. First, suppose that investors cannot commit capital to particular originators, but that originators can commit to state-contingent capital structure choices at time 0 before the state is realized. Originators then solve

$$\max_{d_H, d_L} \; p \cdot \pi_H [d_H] + (1 - p) \cdot N_L \cdot \pi_L [d_L],$$

where $\pi_S [d_S]$ is the profit to originators in state $S$ if they choose to issue debt with face value $d_S$. In this problem, $0 \leq N_L \leq 1$ is the probability that the originator is able to finance his loan pool in the low state. $N_L$ is a function of the number of informed investors, $K$, which depends on aggregate $d_H$ through the zero-profit condition (4). An infinitesimal originator cannot affect aggregate $d_H$ and thus takes $N_L$ as given. From his perspective, his choice of $d_H$ only affects his payoff in the high state, so we arrive again at the private market solution. By contrast, the planner recognizes that the choice of $d_H$ impacts $N_L$.

More generally, if individual originators are small but not infinitesimal, $N_L$ does vary with the $d_H$ chosen by an individual originator. However, it varies less from an individual originator's perspective than it does from the planner's perspective. The intuition is that if an individual originator could precommit to a different $d_H$, the benefits of that decision (higher $K$ and more loan pools funded in the low state) cannot be promised exclusively to that particular originator: some benefits will accrue to others.

Now consider the second commitment problem – that originators cannot commit to capital structures than $d_S^*$ once state $S$ is realized. To isolate this problem, suppose that there is a single monopolistic originator who cannot commit to state-contingent capital structure choices at time 0. This monopolist would fully internalize the benefits of having additional informed capital in the low state. However, once the high state is realized, he will still set $d_H^* = v_H^B$. Investors anticipate this at time 0 and choose not to become informed.

In the presence of a financing friction, underfunding will be present unless there is a single monopolistic originator with a commitment technology. Indeed, a monopolist with a commitment technology would arrive at the same solution as the planner.[14] Intuitively, originators always end up bearing the full cost of information infrastructure. However, when there are many small originators, each tries to shirk his share of these costs by issuing large amounts of risk-free debt in the high state. Information infrastructure is a public good and as with any public good the result of this shirking is underprovision in the private market

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[14]Note that for $d_S \leq v_S^B$, $\pi_S [d_S] = V_S - 1 - (1 - d_S) \cdot r_S$. Substituting for $d_L^* = v_L^B$ and using the zero-profit condition of informed investors, the monopolistic originator's objective function can be rewritten $p N_H (V_H - 1) + (1 - p) N_L (V_L - 1) - cK$, which is the same as the planner's problem.

equilibrium. In contrast, a monopolistic originator with a commitment technology has no incentives to shirk since the costs cannot be passed off.

### 2.3.2 Magnitude of Planner's Welfare Improvements

How much can the planner increase total surplus by regulating originator capital structure decisions in the high state? Let $G$ be the difference in total surplus between the planner's solution and the private market equilibrium. This is the NPV of the additional low-state loan pools that the planner can fund net of the cost of additional informed capital:

$$G = (1-p)\left(1 - N_L^*\right)\left(V_L - 1\right) - c\left(K^{**} - K^*\right).$$

The welfare gain is maximized when $K^*$ is as small as possible. Since $r > c$ when informed capital is maximally scarce, there will always be enough informed capital to fund all loan pools in the high state, so $K^* \geq 1 - v_H^B$.[15] Thus, we have

$$G < \left(v_H^B - v_L^B\right)\left((1-p)\frac{V_L - 1}{1 - v_L^B} - c\right) \equiv G_{\max}. \tag{9}$$

As discussed above, for the planner's solution to diverge from the private market outcome, we need a wedge between the social and private returns to informed capital in the low state. As long as the wedge is large enough to ensure that the planner's solution and the private market outcome diverge, expression (9) shows that the maximum welfare gain is independent of the size of the wedge.

What is the minimum wedge required to obtain a gain of $G_{\max}$? Write the return earned by informed investors in the low state as a fraction of the full surplus of loan pools in the low state. That is, let $r_L = (1-w)\left(V_L - 1\right)/\left(1 - v_L^B\right)$, where $w$ is the wedge between the social and private returns to informed capital.

Using conditions (6) and (7), we can show that to obtain $G_{\max}$ the wedge must be at least

$$w > \frac{G_{\max}}{(1-p)\left(V_L - 1\right)}\frac{1 - v_L^B}{v_H^B - v_L^B} \equiv w_{\min} \tag{10}$$

Note that $(1-p)\left(V_L - 1\right)$ is total ex ante surplus achievable in the low state. Thus, expression (10) allows us to relate the planner's maximum welfare gain $G_{\max}$ to the total surplus achievable in the low state. If we want the gain to be $X\%$ of the achievable low state surplus,

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[15]Note that $N_L^* = K^*/\left(1 - v_L^B\right)$ and $K^{**} = 1 - v_L^B$, so we have $G = \left((1-p)\left(V_L - 1\right)/\left(1 - v_L^B\right) - c\right)\left(1 - v_L^B - K^*\right)$ which is decreasing in $K^*$. Substituting $K^* = 1 - v_H^B$, we obtain the expression for $G_{\max}$.

we need a wedge of at least $X\%$ between the private and social returns to informed capital in the low state (assuming $v_H^B < 1$).

The following proposition summarizes the results of this section.

**Proposition 4** *The maximum gain in total surplus that the planner can achieve by regulating debt issuance in the high state is given by (9). The minimum size of the wedge between the private and social returns to informed capital in the low state necessary to obtain this gain is given by (10). These bounds are tight.*

### 2.3.3 Numerical Example

The propositions above show that the planner's solution can diverge from the private market equilibrium. To understand the magnitude of this divergence, we consider a simple numerical example. Let the probability of liquidity shocks be $\ell = 40\%$ and the amount of informed short selling be given by $M = 5$. Let the probability of the high state be $p = 75\%$. Suppose that good loan pools pay $v^G = \$1.30$ and that bad loan pools pay $v_H^B = \$0.99$ in the high state and $v_L^B = \$0.55$ in the low state, and that $\theta = 95\%$ of all loan pools are good. Then we have $V_H = \$1.28$ and $V_L = \$1.26$. We assume that the cost of becoming informed is $c = 10\%$. We parameterize the required returns of the informed as $r[K, e] = 0.40 - 30(K - e)$ so that $r = 40\%$ when the informed are maximally scarce. This implies that informed investors capture $1 - w = 67\%$ of the surplus in the low state when they are maximally scarce.

Table 1 describes the private market equilibrium and the planner's interventions for these parameter values. In the private market outcome, loan pool origination collapses in the low state. Despite the fact that loan pool NPVs are nearly the same in the high state and the low state, only 0.05 loan pools are funded in the low state.

When the planner intervenes and restricts the amount of risk-free debt issued in the high state, all loan pools are funded in the low state. The planner must restrict debt issuance significantly to achieve this outcome because the scarcity returns earned by informed investors decline rapidly when they are not maximally scarce (i.e. $r[\cdot]$ is steeply downward sloping). Note that the gain in total surplus from the planner's intervention is smaller than the increase in the number of low pools funded, reflecting the costs of additional informed capital. Still, the increase in total surplus is economically significant. By reducing the amount of risk-free debt issued in the high state, the planner can increase total surplus by 9.1%.

Given the assumed parameter values, the planner can also increase total surplus by requiring the debt issued in the high state to be riskier. Indeed, the planner is able to fund all loan pools in the low state and achieve the same gains in surplus by making the debt issued in the high state risky. Only a small increase in $d_H$ is required to achieve full funding of loan

Table 1: Numerical Example

| Parameter | Private Market | Planner (lower $d_H$) | Planner (raise $d_H$) |
|---|---|---|---|
| $d_H$ | $0.99 | $0.56 | $0.994 |
| $d_L$ | $0.55 | $0.55 | $0.55 |
| $K$ | 0.02 | 0.45 | 0.45 |
| $N_H$ | 1 | 1 | 1 |
| $N_L$ | 0.05 | 1 | 1 |
| Total Surplus | 0.21 | 0.23 | 0.23 |

pools because the scarcity returns earned by informed investors in the low state nearly cover the costs of information infrastructure. Thus, the planner only needs to increase the adverse selection profits earned by the informed in the high state a little bit to induce more entry.

Figure 3 shows total surplus achieved by the planner for various values of $d_H$. The top two panels use the parameter values from the numerical example above, where the planner can fund all loan pools in the low state by either raising or lowering $d_H$. The top left panel shows that surplus is maximized when the planner sets $d_H = d_H^{**} = \$0.56$ (the solid triangle) and fully funds all loan pools. Surplus is decreasing to the left of $d_H^{**}$ because lowering $d_H$ further increases the demand for informed capital in the primary market, encouraging more investors to become informed at time 0. This is costly and has no benefit since full funding of loan pools in the low state has already been achieved. Surplus is decreasing to the right of $d_H^{**}$ because increasing $d_H$ reduces the demand for informed capital, resulting in fewer investors becoming informed and leading to underfunding in the low state.

The top right panel shows that the planner can also achieve the maximal surplus by raising $d_H$. The private market equilibrium is given by $d_H = d_H^* = \$0.99$ (the solid circle) and the planner can achieve full funding in the low state by setting $d_H = d_H^{**} = \$0.994$. Surplus decreases to the right of $d_H^{**}$ because further raising $d_H$ increases the adverse selection profits available to informed investors in the secondary market, encouraging more investors than are necessary to fund all loan pools in the low state to become informed at time 0. Surplus decreases to the left of $d_H^{**}$ because lowering $d_H$ reduces adverse selection profits, discouraging investors from becoming informed and creating underfunding in the low state.

The bottom two panels of Figure 3 use a slightly different set of parameter values ($v_L^B = \$0.50$ and $r[K, e] = 0.35 - 20(K - e)$) to demonstrate a case where the planner can maximize surplus by reducing $d_H$ but not by raising it. As the bottom right panel demonstrates, the planner can increase surplus relative to the private market equilibrium by raising $d_H$. However, the constraint that originators cannot be forced to raise more than $1 of financing (i.e., we must have $P[d_S; D] \leq 1$) prevents the planner from raising $d_H$ enough to achieve the amount of surplus that can be achieved by lowering $d_H$.
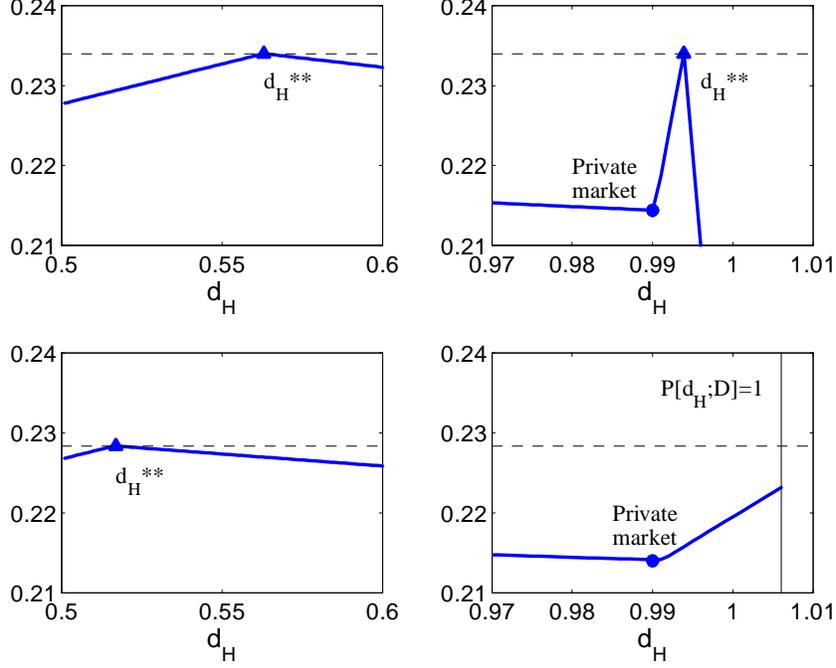
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Figure 3: Surplus as a Function of High State Debt $d_H$.

Figure 4 shows the effects varying $\theta$, which controls the NPV of the average loan pool, and $p$, the frequency of the low state, while holding fixed all other parameters ($v^G$, $v_L^B$, $c$, and $w$). The dashed red line corresponds to condition (6), while the solid blue line corresponds to condition (7). In Regions 1 and 2 the social benefit of additional informed capital does not outweigh its cost.[16] In Region 1 many loan pools are bad ($\theta$ is low), and in Region 2 the low state is infrequent ($p$ is high). In Region 4 there is no underfunding in the private market equilibrium because enough investors become informed to fund all loan pools in the low state. In Region 3 there is socially inefficient underfunding in the private market equilibrium. In this region, the planner would regulate originator capital structure decisions in the high state.

How would the figure change if we modified the other parameters? Changes that increase the social benefit of loan pools (i.e., increasing $v^G$ or $v_L^B$) or decrease the cost of becoming informed $c$ shift the regional borders up and to the left. There would be fewer parameter values where underfunding is efficient and more parameter values where there is no underfunding. Increasing the size of the financing friction $w$ increases the area of Region 3, where underfunding is inefficient. Conversely, when there is no financing friction, Region 3 vanishes.

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[16]In Regions 1 and 2 condition (7) does not hold, so the planner would want to raise $d_H$ if that would lower $K$.
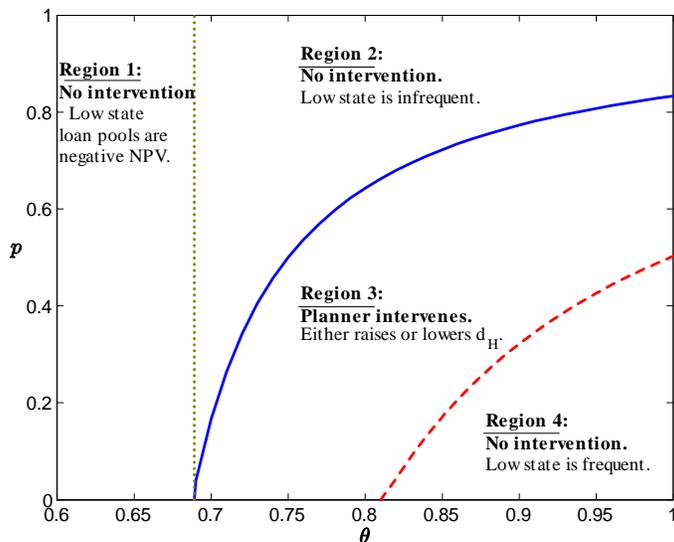
Figure 4: Model Behavior Varying the Frequency of the Low State $p$ and the NPV of the Average Loan Pool $\theta$.

## 2.4 The Planner's Problem: Debt Guarantees

Beyond the ex ante capital structure regulations analyzed above, the planner could also try to increase the amount of debt financing used in the low state ex post. This would better leverage the fixed amount of informed capital available, increasing the number of loan pools it can be spread across. We now consider an intervention where the planner can use debt guarantees, financed by distortionary taxes, to increase the amount of risk-free debt that originators can sell. The Term Asset-backed Securities Loan Facility (TALF) established by the Federal Reserve during the recent financial crisis essentially served this purpose, providing non-recourse leverage to sophisticated investors in securitizations.

Note that this is somewhat different than our analysis of ex ante regulations above. In the previous section, the planner effectively encouraged the use of risky debt financing in the high state by raising $d_H$ without the use of guarantees. Rather than analyzing debt guarantees in this section, we could examine the comparable ex post intervention of raising $d_L$. In other words, the planner would simply force originators to use more and, hence, riskier debt financing in the low state.

We do not consider this intervention for two reasons. First, it is not robust within the model. Our model has the flexibility to capture the idea that uninformed investors suffer from Knightian uncertainty and are ambiguity averse as in Caballero and Krishnamurthy (2008) and Easley and O'hara (2010). Specifically, if they were uncertain about the true values of $\ell$ and $M$, ambiguity averse uninformed investors would make the "worst case" assumption

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that $\ell = 1$ and $M \to \infty$, implying that $P[D; d_S] = \min\{v_S^B, d_S\}$. If uninformed investors behave in this manner, an ex post intervention to raise $d_L$ would be ineffective. Uninformed investors would never pay more than $v_L^B$ for debt in bad times, regardless of its face value. Second, unmodeled frictions would likely render the intervention ineffectual in practice. For instance, uninformed investors accustomed to buying safe securities may require approval from investment committees or management before they can start buying risky securities. In contrast, the ex ante regulations we consider above force the structure of markets to adapt before bad times come. Thus, we analyze the ex post provision of debt guarantees, which we believe is a more realistic intervention in bad times.

We continue to assume that condition (7) is met so that it is optimal for all loan pools to be financed in the low state. We assume that the planner finances guarantees using distortionary taxes, which carry deadweight loss $\frac{1}{2}\gamma\tau^2$ when amount $\tau$ is raised. If the planner guarantees debt up to face value $d_L$, she will have to raise taxes to make a total of $\tau = (1-\theta)\left(d_L - v_L^B\right)$ in guarantee payments, resulting in a deadweight loss of $\frac{1}{2}\gamma(1-\theta)^2\left(d_L - v_L^B\right)^2$.

The planner first sets the optimal $d_L$ and then adjusts $d_H$ so that all loans pools can be financed in the low state (i.e., sets $d_H$ such that $K[d_H] = 1 - d_L$).[17] Thus, the planner's objective function can be written as

$$p(V_H - 1) + (1-p)(V_L - 1) - c(1 - d_L) - \frac{1}{2}(1-p)\gamma(1-\theta)^2\left(d_L - v_L^B\right)^2.$$

The planner trades off the costs of additional informed capital against the distortionary costs of debt guarantees. The optimal face value of guaranteed debt is given by

$$d_L^{***} = v_L^B + \frac{c}{\gamma(1-p)(1-\theta)^2}. \tag{11}$$

The planner's solution can be summarized by the following proposition.

**Proposition 5** *Suppose that conditions (3), (6), and (7) are satisfied. Then the planner's solution is a triple $(K^{***}, d_H^{***}, d_L^{***})$ such that: (i) $d_L^{***}$ is given by (11); (ii) $K^{***} = 1 - d_L^{***}$; (iii) $d_H^{***}$ satisfies (4) given $K^{***}$ and $d_L^{***}$; and (iv) the number of projects undertaken is $N_H = 1$ in the high state and $N_L = 1$ in the low state.*

**Corollary 1** *The planner's solution with debt guarantees approaches the planner's solution without guarantees as the distortionary costs of debt grow large: $(K^{***}, d_H^{***}, d_L^{***}) \to (K^{**}, d_H^{**}, d_L^{**})$ as $\gamma \to \infty$. Furthermore, there is a critical value $\overline{\gamma}$ such that for $\gamma > \overline{\gamma}$ the planner's solution involves a combination of debt limits and debt guarantees: $d_H^{***} < d_H^*$ and $K^{***} > K^*$.*

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[17]For simplicity, we only consider lowering $d_H$ in this section. As discussed above, the planner could also potentially raise $d_H$ to encourage the entry of informed investors.

### 2.4.1 Desirability of Debt Guarantees

The optimal level of guarantees equates the marginal deadweight cost of taxation with the marginal cost of additional informed capital, $c$. An important distinction between using guarantees ex post and regulating capital structure ex ante is that the costs of guarantees are only borne in the low state, whereas the costs of additional informed capital are borne unconditionally. Thus, ex post guarantees become more attractive as either $p \to 1$ so that crises are extremely rare or as $\theta \to 1$ so that guarantees are relatively inexpensive.

The planner always opts to guarantee some debt because there is no other taxation in this economy. Thus, regardless of the value of $\gamma$, the first dollar of taxation has marginal cost 0 so that guarantees are initially quite appealing. In an economy where the level of taxation is already high, the planner might not opt to use any debt guarantees.

The corollary notes that as taxation becomes increasingly expensive (i.e., as $\gamma$ increases), the planner will rely less on guarantees and more on altering $d_H$. Of course, debt guarantees may create distortions unrelated to taxes. For instance, the expectation of ex post guarantees may create moral hazard problems or distort the ex ante price of risk, potentially leading to overinvestment in good times. We can think of these costs as being folded into $\gamma$.

### 2.4.2 Numerical Example (continued)

We now add debt guarantees to our numerical example. Recall that the private market equilibrium is given by $d_H^* = \$0.99$, $d_L^* = \$0.55$, and $K^* = 0.02$, and the planner's solution involving only debt limits is given by $d_H^{**} = \$0.56, d_L^{**} = \$0.55$, and $K^{**} = 0.45$.

For $\gamma = 1000$, the planner's solution is given by $d_H^{***} = 0.72$, $d_L^{***} = 0.71$ so the planner uses a combination of debt limits in the high state and debt guarantees in the low state. We have $K^{***} = 0.29$, so that all loan pools are funded in the low state. Total surplus is 0.24, an increase of 13% over the surplus achieved in the private market equilibrium. The value of $\overline{\gamma}$ is 356. For any $\gamma > 356$, the planner's intervention will involve a combination of debt limits and guarantees. While these values of $\gamma$ seem large, they may be reasonable considering that $\gamma$ represents both the direct and indirect distortionary costs of debt guarantees.

## 3 Extensions

We now consider several extensions to the baseline model presented above. First, in Section 3.1 we explicitly add asset pooling to the model, which allows us to contrast securitization markets to the market for long-term corporate bonds. In Section 3.2 we add aggregate risk to the model. Finally, in Section 3.3, we relax the assumption that the payoffs on loan pools are

binary. Once we allow for continuously distributed payoffs, originators find it optimal to issue debt that is relatively low-risk and informationally insensitive, but not completely risk-free.

## 3.1 Adding Asset Pooling

In the baseline model, we take loan pool payoffs as given. The instability of the private market equilibrium is driven by the fact that bad loan pools are much worse in the low state than in the high state (i.e., $v_L^B < v_H^B$) so that the amount of financing that can be raised from uninformed investors drops substantially.

Why should this be the case in securitization markets? Pooling loans diversifies away idiosyncratic risk, leaving behind only systematic risks. However, loadings on systematic risk factors may vary across loan pools. For example, in good times the worst pools of subprime mortgages may not perform much differently than the best pools. But in bad times, the difference between good and bad pool payoffs may become large.

A simple way to express this idea is to assume that individual loan payoffs can be written as $v_i = \alpha - \beta_i f + \varepsilon_i$, where $f \in \{0, F\}$ represents systematic risk, $\beta_i \in \{0, 1\}$ represents loadings on this risk, and $\varepsilon_i \in \{-\varepsilon, \varepsilon\}$ is an idiosyncratic shock. In good times, $f = 0$ and an asset's payoff is only affected by its idiosyncratic risk $\varepsilon_i$, not its $\beta$. However, in bad times, $f = F$ and the asset's $\beta$ does affect its payoff. If we only pool assets with the *same* $\beta$, we eliminate idiosyncratic risk but not systematic risk, so diversified pools always pay $v^G = v_H^B = \alpha$ in good times, but can pay either $v^G = \alpha$ or $v_L^B = \alpha - F$ in bad times. In contrast, an undiversified asset can pay either $\alpha + \varepsilon$ or $\alpha - \varepsilon$ even in good times. Thus, the variance of payoffs on a diversified asset pool is low in good times and rises in bad times, while the variance of payoffs on an undiversified asset is high even in good times.

This argument also suggests an important distinction between long-term corporate bond markets and securitization markets within the model. The financial performance of an individual corporation can be quite poor even in good times. In other words, $v_H^B$ may be quite low in the corporate context. As a result, there are always many informationally sensitive claims for informed investors to purchase, and incentives to build information infrastructure are strong even in good times. Thus, the model suggests that a lack of informed investors is unlikely to constrain corporate issuance in bad times.[18] And indeed, while the corporate bond market appears to go through cold spells with little issuance, it does not seem to suffer from complete shutdowns due to the inability of uninformed investors to evaluate corporate credit.

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[18]Formally, when $v_H^B$ and $v_L^B$ are both low, condition (6) cannot be satisfied and enough informed capital enters to fund all projects in the low state. If condition (3) holds, we will have $d_H^* = v_H^B$ and $d_L^* = v_L^B$. Then, as $v_H^B - v_L^B \to 0$, $p \cdot r\left[K, v_H^B\right]\left(1 - v_H^B\right) / \left(1 - v_L^B\right) + (1-p) \cdot r\left[K, v_L^B\right] \to r\left[K, v_L^B\right]$. Since $c < r\left[1 - v_L^B, v_L^B\right]$ and $\partial r / \partial K < 0$, this implies $K^* > 1 - v_L^B$ so all pools are funded.

For instance, quarterly issuance of consumer asset-backed securities (ABS), securitizations backed by credit cards, student loans, and auto loans, averaged $53 billion per quarter from 2007Q4-2008Q2 but only $11 billion per quarter from 2008Q3-2009Q1 in the depths of the financial crisis. In contrast, non-financial investment grade corporate bond issuance averaged $100 billion per quarter over both periods.

## 3.2   Adding Aggregate Risk

A second extension of our model allows us to capture aggregate uncertainty at time 1, in contrast to the baseline model where all aggregate uncertainty is resolved at time 1.

We now assume that all loan pools are homogenous and well diversified, but that an uncertain fraction of the loans in the pools are bad. Good loans pay $v^G$ and bad loans pay $v^B$ irrespective of the aggregate outcome. At time 1 the state $S$ is revealed, but now the state reveals the quantity of aggregate risk, but not its realization. Specifically, the mix of good and bad loans is still uncertain at time 1 and will be determined at time 2 by a macroeconomic shock that can either be positive or negative, denoted $O \in \{P, N\}$. In both states, the probability of a positive shock is $q$ and that of a negative shock is $1 - q$. If the shock is positive, the fraction of good loans in each pool is $f^P$ irrespective of the state. If the shock is negative, the fraction of good loans is $f_S^N$ in state $S$. We assume that $f_L^N << f_H^N < f^P$ so the fraction of good loans is lower if a negative shock occurs in the low state than if a negative shock occurs in the high state. The state $S$ reveals the quantity of aggregate risk, and the arrival of the low state at time 1 reveals lower aggregate expected payoffs and higher aggregate uncertainty, or what Geanakoplos (2009) calls "bad, scary news".

We assume that the benefits of being informed involve learning about the aggregate shock at time 2. Specifically, at time 2 informed investors learn whether the aggregate shock will be positive or negative, while uninformed investors and market makers only learn this information at time 3. The informed will then trade in the secondary market, shorting debt and off-loading equity if the aggregate shock is negative. To prevent the volume of trade from revealing the shock, we follow Rock (1986) and assume that the uninformed market makers must simply post a bid price at time 2 and cannot condition their bid on the volume of trade. Under this assumption, uninformed market makers charge an adverse selection discount at time 2 since they know they will end up buying more when the aggregate shock is negative.

In state $S$, the expected value of each loan pool is $v^P = f^P v^G + \left(1 - f^P\right) v^B$ if the aggregate outcome is positive or $v_S^N = f_S^N v^G + \left(1 - f_S^N\right) v^B$ if the outcome if negative. As a result, the formal analysis for the baseline model carries through exactly if we replace $v^G$ with $v^P$, $v_S^B$ with $v_S^N$, and $\theta$ with $q$. Specifically, if the low state arrives at time 1, the uninformed charge a steeper discount because they fear adverse selection by investors who have learned more

about aggregate loan payoffs.

Note that the nature of information is somewhat different here than in the baseline model. Adverse selection operates at the asset class level as opposed to the security level: it is a general inability to understand a given asset class that causes the uninformed to move to the sidelines in bad times. This is a somewhat distinct mechanism underlying the shutdowns of markets for near-riskless assets, and may in fact be an important mechanism in reality.

## 3.3 Allowing for Continuous Loan Pool Payoffs

Lastly, we relax the assumption that loan pool payoffs are binary. We analyze the model under the assumption that the payoffs to loan pools of type $Q$ in state $S$ have cumulative distribution function $F_S^Q[v]$. We assume $F_H^G[v] \leq F_H^B[v]$, $F_L^G[v] \ll F_L^B[v]$, and $F_H^B[v] \ll F_L^B[v]$. As above, the private market equilibrium can be unstable, with a lack of informed capital constraining loan pool origination in the low state, and the planner will intervene to increase the issuance of risky securities, encouraging more investors to become informed.

Two additional economic intuitions arise with this extension. First, originators find it optimal to issue debt that is somewhat risky, in contrast to the baseline model where originators wanted to issue risk-free debt. With continuously distributed loan pool payoffs, the scope for adverse selection rises smoothly as the face value of debt increases. Thus, originators optimally choose an interior face value of debt, trading off the adverse selection costs of risky debt against the higher returns required by informed investors who purchase equity.

Second, the equilibrium response of originators in the low state may lower the social returns to ex ante interventions in the high state. In particular, increasing the number of informed investors makes them less scarce, lowering the returns they can earn in the primary market for equity. In response, originators lower $d_L^*$, issuing less debt and more equity. Since each originator is consuming more informed capital, this means that fewer loan pools can be financed relative to a world where originators do not alter $d_L$ from the private market equilibrium. Thus, the response of originators *lowers* the social returns to a given increase in the number of informed investors. This mechanism does not come into play in the discrete payoff version of the the model because originators are at a corner solution in the low state.

### 3.3.1 Private Market Equilibrium

**Security Prices and Capital Structure**  Our analysis of the continuous model proceeds analogously to our analysis of the baseline model above. Specifically, the price uninformed are willing to pay for debt claims at time 1 is the same as (1) replacing $\min\{v^G, d_S\}$ by

$E_S^G \left[ \min \{v, d_S\} \right]$ and $\min \{v_S^B, d_S\}$ by $E_S^B \left[ \min \{v, d_S\} \right]$.[19] Similarly, the price informed investors are willing to pay for equity claims is the same as (2) replacing $\max \{v^G, d_S\}$ by $E_S^G \left[ \max \{v, d_S\} \right]$ and $\max \{v_S^B, d_S\}$ by $E_S^B \left[ \max \{v, d_S\} \right]$. As in the baseline model originators choose $d_S$ to maximize $P \left[ d_S; E \right] + P \left[ d_S; D \right]$. The first order condition for $d_S$ is

$$\underbrace{(1 - F_S \left[ d_S^* \right]) \frac{r_S}{1 + r_S}}_{\text{Marginal cost of equity}} = \underbrace{\frac{M}{M + \ell} \theta \ell \left( F_S^B \left[ d_S^* \right] - F_S^G \left[ d_S^* \right] \right)}_{\text{Marginal cost of debt}} \tag{12}$$

where $F_S \left[ \cdot \right] = \theta F_S^G \left[ \cdot \right] + (1 - \theta) F_S^B \left[ \cdot \right]$ is CDF of the average pool payoff. This expression is the generalization of (3) to the case where pool payoffs are continuously distributed.[20] Specifically, it equates the marginal cost of equity due to the higher required returns of the informed with the marginal cost of debt due to the adverse selection discount charged by the uninformed.

**Example: Uniform Distribution**  To see that originators choose to issue risky debt in this more general model, consider the case where loan pool payoffs are uniformly distributed. Suppose that bad pool payoffs are uniformly distributed on $\left[ v_S^B, v_S^B + \sigma \right]$ in state $S$ and good pool payoffs are uniformly distributed on $\left[ v^G, v^G + \sigma \right]$ in both states. In Appendix B, we calculate the optimal face value of debt and implied default probabilities. To understand the default probabilities implied by this example, we calculate the probability of default at optimal face value of debt for a variety of parameter values. We hold fixed $v^B = 0.2$, $v^G = 0.9$, $\sigma = 0.9$, $\theta = 0.95$, and $M = 5$, and vary $r$ and $\ell$. These parameters capture the idea that while most loan pools are good the payoffs on bad loan pools can be quite low.

The default probabilities we calculate are best thought of as the probability of default over the life of the security, which is typically 5-10 years for securitizations of consumer debt. For reference, 10-year default probabilities historically average about 1% for AAA corporate bonds and about 2.5% for AAA consumer ABS (Moody's 2010).[21] Table 2 shows that the model is able to produce similarly low probabilities of default, particularly when the required return of informed investors is relatively low.

**Investor Decisions at Time** $0$  The private market equilibrium is analogous to what we derived in the baseline model. For there to be underfunding in the low state, we need (6) to

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[19] $E_S^Q \left[ \cdot \right]$ denotes the expectation over distribution $F_S^Q \left[ \cdot \right]$.

[20] In the case of discrete payoffs $F_S^Q \left[ d_S \right] = 1\{d_S \leq v_S^Q\}$. Thus, for $v_S^B < d_S < v^G$, the marginal cost of equity is $\theta r_S / (1 + r_S)$ and the marginal cost of debt is $\theta \ell M / (M + \ell)$. These are both expressed as the costs *relative* to an MM world where neither the adverse selection or scarcity frictions is operative. Thus, originators choose to issue perfectly riskless debt if (3) holds.

[21] Consumer ABS does not include mortgage-backed securities or CDOs. The 10-year default probability for AAA private-label MBS is 5.6%, while the 10-year default probability for AAA CDOs is 43%.

Table 2: Default Probabilities with Continuous Payoffs

|   |   | $\ell$ | | | |
|---|---|---|---|---|---|
|   |   | 0.1 | 0.2 | 0.3 | 0.4 |
|   | 0.01 | 0.52% | 0.27% | 0.18% | 0.14% |
| $r$ | 0.05 | 2.5% | 1.3% | 0.88% | 0.67% |
|   | 0.1 | 20% | 2.4% | 1.7% | 1.3% |
|   | 0.2 | 57% | 15% | 3.0% | 2.3% |

be satisfied. Under this assumption, we will have $1 - P\left[d_H^*; D\right] < K^* < 1 - P\left[d_L^*; D\right]$ and the amount of informed capital that enters satisfies the zero profit condition (4).[22] The following proposition summarizes the private market equilibrium in this extension of the model.

**Proposition 6** *Suppose that condition (6) is satisfied. Then the private market equilibrium is a triple $(K^*, d_H^*, d_L^*)$ such that: (i) originator capital structure decisions $d_S^*$ satisfy (12); (ii) $K^*$ satisfies the time $0$ zero-profit condition (4); and (iii) the number of loan pools originated is $N_H^* = 1$ in the high state and $N_L^* = K^* / \left(1 - P\left[d_L^*; D\right]\right) < 1$ in the low state.*

### 3.3.2 The Planner's Problem

The planner's solution is similar to what we derived in the baseline model. The planner wishes to encourage more informed capital to enter by either raising or lowering $d_H$ if:

$$(1-p)(V_L - 1) \left( \overbrace{\frac{1}{1 - P\left[d_L; D\right]}}^{\text{Direct term}} + \overbrace{\frac{K}{\left(1 - P\left[d_L^*; D\right]\right)^2} \overbrace{\frac{\partial P\left[d_L^*; D\right]}{\partial d_L^*}}^{+} \overbrace{\frac{\partial d_L}{\partial K}}^{\leq 0}}^{\text{Indirect term due to response of } L\text{-state originators}} \right) > c. \quad (13)$$

The first term gives the generalization of condition (7). The second term is new and *lowers* the social returns to a given increase in $K$. The intuition is that increasing $K$ lowers $r_L$ which causes originators to issue less debt and more equity in the bad state. Individual originators in the $L$ state do not internalize the fact that using more equity lowers the probability that other originators obtain funding. In other words, informed capital suffers from a tragedy of the commons problem which lowers the social returns to interventions in the high state designed to raise $K$. As in the baseline model, whether the planner wishes to lower $d_H$ or raise $d_H$ depends on the sign of $\partial K^* / \partial d_H$.

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[22]To extend the previous analysis to the continuous case, we obviously must use the $P\left[d_S^*; D\right]$ function for continuous payoffs in (6) and (4). Furthermore, the secondary market adverse selection profits of the informed in (5) are now given by $(M/ (M + \ell)) \ell\theta \left(E_S^G \left[\min \{v, d_S^*\}\right] - E_S^B \left[\min \{v_S^B, d_S^*\}\right]\right)$.

**Proposition 7** *Suppose that conditions (6) and (13) are satisfied. Then the planner's solution is a triple $(K^{**}, d_H^{**}, d_L^{**})$ such that: (i) $d_L^{**} = d_L^*$ ; (ii) $K^{**} = 1 - P[d_L^{**}; D] > K^*$; and (iii) the number of projects undertaken is $N_H^{**} = 1$ in the high state and $N_L^{**} = 1$ in the low state. This can always be implemented by choosing some $d_H^{**} < d_H^*$. It may also be possible to implement this outcome by choosing some $d_H^{**} > d_H^*$.*

# 4 Discussion

In this section, we first discuss the empirical implications that distinguish our model from other explanations of securitization market collapses. We then examine several historical shutdowns of markets for near-riskless securities, arguing that our model describes a key mechanism underlying these past market freezes. Finally, we discuss the distinctive policy implications that flow from our model.

## 4.1 Empirical Implications

In addition to our model, several other explanations have been advanced for the collapse of securitization markets in the recent financial crisis. Explanations based on fire sales have received significant attention in recent empirical and theoretical work.[23] In fire-sales models, forced liquidations by leveraged investors create attractive investment opportunities in the secondary market, which draw capital away from the primary market.

Such models imply very different patterns of ABS holdings and flows among investors than our model. In particular, a key implication of the fire-sales view is that aggregate holdings should move from leveraged, sophisticated investors to unleveraged, unsophisticated investors over the course of the crisis. In contrast, our model suggests that informed investors should take on a bigger role in bad times as uninformed investors move to the sidelines. It would be possible to distinguish between these two contrasting views using data on the ABS holdings of various investor types through the crisis.

A second empirical implication of our model is that the instabilities associated with near-riskless debt will be most severe in markets with a large number of small originators because large, repeat originators should partially internalize the benefits of cultivating an informed investor base.[24] Fire sales models make no such prediction. The structure of the primary

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[23] On the empirical side, see Gorton and Metrick (2010, 2011) and He, Khang, and Krishnamurthy (2010). On the theoretical side, see Brunnermeier and Pedersen (forthcoming), Davila (2011), Geanakopolos (2009), Stein (2010), and Shleifer and Vishny (2010a,b).

[24] Some of the largest debt issuers do appear to make an effort to cultivate their investor bases. For instance, since it is a true monopolist, the U.S. Treasury can make long-term investments to attain low and stable financing costs. Treasury spent several years in the late 1990s developing a market for inflation-protected

market has no bearing on the potential for forced liquidations in the secondary market.

Our model also has implications that distinguish it from accounts that emphasize neglected risks or mistakes by uninformed investors (see e.g., Coval, Jurek, and Stafford (2009a,b) and Gennaioli, Shleifer, and Vishny (2011)). Such accounts cannot explain recurring shutdowns in markets for near-riskless securities without appealing to recurring mistakes, which may be unlikely if sophisticated investors learn from mistakes. By contrast, our model suggests an externality that can lead to recurring breakdowns in markets for near-riskless assets. Identifying a clear market failure and regulations to address it is an important step in terms of normative analysis. However, it is not our intention to suggest that mistakes did not play a role in the recent crisis. Indeed, if uninformed investors neglect certain risks in normal times, this would likely exacerbate the basic inefficiency in our model. Specifically, such mispricing would make financing from uninformed investors even more attractive to issuers in good times, leading to even greater underinvestment in information infrastructure by investors.

A third set of accounts of the recent financial crisis emphasize investor over-reliance on credit ratings. According to these accounts, many investors outsourced their credit analysis to the credit rating agencies prior to the crisis, but then lost faith in credit ratings as many AAA-securities suffered downgrades in 2007 and 2008. Unable to analyze securities themselves, these investors simply withdrew from the market.

These accounts correspond closely to the mechanism in our model. Investors who outsource their analysis to rating agencies economize on the costs of information infrastructure, but withdraw from the market when they lose faith in the rating agencies in bad times. In this interpretation of the model, our results suggest that originators may rationally choose to issue large quantities of highly-rated securities to outsourcing investors in good times, even if they foresee the possibility that these investors will exit the market in bad times.

## 4.2 Historical Episodes

With these empirical implications in mind, we now describe four historical episodes that we argue illustrate the mechanism in our model at work. The episodes are: (i) the shutdown of the market for non-mortgage consumer credit securitizations in 2008, (ii) the collapse of the market for high-yield collateralized debt obligations (CDOs) in 2002, (iii) the collapse of the market for collateralized mortgage obligations (CMOs) in 1994, and (iv) the collapse of the market for non-financial commercial paper following the Penn Central default in 1970. In each case, we argue that a lack of analytical infrastructure forced uninformed investors to move to the sidelines following a rise in uncertainty.

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securities, despite the fact that these instruments were initially quite illiquid and thus expensive from the issuer's perspective (Dudley, Ezer, and Roush 2009 and Longstaff, Fleckenstein, and Lustig 2010).

### 4.2.1 Consumer Credit Securitizations in 2008

Figure 5 depicts the late-2008 collapse in issuance of securitizations backed by credit card debt, auto loans, and student loans. Underwriting standards deteriorated less prior to the crisis in non-mortgage credit markets than in the mortgage market (Dudley 2009). Nonetheless, issuance of consumer ABS completed collapsed during the financial crisis in late 2008.[25]

Unlike the market for subprime mortgage securitizations, the shutdown of the consumer ABS market was not driven by investor losses, which suggests that forced liquidations were not a key driver. Instead, as Donald Kohn, the Vice Chairman of the Federal Reserve, explained "Investors became wary of all structured securities" (Kohn 2009). This broad retreat from the market could be ascribed to "the fact that these securities were often complex and heterogeneous and, thus, hard to value" (Dudley 2009). This suggests that policy makers viewed the lack of information infrastructure as an important factor contributing to the shutdown of this market. Market participants also recognized that the sudden withdrawal of a large class of uninformed investors was a problem. Indeed, in late 2008 the American Securitization Forum (ASF) to call for a "new investor base" to help speed the recovery of securitization markets. The ASF also recommended that traditional investors in securitizations "develop additional capabilities to analyze and manage credit, market, liquidity, and other risks."

The policy response to the collapse of this market also suggests that there were not enough informed investors to offset the withdrawal of uninformed investors. Specifically, the Federal Reserve introduced the TALF program to provide leverage to sophisticated investors buying consumer ABS. These investors had not traditionally played a large role in the market, but they had the information infrastructure needed to evaluate new issues. Like the debt guarantees studied in Section 2.4, TALF effectively increased the number of securitizations that could be funded with limited informed capital.

### 4.2.2 High Yield Collateralized Debt Obligations in 2002

While the recent financial crisis is the most prominent example of the collapse of a market for near-riskless securities, it is not the only example. There have been similar episodes in the past, suggesting that mistakes may not fully explain these collapses. For instance, the market for high-yield CDOs, securitizations where the underlying collateral is high-yield bonds, collapsed in 2002. This market grew rapidly in the late 1990s and early 2000s, largely based on the participation of investors who did not "have the monitoring capabilities to track their investments, or infrastructure to examine them on a regular basis" (Pacelle and

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[25]This collapse was not simply due to declining demand for consumer credit. According to the Federal Reserve's G.19 release, securitized consumer credit outstanding fell by nearly 16% from October 2007 to December 2009, whereas total consumer credit outstanding fell by only 1% over the same period.
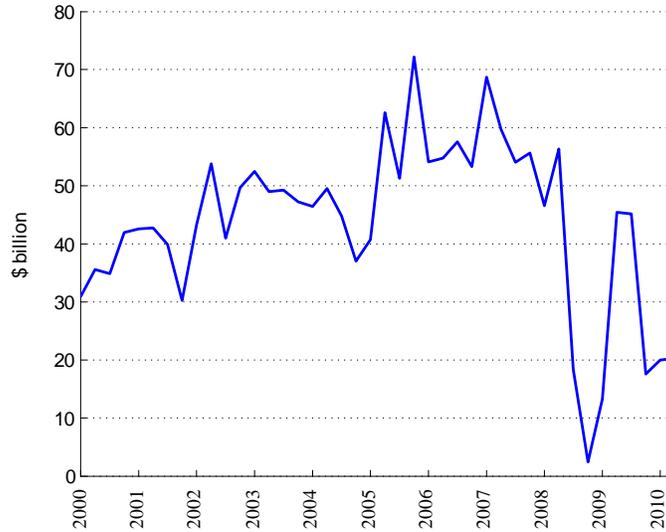
Figure 5: Quarterly Issuance of Consumer Asset-Backed Securities.
(Source: Thompson SDC)

Zuckerman 2001). The market collapsed in the run-up to the Worldcom default in July 2002, as uninformed investors who did not have the ability to analyze CDOs withdrew once they lost faith in credit ratings. These investors also made an effort to increase their analytical infrastructure after the crash. For instance, according to the Financial Times, "Moody's KMV, the credit risk subsidiary of Moody's, says it has been recently receiving more phone calls from investors asking for information on how to analyze CDO structures better" (Wiggins 2002).

This episode is particularly interesting because the market for the underlying assets (high-yield bonds) did not collapse. As Figure 6 shows, high yield bond issuance was actually increasing at the same time that high yield CDO issuance was collapsing. In the context of our model, this can be explained by the fact that many high-yield bonds were still held in untranched form. Thus, many investors had significant information production infrastructure and were able to provide financing.

### 4.2.3 Collateralized Mortgage Obligations in 1994

The collapse of the market for collateralized mortgage obligations (CMOs) in 1994 is another example of instability in markets for near-riskless securities. The assets underlying CMOs are typically fixed rate mortgages guaranteed by the government sponsored enterprises (GSEs), Fannie Mae and Freddie Mac. CMOs became very popular in the late 1980s and early 1990s, accounting for over 70% of GSE mortgage securitizations in 1991. However, the market col-
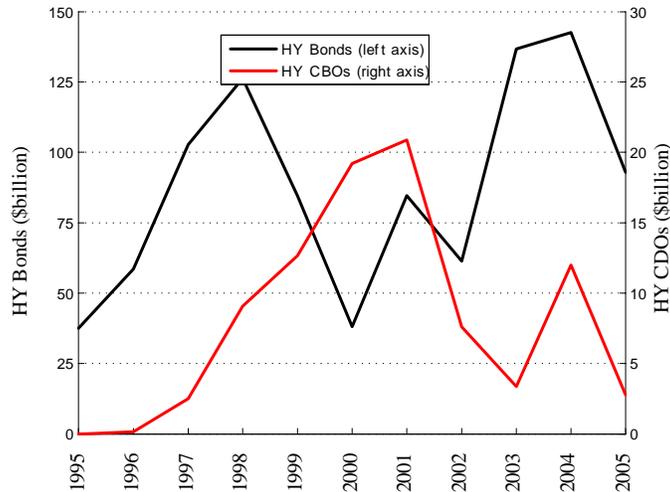
Figure 6: Annual Issuance of High-Yield Bonds and CDOs.
(Source: Thompson SDC)

lapsed in April 1994 when rapid interest rate hikes by the Federal Reserve caused the cash flow behavior of the underlying mortgages to change dramatically. Unable to analyze CMOs to determine whether or not they were actually immune to this cash flow risk, uninformed investors suddenly "[didn't] want to have anything to do with any structured mortgage product" (Carroll and Lappen 1994). While less than 10% of GSE mortgage-backed securities were CMOs in 1995, the market did recover over time.

### 4.2.4 Commercial Paper Markets in 1970 and 2007

Thus far, our examples have focused on long-term securities to highlight the distinction between the instabilities in our model and those that arise when long-term assets are funded with short-term liabilities.[26] However, the creation of short-term claims is an important channel for creating near-riskless securities, and we believe that the externality our model pinpoints may also be present in markets for short-term near-riskless securities.[27]

A prime example is the collapse of the market for non-financial commercial paper following the default of Penn Central in 1970. Commercial paper outstanding contracted by 10% in the three weeks following Penn Central's bankruptcy and by a total of 21% within a year of the default. The withdrawal of uninformed investors again played an important role in this market

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[26]See Brunnermeier and Pedersen (2009) and Brunnermeier and Oehmke (forthcoming).

[27]Although corporations may not be able to create large amounts of adverse selection-free long-term debt (as we argued above), they can issue commercial paper that is adverse selection-free over short maturities. As a result, the commercial paper market may be subject to the instabilities highlighted by our model, even though the market for long-term corporate bonds is not.

shutdown. At the time "non-financial corporations [were] probably the principal purchasers of commercial paper" (Schadrack and Breimyer 1970). To these investors, financial conditions "were not known at the firm-level with any precision," and market participants found it "difficult to assess the ramifications [of the Penn Central default]" (Calomiris 1993).

The indiscriminate panic that took place following the Penn Central default is strikingly similar to events in the ABCP market in the third quarter of 2007. As discussed by Covitz, Liang, and Suarez (2009), ABCP issuers faced large "relatively indiscriminate" withdrawals in 2007Q3. This is not surprising since ABCP investors had "little incentive to invest in information gathering about issuers of commercial paper" (Kacperczyk and Schnabl 2010). This again suggests that the inability of relatively uninformed investors to produce information about asset quality played an important role in exacerbating the crisis.

## 4.3  Policy Implications

In addition to having different empirical predictions than other explanations of securitization market collapses, our model also has distinctive policy implications. For instance, recent work on fire sales, including Stein (2010) and Hanson, Kashyap, and Stein (2011), emphasizes the role of leveraged investors and suggests haircut regulation: creating position-level capital requirements for leveraged investors that would work like margin requirements in equity markets. Such regulations would limit the scope for forced liquidations in bad times, thus reducing the chances of market disruptions.

However, unlevered investors such as mutual funds, pensions, and insurance companies hold a meaningful fraction of securitizations. These investors may still move to the sidelines in bad times if they do not have adequate information production infrastructure. Thus, as our model suggests, one might want to regulate the capital structures of securitization trusts directly. Similar to bank capital requirements,[28] such regulation might stipulate that no more than 50% of the securities backed by a given pool could be rated AAA or AA. This might be done by having AAA-rated senior debt comprise less than 50% of the pool and making the next tranche large enough so that it is rated below AA. This would correspond to the planner lowering $d_H$ in our model. Alternatively, the senior-most tranche could be very large so that

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[28]Our work is also related to the literature on bank capital regulation, which notes that capital requirements encourage market discipline by forcing banks to issue informationally sensitive securities (see, e.g., Dewatripont and Tirole (1993)). As in our model, capital requirements may also provide benefits by creating a group of investors informed about a bank's balance sheet. Such investors may help explain why banks often can raise capital in bad times even though bank managers seem reluctant to do so, perhaps due to agency considerations. Conversely, beyond the benefits they provide in our model, informed investors may play a more traditional disciplining role. Indeed, some have argued that the advent of ABS CDOs, securitizations that use the junior tranches of other securitizations as the underlying assets, pushed informed investors out of the market and "permitted issuers to distribute loan pools with increasingly worse underwriting" (Pozsar et al. 2010).

it is rated below AA, which would correspond to the planner raising $d_H$ in the model. Both regulations create more informationally sensitive securities and, thus, provide incentives for a larger number of investors to "get in shape" in normal times, so that they are able to do the required "heavy lifting" in bad times.

# 5    Conclusion

We present a model in which too many informationally insensitive securities are issued in good times. The model has two key ingredients. First, there is a wedge between the social and private returns to information production infrastructure. Second, the information infrastructure of investors is fixed in the short run.

When combined, these ingredients result in a world where individual originators rationally economize on financing costs in good times by issuing large amounts of informationally insensitive securities to uninformed investors. This reduces the returns that informed investors earn in good times, discouraging investors from building information infrastructure ex ante. In bad times when the amount of financing that can be raised from uninformed investors drops, there may be insufficient informed capital and positive NPV loans may go unfunded.

More broadly, our approach highlights that the infrastructure and organization of professional investors is in part determined by the menu of securities offered by originators. Since robust infrastructure is a public good to originators, it may be underprovided in the private market equilibrium. The individually rational decisions of originators may lead to an infrastructure that is overly prone to disruptions in bad times. Policies regulating originator capital structure decisions may help create a more robust infrastructure.

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# A  Microfounding the Market Power of the Informed

In the main text, we assume that the return earned by informed investors is a function of their scarcity: $r_S = r[K, e_S]$ where $e_S = 1 - P[d_S; D]$ is originators demand for equity. We assumed that $r[\cdot]$ has three properties:

1. Returns to informed capital exceed $c$ when it is maximally scarce: $r[K, e_S] > c$ when $K \leq e_S$.

2. Informed capital earns a higher return when it is more scarce: $\partial r / \partial K < 0$ and $\partial (r[K, e] \cdot e) / \partial e > 0$.

3. There is a financing friction that prevents informed investors from capturing the full surplus associated with loan pools even when they are maximally scarce: $r_L < (V_L - 1) / e_L$ where $V_L = \theta v^G + (1 - \theta) v_L^B$ the expected value of the average loan pool in the low state.

## A.1  Walrasian Pricing

If we assume Walrasian pricing, then we will have $r[K, e_S] = 0$ when $K > e_S$ and $r[K, e_S] = (1 - w)(V_S - 1)/e_S$ when $K \leq e_S$. Here $0 < w < 1$ is the financing wedge; informed investors can only capture fraction $(1 - w)$ of the loan pool surplus even when they are maximally scarce. Now condition (6) in the main text reduces to

$$(1 - p) \cdot r[1 - d_L^*, 1 - d_L^*] = (1 - p)(1 - w)(V_L - 1) / \left(1 - v_L^B\right) < c.$$

If this condition is met, then if $1 - v_L^B$ investors (enough to fund all loan pools in the low state) become informed, they will not earn enough to recoup their infrastructure costs. In this case, then exactly $1 - v_H^B$ investors become informed and there will be underfunding in the low state. The planner then can set $d_H^{**} = v_L^B$ to ensure that all projects are funded in the low state. Social welfare is greater in the planner's solution than the private market outcome if

$$p(V_H - 1) + (1 - p)\frac{1 - v_H^B}{1 - v_L^B}(V_L - 1) - c\left(1 - v_H^B\right) < p(V_H - 1) + (1 - p)(V_L - 1) - c\left(1 - v_L^B\right)$$

which reduces to the familiar condition $(1 - p)(V_L - 1) / \left(1 - v_L^B\right) > c$.

## A.2  Search Version

To obtain returns that are continuous in the scarcity of informed investors, we use a variant of the search/bargaining model of Rubinstein and Wolinsky (1985). Let the discount rate be $\rho$. In our case, the mass of originators (i.e., potential sellers) is $e_S$ and the mass of informed investors (i.e., potential buyers) is $K$, so the fraction of buyers is $\mu = K/(K + e_S)$. Investors and originators bargain over the fraction of total surplus $(V_S - 1)$ that each will receive, with the originator receiving fraction $\lambda$ and the investor receiving fraction $1 - \lambda$. The rate at which investors meet originators is proportional to the number of originators, $\alpha(1 - \mu)$, and the rate

at which originators meet investors is proportional to the number of investors, $\alpha\mu$, for some exogenous contact rate $\alpha$.

Let $W_I$ and $W_O$ be the value functions for investors and originators at the beginning of the game. Given a bargaining outcome $\Lambda$, these can be written as

$$\rho W_I = \alpha\left(1-\mu\right)\left(\left(1-\Lambda\right)-W_I\right) \tag{14}$$

$$\rho W_O = \alpha\mu\left(\Lambda - W_O\right). \tag{15}$$

In the bargaining game, either the investor or originator is randomly chosen and offers a division, $\lambda$. If there is no agreement, the investor and originator wait for interval $\delta$ and then one is randomly selected and offers another division. However, in interval $\delta$ either party can meet a new bargaining partner and leave the current negotiation. One can show that as $\delta \to 0$, the subgame perfect equilibrium in the game is given by the Nash bargaining solution with $W_I$ and $W_O$ as the threat points.[29] Thus, $\lambda$ maximizes $\left(\lambda - W_O\right)\left(1 - \lambda - W_I\right)$, so we have

$$\lambda = \frac{1}{2}\left(1 + W_O - W_I\right) \tag{16}$$

In equilibrium, we have $\Lambda = \lambda$ and solving (14), (15), and (16) for $\lambda$ yields

$$\lambda = \frac{\rho + \alpha\mu}{\alpha + 2\rho}. \tag{17}$$

Taking the limit as $\rho \to 0$ yields $\lambda = \mu$.

Thus, the informed investors (buyers) capture fraction $\left(1-\lambda\right) = \left(1-\mu\right) = e_S/\left(K + e_S\right)$ of the surplus. This fraction is decreasing in $K$ and increasing in $e_S$, the amount of equity financing backing each project. The informed investors (buyers) capture $\left(1-\lambda\right)$ of the surplus $\left(V_S - 1\right)$ in return for an investment of $e_S$, so the return they earn per dollar invested is

$$r_S = \left(1-\lambda\right)\frac{\left(V_S - 1\right)}{e_S} = \frac{V_S - 1}{K + e_S}.$$

Note that

$$r_S = \frac{V_S - 1}{K + e_S} < \frac{V_S - 1}{e_S}$$

so long as $K > 0$. Furthermore, note that $\partial r_S\left[K, e_S\right]/\partial K < 0$ and $\partial r_S\left[K, e_S\right]/\partial e_S < 0$. The total dollar return earned by the informed per pool is

$$r_S\left[K, e_S\right] \cdot e_S = \left(1-\lambda\right)\left(V_S - 1\right) = \frac{e_S}{K + e_S}\left(V_S - 1\right)$$

which is increasing in $e_S$ and decreasing in $K$. Thus, $r_S\left[K, \left(1 - P\left[D, d_S\right]\right)\right] \cdot \left(1 - P\left[D, d_S\right]\right)$ is decreasing in $d_S$.[30] Thus, properties 2 and 3 of the return function assumed in the main text follow from this simple model of search/bargaining.

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[29] As $\delta \to 0$, the prices proposed by the buyer and seller converge to the same limit.

[30] This model also implies that the return earned by uninformed investors is 0 since the mass of buyers (uninformed investors) is infinite and the mass of sellers is finite.

# B Proofs

## B.1 Proof of Proposition 1

We first show that the originator's problem is equivalent to maximizing $P[d_S; E] + P[d_S; D]$. Let $V_E[d_S] = (1 + r_S) \cdot P[d_S; E]$ be the value the equity of the loan pool. To raise $1 - P[d_S; D]$ dollars from informed equity investors, the originator must sell fraction $(1 - P[d_S; D])(1 + r_S)/V_E[d_S]$ of the equity in the pool. Thus, the value of the stake retained by the originator is

$$V_E[d_S]\left(1 - \frac{(1 - P[d_S; D])(1 + r_S)}{V_E[d_S]}\right) = (1 + r_S)(P[d_S; E] + P[d_S; D] - 1).$$

Since originators take $r_S$ as fixed, this is equivalent to maximizing $P[d_S; E] + P[d_S; D]$.

We next show that (as assumed in the text) at $d_S^*$ uninformed investors have higher valuations for debt and informed investors have higher valuations for equity. Informed investors would only be willing to pay $v_S^B/(1 + r_S)$ for debt claims, while uninformed investors are willing to pay $v_S^B$. Similarly uninformed investors would be willing to pay $\theta\left(1 - M\ell(M + \ell)^{-1}\right)\left(v^G - v_S^B\right)$ for equity claims, while informed investors are willing to pay $\theta\left(v^G - v_S^B\right)/(1 + r_S)$. Since (3) implies $1 - M\ell(M + \ell)^{-1} < 1/(1 + r_S)$, informed investors have higher valuations.

The fact that $K^* < 1 - d_L^*$ follows from condition (6), the zero-profit condition of the informed (4), and the continuity of the scarcity returns earned by the informed $r[\cdot]$.

## B.2 Proof of Proposition 2

We first show that total originator surplus can be written as

$$pN_H(V_H - 1) + (1 - p)N_L(V_L - 1) - cK.$$

The profits of originators are given by

$$pN_H(1 + r_H)(P[d_H; E] + P[d_H; D] - 1)$$
$$+ (1 - p)N_L(1 + r_L)(P[d_L; E] + P[d_L; D] - 1).$$

The profits of uninformed investors are given by

$$pN_H((1 - \ell)E[\min\{v_H, d_H\}] + \ell P_2[d_H; D] - P[d_H; D])$$
$$+ (1 - p)N_L((1 - \ell)E[\min\{v_L, d_L\}] + \ell P_2[d_L; D] - P[d_L; D]).$$

The profits of informed investors are given by

$$p\left(N_H r_H(1 - P[d_H; D]) + \frac{M}{M + \ell}\ell\theta\left(\min\{v^G, d_H\} - \min\{v_S^B, d_H\}\right)\right)$$
$$+ (1 - p)\left(N_L r_L(1 - P[d_L; D])\frac{M}{M + \ell}\ell\theta\left(\min\{v^G, d_L\} - \min\{v_S^B, d_L\}\right)\right) - cK,$$

Summing yields $pN_H(V_H - 1) + (1 - p)N_L(V_L - 1) - cK$ as desired. Since investor and market maker profits are zero it follows that total social surplus equals to originator surplus.

As discussed in the text, we will always have $N_H = 1$ since $r > c$ when informed investors are maximally scarce. Enough investors become informed to fund all loan pools in the high state. Now define $K[d_H]$ implicitly using the zero profit condition (4) and use the relation $N_L = K[d_H] / (1 - v_L^B)$ to write total surplus as

$$p(V_H - 1) + (1 - p) \frac{K[d_H]}{1 - v_L^B} (V_L - 1) - cK[d_H].$$

Differentiating with respect to $d_H$ yields

$$\left( (1 - p) \frac{V_L - 1}{1 - v_L^B} - c \right) \frac{\partial K}{\partial d_H}.$$

Write the zero profit condition of the informed as $0 = \Pi(K, d_H, d_L^*[K])$. Then we have $sign(\partial K^* / \partial d_S) = sign(-(\partial \Pi / \partial d_H) / (\partial \Pi / \partial K)) = sign(\partial \Pi_H / \partial d_H)$. So to sign $\partial K / \partial d_H$, we only need to sign $\partial \Pi_H / \partial d_H$. Assuming $N_H = 1$, we have

$$\frac{\partial \Pi_H}{\partial d_H} = \overbrace{\frac{\partial}{\partial d_H} [r_H [K, (1 - P[d_H; D])] (1 - P[d_H; D])]}^{<0} + \overbrace{\frac{M}{M + \ell} \ell\theta (1 [d_H > v_H^B] - 1 [d_H > v^G])}^{\geq 0}.$$

For $d_H < v_H^B$, the second term is zero so we have $\partial \Pi_H / \partial d_H < 0$. Thus, for $d_H < v_H^B$ we will have $\partial K / \partial d_H < 0$, so the planner will be able to increase total surplus by decreasing $d_H$ so long as condition (7) holds.

## B.3   Proof of Proposition 3

When $v_H^B < d_H < v^G$ we have

$$\frac{\partial \Pi_H}{\partial d_H} = (1 - P[d_H; D]) \frac{\partial r_H}{\partial d_H} - r_H \left( \theta - \frac{M}{M + \ell} \ell\theta \right) + \frac{M}{M + \ell} \ell\theta.$$

The sum of the last two terms is greater than zero when condition (3) holds, i.e. exactly when the originators want to issue risk-free debt. Thus, condition (3) is necessary, though not sufficient for the planner to increase surplus by raising $d_H$. If we also have $\partial r_H / \partial e_H < 0$ so that $\partial r_H / \partial d_H > 0$, as is the case in the search model outlined in Appendix A, then we always have $\partial \Pi_H / \partial d_H > 0$ for $v_H^B < d_H < v^G$. However, if $\partial r_H / \partial d_H < 0$, as in the numerical example in Section 2.3, then the sign of $\partial \Pi_H / \partial d_H > 0$ would depend on the magnitude of $\partial r_H / \partial d_H$.

When raising $d_H$ the planner is subject to the constraint that $P[d_H; D] \leq 1$. Thus, for $v_H^B < d_H < v^G$ the maximum value of $d_H$ satisfies

$$1 = \theta d_H + (1 - \theta) v_H^B - \theta\ell M (M + \ell)^{-1} (d_H - v_H^B)$$

$$d_H = v_H^B + \frac{1 - v_H^B}{\theta (1 - \ell M (M + \ell)^{-1})}$$

This value of $d_H$ yields

$$\left(1 - v_H^B\right) \frac{\ell M}{M + \ell - \ell M}$$

of adverse selection profits for the informed in the good state.

To achieve full funding of loan pools in the low state, the planner must induce $K = 1 - v_L^B$ informed investors to enter. The zero profit condition for the informed would then be

$$p\left(r_H \left(1 - P\left[d_H; D\right]\right) + \frac{M}{M + \ell}\ell\theta \left(\min\left\{v^G, d_H\right\} - \min\left\{v_S^B, d_H\right\}\right)\right) + (1 - p)\, r_L \left(1 - v_L^B\right) = c\left(1 - v_L^B\right).$$

If

$$\underbrace{\frac{M\ell}{M\left(1 - \ell\right) + \ell}\left(1 - v_H^B\right)}_{\text{maximum adverse selection profits}} > c\left(1 - v_L^B\right)$$

(this is condition (8) from Section 2.3), then the fact that $r > c$ when informed capital is maximally scarce implies that $(1 - p)\, r_L \left(1 - v_L^B\right) > (1 - p)\, c\left(1 - v_L^B\right)$, so there is a feasible value of $d_H$ that satisfies this zero profit condition.

## B.4  Proof of Proposition 4

We have

$$G_{\max} = \left(v_H^B - v_L^B\right)\left[(1 - p)\frac{V_L - 1}{1 - v_L^B} - c\right].$$

That is, the gain is independent of the size of the wedge, so long as the wedge is large enough.

What is the minimum required size of the wedge required to obtain a gain of $G_{\max}$? We need $w$ such that

$$c > (1 - p)\,(1 - w)\frac{V_L - 1}{1 - v_L^B}$$

so that it is possible to satisfy condition (6). Rearranging to solve for $w$ and substituting the definition of $G_{\max}$ yields

$$w_{\min} > \frac{G_{\max}}{(1 - p)\,(V_L - 1)}\frac{1 - v_L^B}{v_H^B - v_L^B}.$$

## B.5  Proof of Proposition 5

We have

$$d_L^{***} = v_L^B + \frac{c}{\gamma\,(1 - p)\,(1 - \theta)^2}.$$

Note that $d_H^{***}$ is a function of $d_L^{***}$ and $K^{***}$ is a function of $d_H^{***}$. Since $d_L^{***} \to d_L^{**}$ as $\to \infty$, we will have $d_H^{***} \to d_H^{**}$ and $K^{***} \to K^{**}$ as well. The existence of $\overline{\gamma}$ is a consequence of the continuity of the triple $\left(K^{***}, d_H^{***}, d_L^{***}\right)$ in $\gamma$ and the fact that $d_H^{**} < d_H^*$ and $K^{**} > K^*$.

# B.6 Proof of Proposition 6

**Details of the Uniform Distribution Example** Suppose that bad pool payoffs are uniformly distributed on $\left[\underline{v}^B_S, \underline{v}^B_S + \sigma\right]$ in state $S$ and good pool payoffs are uniformly distributed on $\left[\underline{v}^G, \underline{v}^G + \sigma\right]$ in both states. Assume that $\underline{v}^B_S < \underline{v}^G < \underline{v}^B_S + \sigma$ so that there is some overlap between the payoffs on good and bad pools. Under these assumptions, it is easy to show that the optimal face value of debt chosen by originators is

$$
d^*_S = \begin{cases} \underline{v}^B_S + \sigma - \theta\left(\frac{1+r_S}{r_S}\frac{M}{M+\ell}\ell - 1\right)\left(\underline{v}^G - \underline{v}^B_S\right) & \text{if } \underline{v}^G - \underline{v}^B_S < \sigma\frac{\frac{r_S}{1+r_S}}{\theta\frac{\ell M}{M+\ell}+(1-\theta)\frac{r_S}{1+r_S}} \\ \underline{v}^B_S + \sigma\frac{\frac{r_S}{1+r_S}}{\theta\frac{\ell M}{M+\ell}+(1-\theta)\frac{r_S}{1+r_S}} & \text{if } \underline{v}^G - \underline{v}^B_S > \sigma\frac{\frac{r_S}{1+r_S}}{\theta\frac{\ell M}{M+\ell}+(1-\theta)\frac{r_S}{1+r_S}} \end{cases}.
$$

If $\underline{v}^G - \underline{v}^B_S$ is small, then $\underline{v}^G < d^*_S < \underline{v}^B_S + \sigma$ and debt backed by both good and bad pools is risky given the choice of $d^*_S$. If $\underline{v}^G - \underline{v}^B_S$ is large, then $\underline{v}^B_S < d^*_S < \underline{v}^G$ so only debt backed by bad pools is risky. The default probability implied by this choice of $d^*_S$ is $\pi^*_S = \theta \cdot F^G_S\left[d^*_S\right] + (1-\theta) \cdot F^B_S\left[d^*_S\right]$. Specifically, we have

$$
\pi^*_S = \begin{cases} 1 - \frac{\theta}{\sigma}\left(\frac{1+r_S}{r_S}\frac{M}{M+\ell}\ell\right)\left(\underline{v}^G - \underline{v}^B_S\right) & \text{if } \underline{v}^G - \underline{v}^B_S < \sigma\frac{\frac{r_S}{1+r_S}}{\theta\frac{\ell M}{M+\ell}+(1-\theta)\frac{r_S}{1+r_S}} \\ \frac{(1-\theta)\frac{r_S}{1+r_S}}{\theta\frac{\ell M}{M+\ell}+(1-\theta)\frac{r_S}{1+r_S}} & \text{if } \underline{v}^G - \underline{v}^B_S > \sigma\frac{\frac{r_S}{1+r_S}}{\theta\frac{\ell M}{M+\ell}+(1-\theta)\frac{r_S}{1+r_S}} \end{cases}.
$$

**Model with continuous loan payoffs** The price the uninformed are willing to pay for debt claims at time 1 is

$$
P\left[d_S; D\right] = \underbrace{\theta E^G_S\left[\min\left\{v, d_S\right\}\right] + (1-\theta) E^B_S\left[\min\left\{v, d_S\right\}\right]}_{\text{expected value}}
$$
$$
- \underbrace{\left(\frac{M}{M+\ell}\right)\ell\theta\left(E^G_S\left[\min\left\{v, d_S\right\}\right] - E^B_S\left[\min\left\{v, d_S\right\}\right]\right)}_{\text{adverse selection discount}}
$$

where where $E^Q_S\left[\cdot\right]$ denotes the expectation over distribution $F^Q_S\left[\cdot\right]$. The price informed investors are willing to pay for equity claims is

$$
P\left[d_S; E\right] = \frac{\theta E^G_S\left[\max\left\{v, d_S\right\}\right] + (1-\theta) E^B_S\left[\max\left\{v, d_S\right\}\right]}{1+r_S}.
$$

As in the simple discrete model there are two opposing MM violations and originators choose $d_S$ to maximize $P\left[d_S; E\right] + P\left[d_S; D\right]$. The first order condition for $d_S$ is

$$
\underbrace{\left(1 - F_S\left[d^*_S\right]\right)\frac{r_S}{1+r_S}}_{\text{Marginal cost of equity}} = \underbrace{\frac{M}{M+\ell}\theta\ell\left(F^B_S\left[d^*_S\right] - F^G_S\left[d^*_S\right]\right)}_{\text{Marginal cost of debt}}.
$$

## B.7 Proof of Proposition 7

Impact of a small increase in $d_H$ on welfare is

$$\left( (1-p) \frac{\partial N_L}{\partial K} (V_L - 1) - c \right) \frac{\partial K}{\partial d_H}.$$

Recall that $N_L = K/(1 - P[d_L; D])$, so that

$$\frac{\partial N_L}{\partial K} = \left( \overbrace{\frac{1}{1 - P[d_L^*; D]}}^{\text{Direct term}} + \overbrace{\frac{K}{(1 - P[d_L^*; D])^2} \overset{+}{\frac{\partial P[d_L^*; D]}{\partial d_L^*}} \overset{\leq 0}{\frac{\partial d_L^*}{\partial K}}}^{\text{Indirect term due to response of $L$-state originators}} \right)$$

where

$$\frac{\partial d_L^*}{\partial K} = \overbrace{\frac{\partial d_L^*}{\partial r_L}}^{>0} \overbrace{\frac{\partial r_K}{\partial K}}^{<0}.$$

Thus, the planner will want to vary $d_H$ in order to raise $K$ if

$$(1-p)(V_L - 1) \overbrace{\left( \frac{1}{1 - P[d_L; D]} + \frac{K}{(1 - P[d_L^*; D])^2} \frac{\partial P[d_L^*; D]}{\partial d_L^*} \frac{\partial d_L^*}{\partial K} \right)}^{\partial N_L / \partial K} > c.$$

To compute $\partial d_L^* / \partial K$, we need a general equilibrium approach that recognizes that $r_L$ depends on $d_L$ and not just $K$. Recall that originators choose

$$\frac{r_L}{1 + r_L} (1 - F_L(d_L)) - \frac{M}{M + \ell} \ell \theta \left( F_L^B(d_L) - F_L^G(d_L) \right) = 0.$$

The second order condition is

$$-\frac{r_L}{1 + r_L} f_L^B(d_L) - \theta \left( \frac{r_L}{1 + r_L} - \ell \frac{M}{M + \ell} \right) \left( f_L^G(d_L) - f_L^B(d_L) \right) < 0,$$

so that the partial equilibrium response of $d_L$ to a change in $r_L$ is

$$\frac{\partial d_L}{\partial r_L} \Big|_{partial} = \frac{\frac{1}{(1 + r_L)^2} (1 - F_L(d_L))}{\frac{r_L}{1 + r_L} f_L^B(d_L) + \theta \left( \frac{r_L}{1 + r_L} - \ell \frac{M}{M + \ell} \right) \left( f_L^G(d_L) - f_L^B(d_L) \right)},$$

so we would compute

$$\frac{\partial d_L}{\partial K} \Big|_{partial} = \frac{\partial d_L}{\partial r_L} \Big|_{partial} \frac{\partial r_L}{\partial K}.$$

However, we are leaving out the fact that the change in $d_L$ itself impacts $r_L$. Thus, we

need to implicitly differentiate

$$\frac{r_L\left[K,1-P\left[D;d_L\right]\right]}{1+r_L\left[K,1-P\left[D;d_L\right]\right]}\left(1-F_L\left(d_L\right)\right)-\frac{M}{M+\ell}\ell\theta\left(F_L^B\left(d_L\right)-F_L^G\left(d_L\right)\right)=0$$

recognizing that $d_L$ is a function of $r_L$. We have

$$\frac{\partial d_L}{\partial K}|_{GE}=\frac{\frac{1}{(1+r_L)^2}\left(1-F_L\left(d_L\right)\right)}{\frac{r_L}{1+r_L}f_L^B\left(d_L\right)+\theta\left(\frac{r_L}{1+r_L}-\ell\frac{M}{M+\ell}\right)\left(f_L^G\left(d_L\right)-f_L^B\left(d_L\right)\right)-\overbrace{\frac{\frac{\partial r_L}{\partial P\left[D;d_L\right]}\frac{\partial P\left[D;d_L\right]}{\partial d_K}}{(1+r_L)^2}}^{+}}\frac{\partial r_L}{\partial K}.$$

Assuming the denominator is positive, we then we have

$$\frac{\partial d_L^*}{\partial K}|_{GE}<\frac{\partial d_L}{\partial K}|_{partial}<0.$$

The idea is that increasing in $K$ lowers $r_L$ which causes originators to issue less debt and more equity in the bad state. The increase in equity issuance (reduction in debt issuance) further lowers $r_L$, leading originators to issue even more equity.

**Impact of $d_H$ on capital $K$ holding $d_L$ constant**  As before, we need to sign $\partial K/\partial d_H$ to understand whether the planner will want to raise or lower $d_H$ to encourage more investors to become informed. We first assume that we hold $d_L$ fixed as we vary $d_H$. This means that we do not allow originators in the $L$ state to reoptimize $d_L$ in response to any changes in $r_L$ induced by changes in $K$. We relax this assumption below and allow originators to re-optimize.

Recall that the zero profit condition of the informed can be written as

$$0=\Pi\left(K,d_H,d_L\right)=-c+p\left(N_H/K\right)\Pi_H+\left(1-p\right)\left(N_L/K\right)\Pi_L$$

where

$$\Pi_S=r_S\left[K,\left(1-P\left[d_S;D\right]\right)\right]\left(1-P\left[d_S;D\right]\right)+\frac{M}{M+\ell}\ell\theta\left(E_S^G\left[\min\left\{v,d_S\right\}\right]-E_S^B\left[\min\left\{v,d_S\right\}\right]\right)$$

are per pool profits in state $S$ and $N_S/K=\min\left\{1/K,1/\left(1-P\left[d_S;D\right]\right)\right\}$ is the number of projects in state $S$ scaled by $K$. As before, we have $sign\left(\partial K^*/\partial d_S\right)=sign\left(-\left(\partial\Pi/\partial d_H\right)/\left(\partial\Pi/\partial K\right)\right)=sign\left(\partial\Pi_H/\partial d_H\right)$ since $\partial\Pi/\partial K<0$. Thus, we only need to sign $\partial\Pi_H/\partial d_H$. We have

$$\frac{\partial\Pi_H}{\partial d_H}=\overbrace{\frac{\partial}{\partial d_H}\left[r_H\left[K,\left(1-P\left[d_S;D\right]\right)\right]\left(1-P\left[d_H;D\right]\right)\right]}^{<0}+\overbrace{\frac{M}{M+\ell}\ell\theta\left(F_H^B\left[d_H\right]-F_H^G\left[d_H\right]\right)}^{>0}$$

If the second term is not too large (e.g., if debt is nearly riskless so $F_H^B\left[d_H\right]-F_H^G\left[d_H\right]\approx0$), we have $\partial\Pi\left(K,d_H,d_L\right)/\partial d_H=pK^{-1}\partial\Pi_H/\partial d_H<0$ in which case $\partial K^*/\partial d_H<0$. However, if the second term is large, we have $\partial\Pi\left(K,d_H,d_L\right)/\partial d_H>0$ in which case $\partial K^*/\partial d_H>0$.

Noting that

$$\frac{\partial P\left[d_H; D\right]}{\partial d_H} = (1 - F_H\left[d_H\right]) - \left(\frac{M}{M+\ell}\right)\ell\theta\left(F_H^B\left[d_H\right] - F_H^G\left[dH\right]\right)$$

we have $\partial \Pi_H / \partial d_H < 0$ if

$$\frac{M}{M+\ell}\ell\theta\left(F_H^B\left[d_H\right] - F_H^G\left[d_H\right]\right) < (1 - F_H\left[d_H\right])\frac{r_H + \frac{\partial r_H}{\partial e_S}\left(1 - P\left[d_H; D\right]\right)}{1 + r_H + \frac{\partial r_H}{\partial e_S}\left(1 - P\left[d_H; D\right]\right)}.$$

At the private market equilibrium we have

$$\frac{M}{M+\ell}\theta\ell\left(F_H^B\left[d_H^*\right] - F_H^G\left[d_H^*\right]\right) = (1 - F_H\left[d_H^*\right])\frac{r_H^*}{1 + r_H^*} < (1 - F_H\left[d_H^*\right])\frac{r_H^* + \frac{\partial r_H}{\partial e_S}\left(1 - P\left[d_H^*; D\right]\right)}{1 + r_H^* + \frac{\partial r_H}{\partial e_S}\left(1 - P\left[d_H^*; D\right]\right)}.$$

Thus, at the private market outcome, $\partial \Pi_H\left(K^*, d_H^*\right)/\partial d_H < 0$ and $\partial K^*/\partial d_H|_{d_H=d_H^*} < 0$.

This shows that at the private market equilibrium, the planner can always increase surplus by reducing $d_H$. In contrast to the baseline model, small increases in $d_H$ will always lower surplus in the continuous model. However, assuming that $\Pi_H$ is well behaved, we will have $\partial^2 \Pi_H\left(K, d_S\right)/\partial d_H^2 > 0$ so it is possible that larger increases in $d_H$ can increase surplus. Thus, as in the discrete model, planner can encourage more capital to enter by either lowering $d_H$ below $d_H^*$ or by raising $d_H$ sufficiently far above $d_H^*$. And, depending on the specific parameter, the planner may be able to achieve full funding and maximize total surplus by lowering $d_H$ or by increasing $d_H$.

What is the intuition for why $\partial K^*/\partial d_H|_{d_H=d_H^*} < 0$? Recall that individual originators try to reduce the transfer of wealth to informed investors. However, since they are price-takers, they fail to perfectly minimize this transfer because they take $r_H$ as given. In contrast, a single monopolist originator would perfectly minimize the transfer, internalizing the effect of $d_H$ on $r_H$ and setting $\partial \Pi_H\left(K, d_H^*\right)/\partial d_H = 0$. From this monopolist's preferred $d_H$, both raising and lowering $d_H$ will increase the number of informed investors.

**Impact of $d_H$ on capital allowing $d_L$ to vary**   We now allow originators in the $L$ state to reoptimize $d_L$ in response to any changes in $r_L$ induced by changes in $K$. We have

$$\frac{\partial K}{\partial d_H} = -\frac{\overbrace{\frac{\partial \Pi\left(K, d_H, d_L^*[K]\right)}{\partial d_H}}}{\underbrace{\frac{\partial \Pi\left(K, d_H, d_L^*[K]\right)}{\partial K}}_{<0} + \underbrace{\frac{\partial \Pi\left(K, d_H, d_L^*[K]\right)}{\partial d_L}}_{sign=?}\underbrace{\frac{\partial d_L}{\partial K}|_{GE}}_{\leq 0}},$$

If $\partial \Pi/\partial d_L > 0$, then we have

$$sign\left(\frac{\partial K}{\partial d_H}\right) = sign\left(\frac{\partial \Pi\left(K, d_H, d_L^*[K]\right)}{\partial d_H}\right)$$

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as above. Assuming that $N_L < 1$, we have

$$\frac{N_L}{K}\Pi_L = r_L\left[K,(1-P\left[d_L;D\right])\right]+\frac{\frac{M}{M+\ell}\ell\theta\left(E_L^G\left[\min\{v,d_L\}\right]-E_L^B\left[\min\{v,d_L\}\right]\right)}{\frac{M}{M+\ell}\ell\theta\left(E_L^G\left[\min\{v,d_L\}\right]-E_L^B\left[\min\{v,d_L\}\right]\right)+1-E_L\left[\min\{v,d_L\}\right]}.$$

Therefore, we have

$$\frac{\partial\Pi\left(K,d_H,d_L^*\left[K\right]\right)}{\partial d_L}=-\overbrace{\frac{\partial r_L}{\partial e_L}\frac{\partial P\left[d_L;D\right]}{\partial d_L}}^{sign=?}$$

$$+\overbrace{\frac{M}{M+\ell}\ell\theta\frac{\left(F_L^B\left[d_L\right]-F_L^G\left[d_L\right]\right)\left(1-E_L\left[\min\{v,d_L\}\right]\right)}{+\left(1-F_L\left[d_L\right]\right)\left(E_L^G\left[\min\{v,d_L\}\right]-E_L^B\left[\min\{v,d_L\}\right]\right)}}^{>0}}{\left(\frac{M}{M+\ell}\ell\theta\left(E_L^G\left[\min\{v,d_L\}\right]-E_L^B\left[\min\{v,d_L\}\right]\right)+1-E_L\left[\min\{v,d_L\}\right]\right)^2}.$$

Thus, in general, $\partial\Pi\left(K,d_H,d_L\right)/\partial d_L$ is ambiguous for the same reason that $\partial\Pi\left(K,d_H,d_L\right)/\partial d_H$ is ambiguous. However, in the search model outline in Appendix A, we have $\partial r_L/\partial e_L < 0$ so that $\partial\Pi/\partial d_L$ is unambiguously positive.