Why Do Financial Firms Borrow Short-Term?
Debt Maturity and Information Production

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Abstract
The maturity of a firm’s liabilities affects the information financiers produce about the firm’s assets. In my model, long-term financing creates an excessive tendency for financiers to acquire information and screen out lower quality borrowers. In contrast, short-term financing deters information production at origination but induces it when firms are forced to liquidate, depressing the market value of assets due to adverse selection. Through the feedback effect between firms’ maturity structures and asset prices, increases in uncertainty can impair the aggregate volume of short-term financing and investment. The analysis can jointly rationalize: i) the widespread use of short-term debt by financial firms, ii) fire sales in financial assets, iii) periodic disruptions in short-term funding markets and iv) regulatory concerns about excessive short-term debt.

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1 Introduction

Short-term debt is used pervasively by many types of financial firms. While commercial banks’ access to deposits can rationalize their use of short-term financing, it is less clear why other financial institutions, such as hedge funds, non-bank broker-dealers, mortgage REITs and mortgage originators also rely so heavily on it. This reliance on short-term debt seems puzzling given that it exposes financial firms to potentially costly asset liquidations. Indeed, many observers have argued that the extensive use of short-term debt by financial firms may adversely affect asset prices, investment and the functioning of short-term funding markets.\(^1\)

In this paper, I present a model in which the maturity of firms’ liabilities affects the incentives of financiers to produce information about firms’ assets. When financiers provide long-term financing, they tend to produce an excessive amount of information. Since firms ultimately bear the cost of inefficient information production, they have an impetus to deter it by borrowing short-term. Specifically, short-term financing limits financiers’ exposure to the underlying quality of firms’ assets, reducing their incentives to produce information. However, the downside of short-term financing is that firms may face costly asset liquidations when they refinance.\(^2\)

I first characterize the choice between long and short-term financing in a security design problem in which liquidation costs are exogenous. I then show how these costs arise endogenously when buyers of assets can produce information when firms liquidate. Specifically, while short-term financing deters information production at origination, it triggers information production in the asset market, creating adverse selection. However, since firms’ maturity choices ultimately depend on liquidation costs, a severe enough adverse selection problem impairs the aggregate volume of short-term financing. Furthermore, despite the benefits of short-term financing, I show that firms’ maturity structures can be inefficiently short because firms fail to internalize their impact on adverse selection in


\(^2\)Henceforth, I will refer to liquidation and refinancing interchangeably. Liquidation costs may encompass actual costs of transferring assets or any other cost related to the issuance of financial securities.
the asset market.

Formally, I consider a three period model in which a firm seeks financing for an asset from a lender. The asset’s return depends on its type (good or bad) which is initially unknown to both the firm and lender, and an aggregate state that occurs at the interim date. There are two key ingredients in the model: 1) at the interim date the firm can liquidate a portion of the asset in a competitive outside financial market and 2) before committing funds to finance the asset, the lender can privately incur a cost to learn the asset’s type. Information production is inefficient, i.e. the cost of learning the asset’s type exceeds the social value of avoiding financing the bad asset; however, the lender cannot commit to not doing so. I show that when providing long-term financing, the lender’s private value of information always exceeds the social value of information. Intuitively, the lender bears the full downside of the asset but only receives a portion its cash flows, which makes screening out the bad asset more attractive for the lender. As a result, the lender may acquire information despite it being inefficient.

In some cases the optimal security, which can be interpreted as short-term financing, forces the firm to liquidate a portion of the asset at the interim date following a negative shock. Asset liquidations blunt the lender’s incentives to acquire information by reducing the lender’s expected losses from the bad asset. Hence, the firm uses short-term financing when the benefit of deterring inefficient information production exceeds the expected cost of liquidation. Otherwise, the firm uses long-term financing which inefficiently reduces its investment scale or triggers information production.

Next, I examine a market equilibrium in which there are many firms whose financing decisions affect the size of liquidation costs. When firms liquidate at the interim date, outside investors can incur a cost to acquire information about individual assets and make anonymous offers to buy them. If a firm does not sell its asset to an informed investor, it sells it in a competitive pool of uninformed investors. Information is privately valuable to investors because it allows them to buy good assets at a reduced price. However, this “cream skimming” worsens the quality of assets that flows to the uninformed, leading to adverse selection and higher liquidation costs. Consequently, firms’ initial financing
choices both affect and are affected by the adverse selection at liquidation. Shorter maturities incentivize more investors to become informed which results in higher liquidation costs. When the adverse selection problem in the asset market is mild, all firms use short-term financing. However, in some cases, if all firms were to use short-term financing, liquidation costs would be too high to sustain any short-term financing. Hence, some firms resort to long-term financing, resulting in a reduced level of aggregate short-term financing and investment.

Finally, I perform a normative analysis by asking whether a planner choosing the number of firms using short-term financing can increase welfare. Although short-term financing deters inefficient information production by lenders, firms’ maturities may be inefficiently short. Intuitively, firms internalize the cost of inefficient information production at origination, but not at liquidation because asset prices are market-determined. This externality is similar to Lorenzoni (2008) in that liquidations lower asset prices; however, it arises through inefficient information production rather than the misallocation of real assets. Thus, policies that increase the average maturity of firms’ financing, such as limits or taxes on short-term debt can increase welfare.

Several of the model’s implications are consistent with stylized facts. First, the model can rationalize the widespread use of short-term debt by many types of financial firms. For example, Figure 1 shows that over 80% of hedge funds, mortgage originators and mortgage REITs’ debt is short-term, compared to just over 20% for industrial firms. In practice, financial firms borrow extensively from other financial institutions. These types of lending relationships may be particularly prone to inefficient information generation.

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3Given my focus on financial assets, adverse selection is more likely to be the relevant friction that generates fire sale prices rather than second-best user costs a la Shleifer and Vishny (1992). For an excellent discussion of these issues see Kurlat (2018). Another distinction is that in Lorenzoni (2008) the need to sell assets is a consequence of incomplete insurance markets, while in my model committing to sell assets is exactly what deters financiers from producing information.

4For example hedge funds predominantly borrow from prime brokers within large banks (Ang, Gorovyy, and Van Inwegen (2011)), and mortgage REITs and mortgage originators borrow extensively from banks (Pellerin, Sabol, and Walter (2013b) and Kim et al. (2018)). This raises the question as to why financial firms borrow from banks in the first place. Given their expertise in evaluating financial assets, banks are likely best suited to perform due diligence on other financial firms. However, this expertise can be a double-edged sword in that lenders may be tempted to collect too much information while performing due diligence. In practice prime brokers appear to engage in due diligence on hedge funds (Aikman (2010)).
because the lender has the ability to evaluate the same types of assets as the borrower.\footnote{The following statement by the former head of the Financial Services Authority is consistent with this idea, “I find it difficult, if not impossible, to identify an activity carried out by a hedge fund manager which is also not carried out by the proprietary trading desk within a large bank, insurance company or broker dealer” McCarthy (2006).} Furthermore, financial assets are generally less costly to liquidate than real assets.\footnote{Although I consider an information-based liquidation cost, real assets may also be subject to second-best user costs (e.g. Shleifer and Vishny (1992)).} Hence, the trade-off between inefficient information production and liquidation costs may make short-term debt particularly attractive for financial firms.

Second, the endogenous relationship between asset prices and the volume of short-term financing can help explain the disruptions in short-term funding markets observed in periods of heightened uncertainty. For example, during the 2008/2009 financial crisis, both the total volume and maturity of short-term debt decreased across a variety of markets.\footnote{See Hördahl and King (2008), Krishnamurthy (2010), Covitz, Liang, and Suarez (2013), Gorton, Metrick, and Xie (2014), Gabrieli and Georg (2014) and Pérignon, Thesmar, and Vuillemey (2018) for evidence of shortening maturities and Hördahl and King (2008), Gorton and Metrick (2012a), Gorton and Metrick (2012b) Kim et al. (2018) for evidence on reductions in the volume of short-term debt.} In my model, higher uncertainty increases individual lenders’ incentives to acquire information. Firms respond by shortening their debt maturities to deter information production. However, shorter debt maturities lead to higher liquidation costs through information production in the asset market. If liquidation costs become large enough, the aggregate volume of short-term debt becomes impaired.

Third, the normative analysis implies that firms’ debt maturities may be inefficiently short, resulting in too little information production by financiers at origination and too much information production in the asset market. This implication is consistent with policymakers’ concerns that there is insufficient credit analysis by institutions that lend to financial firms.\footnote{For example in referring to banks’ lending practices prior to the LTCM episode: “There was a lack of balance between the key elements of the credit risk management process... banks compromise[d] other critical elements of effective credit risk management, including upfront due diligence,... ongoing monitoring of counterparty exposure” and “In managing relationships with [hedge funds], banks clearly relied on significantly less information on the financial strength... of these counterparties than is common for other types of counterparties” Basel Committee on Banking Supervision (1999).} Despite information production at origination being inefficient, my analysis suggests shifting some information production from the asset market to origination can raise welfare.

There are two main strands of literature rationalizing financial institutions borrow-
ing short-term. In one class of models, financial firms produce short-term liabilities to meet investors’ liquidity needs (e.g. Diamond and Dybvig (1983) and Goldstein and Pauzner (2005)), or demand for safe assets (e.g. Stein (2012), Krishnamurthy and Vissing-Jorgensen (2012) and Diamond (2016)). Short-term debt can also provide a disciplining role for banks (e.g. Calomiris and Kahn (1991), Flannery (1994), Diamond and Rajan (2001) and Eisenbach (2017)). While the aforementioned models tend to be used to understand banks borrowing short-term from depositors, I argue that my model helps to understand lending between financial institutions in which lenders are predisposed to produce information about borrowers’ assets.

In a more general context, debt maturity can be used to avoid or induce debt overhang (e.g. Myers (1977), Shleifer and Vishny (1992), Hart and Moore (1995) and Diamond and He (2014)). Firms may also borrow short-term to signal their quality when information arrives over time (e.g. Flannery (1986), Diamond (1991), Titman (1992) and Stein (2005)). While in signaling models it is generally irrelevant which party refinances the initial loan, in my setting the firm must refinance from an outside party to induce the initial lender to not acquire information. This contractual feature resembles the ubiquitous variation margins used by financial firms in practice. Finally, Brunnermeier and Oehmke (2013) show that if firms lack commitment in their debt maturity decisions debt maturities may be inefficiently short.10

This paper builds on the literature analyzing security design to prevent endogenous adverse selection. Gorton and Pennacchi (1990) show that risk-free debt can prevent informed traders from taking advantage of uninformed investors with liquidity needs. When assets are risky, Dang, Gorton, and Holmström (2012) find that debt is the optimal security to induce counterparties to not acquire information. Under general assumptions about the information acquisition technology, standard debt is the uniquely optimal se-

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10 Other models of dynamic debt maturity include He and Milbradt (2016), Huang, Oehmke, and Zhong (2019) and Geelen (2019).
curity to avoid endogenous adverse selection (Yang (2019)). To my knowledge, this is the first paper to consider the role of maturity to deter information production. I also relate a firm’s debt maturity to the underlying liquidity of its assets, which can help explain why financial assets are so often financed with short-term debt while real assets are not. Finally, I show how inefficient information production not only leads firms to use short-term debt, but can generate fire sales when firms raise new funds to repay their lenders.

Building on the microfoundations of Dang, Gorton, and Holmström (2012), Gorton and Ordonez (2014) analyze the dynamics of information production in debt markets and its macroeconomic implications. Information about collateral decays over time producing a credit and output boom; however, after an aggregate shock, lenders may suddenly have an incentive to produce information, which can lead to a large drop in output. My model differs in several respects. First, in Gorton and Ordonez (2014) there can only be short-term debt because generations live for one period, while in my model firms choose between short-term and long-term financing. Second, I incorporate endogenous information production in the asset market, to study the interaction between debt maturity, asset prices and aggregate investment. Third, I show that debt maturities can be inefficiently short, leading to excessive information production in the asset market.

The link between debt maturity and asset prices relates to the literature examining financial contracts and market liquidity (e.g. Myers and Rajan (1998), Gromb and Vayanos (2002), Brunnermeier and Pedersen (2008), Acharya and Viswanathan (2011), and Biais, Heider, and Hoerova (2018)). In my setting, the feedback effect between information production at origination and liquidation jointly determines debt maturity and asset market liquidity.

This paper also relates to the body of literature in which information production

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12 The market equilibrium also relates to models of fire sales and pecuniary externalities (e.g. Shleifer and Vishny (1992), Kiyotaki and Moore (1997), Lorenzoni (2008), Shleifer and Vishny (2011), Stein (2012), Malherbe (2014), Kurlat (2016), Dávila and Korinek (2017), Biais, Heider, and Hoerova (2018), Dow and Han (2018) and Kurlat (2018)).
generates adverse selection in financial markets. In Fishman and Parker (2015) buyers information production can generate credit crunches and multiple equilibria in the primary market and in Bolton, Santos, and Scheinkman (2016) the equilibrium acquisition of information is generically inefficient in OTC markets. In the context of primary market securitization, Hanson and Sunderam (2013) show that originators’ production of informationally-insensitive assets ex-ante leads to too little informed capital ex-post. In my setting, the potential of information production at origination can lead firms to defer too much information production ex-post.

Finally, a growing literature explores the macroeconomic implications of adverse selection (e.g. Eisfeldt (2004), Kurlat (2013), Malherbe (2014), Bigio (2015), Moreira and Savov (2017), Neuhann (2017) and Asriyan, Fuchs, and Green (2018)). A distinction between my model and the existing literature is that I consider how adverse selection endogenously arising from firms’ financing choices affects output.

The paper is organized as follows. Section 2 describes the baseline model setup. Section 3 analyzes the model. Section 4 introduces the market equilibrium and Section 5 concludes. All proofs are in the Appendix unless otherwise stated.

## 2 Model Setup

There are three dates, \((t = 0, 1, 2)\) and three agents: a firm that raises funds from a lender at \(t = 0\) and can raise funds from an outside financial market at \(t = 1\). All agents are risk-neutral and there is no discounting.

### 2.1 Agents and Technology

#### 2.1.1 Firm

The firm has no wealth and limited liability. In addition, the firm has access to a technology that requires an investment \(k \in [0, 1]\) at \(t = 0\) to produce a random output \(k \tilde{R}\) at \(t = 2\). The per-unit output \(\tilde{R}\) can take values \(R\) (success) or 0 (failure). Although I refer to the investment technology as a single project, in the case of a financial firm it
can be thought of as an investment strategy or portfolio of assets. Two factors affect the project’s probability of success: i) the project’s type and ii) a publicly observable state at $t = 1$. Specifically, there are two project types $\nu \in \{g, b\}$ (good and bad) which occur with the following probabilities

$$
\nu = \begin{cases} 
g & \text{with prob. } \theta \in (0, 1) 
b & \text{with prob. } 1 - \theta.
\end{cases}
$$

The project’s type is initially unknown to all agents. There are two states $z \in \{h, l\}$ (high or low), which occur with the following probabilities

$$
z = \begin{cases} 
h & \text{with prob. } \pi_h \in (0, 1) 
l & \text{with prob. } \pi_l \equiv 1 - \pi_h.
\end{cases}
$$
The good project succeeds with certainty regardless of the state. In contrast, the bad project succeeds with certainty if the state is high and with probability \( \mu \in (0, 1) \) if the state is low.\(^{13}\) Figure 2 provides a visual description of the project’s probability of success. I define \( \phi \) the probability that the ex-ante average project succeeds following state \( z \)

\[
\phi_h \equiv 1, \quad \phi_l \equiv \theta + (1 - \theta)\mu.
\]

I make the following assumptions

**Assumption 1.**

1. \((\pi_h + \pi_l \mu)R < 1\),
2. \((\pi_h + \pi_l \phi_l)R > 1\).

Assumption 1.1 says that the bad project is NPV negative, while Assumption 1.2 says the ex-ante, average project is NPV positive.\(^{14}\)

**2.1.2 Lender**

The firm borrows from a single, deep-pocketed lender that belongs to a competitive pool of lenders. The lender has access to an information acquisition technology at \( t = 0 \), whereby incurring a cost \( c \geq 0 \) it learns the project’s type \( \nu \). I denote the lender’s information acquisition decision by \( a \in \{0, 1\} \) where \( a = 0 \) refers to the lender not acquiring information and \( a = 1 \) refers to the lender acquiring information. For convenience, I assume if \( a = 1 \), \( \nu \) becomes public knowledge at the end of \( t = 0 \).\(^{15}\) In addition, I focus

\(^{13}\)The probability of success need not be 1 for the good project in both states and the bad project in the high state. The key is that there is a difference in the probability of success across project types in one of the states.

\(^{14}\)The assumption that the bad project is NPV negative (Assumption 1.1) is not strictly necessary; however, it simplifies the exposition by ensuring it is without loss of generality to focus on a single contract rather than a menu. It also ensures that the lender’s participation constraint always binds at the optimum, which further limits the number of forms the optimal contract can take. In the Appendix, I characterize the optimal contract in the case where this assumption is relaxed and show the model’s main qualitative predictions regarding the use of short-term contracts remain.

\(^{15}\)This assumption eliminates the possibility of signaling problems in the outside financial market and is also made in Gorton and Ordonez (2014). All of the results go through if I relax this assumption and impose reasonable off-equilibrium beliefs for the outside financial market.
the analysis on the case where \( c \) is within the following bounds:

Assumption 2. The cost of information acquisition \( c \) is between \( \underline{c} \) and \( \bar{c} \), \( c \in (\underline{c}, \bar{c}) \), where

\[
\underline{c} \equiv (1 - \theta)(1 - \pi_h R - \pi_l \mu R), \quad \bar{c} \equiv \frac{\theta(1 - \phi_l)(1 - \pi_h R)}{\phi_l}.
\]

As shown below, this assumption implies that information acquisition is inefficient, but the cost of information acquisition is sufficiently low to materially affect the financial contracting problem.

2.1.3 Outside Financial Market

At \( t = 1 \) the firm can raise additional funds from a competitive outside financial market. The firm can raise funds by: i) new claims on the existing project’s output, i.e. securities, or ii) the sale of a portion of its existing project, i.e. asset sales. For ease of exposition, I refer to asset sales as the method of raising funds.\(^{16}\)

Formally, at \( t = 1 \) in state \( z \) the firm sells a portion of its project \( q_z \in [0, k] \) for a price \( p^*_z = (1 - \gamma^*_z)\mathbb{E}[\tilde{R}|\mathcal{F}] \) where \( \gamma^*_z \in [0, 1] \) is a liquidation cost that can depend on the

\(^{16}\)In the context of the model there is no difference between asset sales and issuing securities because of the project’s binary payoff.
state and the lender’s information acquisition decision and \( E[\hat{R}|\mathcal{F}] \) is the expected value of the project given all public information after \( z \) has been realized at \( t = 1 \). Although in principle there can be numerous sources of the liquidation cost, a relevant friction for financial assets is adverse selection, which is what I consider in Section 4.

### 2.2 Financial Contracts

At \( t = 0 \) the firm offers the lender a financial contract \( C \), which consists of an investment level and state-contingent liquidations and payments from the firm to the lender at each date. For simplicity, I restrict focus on contracts in which the firm only raises funds for investment at \( t = 0 \) and does not store funds across periods, which I show is without loss of generality in the Appendix. In addition, Assumption 1.1 ensures it is without loss of generality for the firm to offer the lender a single contract rather than a menu.

Formally,

**Definition 1.** A financial contract \( C \equiv \{k, q_z, q_l, d_{1z}, d_{2z}, d_{1l}, d_{2l}\} \) consists of an investment level \( k \), state-contingent liquidations \( q_z \) and state-contingent payments \( d_{1z} \) and \( d_{2z} \) from the firm to the lender at \( t = 1, 2 \), respectively for each state \( z \).

After \( C \) has been offered, and before the lender accepts or rejects it, the lender decides whether to acquire information; however, \( C \) cannot be made contingent on the lender’s information acquisition decision \( a \). As shown below, this friction implies that the lender will have an excessive tendency to acquire information.

I assume that the firm cannot contract with the outside financial market at \( t = 0 \). Furthermore, the firm and lender can commit to not renegotiate \( C \). If the firm fails to make the contractual payments at \( t = 1 \) the remainder of the project is liquidated in the outside financial market and all proceeds are given to the lender. Since contracts are

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\(^{17}\) If the lender acquires information and discovers the project is bad, the initial cost of financing cannot be recouped in expectation regardless of the terms of the contract.

\(^{18}\) This assumption can be rationalized if the lender must incur an initial cost of due diligence which is too costly for the outside financial market to incur. A cost of due diligence can also rationalize the firm borrowing from a single lender at \( t = 0 \) to avoid duplicative monitoring costs (e.g., Diamond (1984)).

\(^{19}\) As shown in Section 4, the specific form of liquidation cost I focus on is information-based; hence, the lender’s value of the asset at \( t = 1 \) coincides with that of the outside financial market, eliminating the incentive to refinance with the lender at \( t = 1 \).
state-contingent, it is without loss of generality to focus on cases where default does not occur in equilibrium. Figure 3 displays the timing of the model.

### 2.3 Baseline Model Discussion

In this section I discuss some of the main features of the baseline model. An important assumption is the firm and lender begin symmetrically uninformed. One rationale for this occurring in financial markets is that lenders and firms both invest in the same types of assets. For instance, banks employ traders and research analysts that have expertise in the same securities as the hedge funds they lend to. Nonetheless, in the Appendix I analyze the case in which the firm is endowed with private information about its project quality and show the main qualitative results remain so long as the initial information is not too precise.

What type of information could be socially inefficient to produce? While financial firms certainly generate information about their own assets, certain pieces of information may not be worth producing. For instance, a hedge fund would probably not pay their analysts to investigate individual houses before purchasing a mortgage-backed security. As I show below, however, a bank lending long-term to that hedge fund may want to investigate the houses. Consistent with this example, I show in the Appendix that if the firm is also given the option to acquire information about the project, the firm does not.
3 Model Analysis

3.1 Benchmark: Information Acquisition is Contractible

To gain intuition, I first analyze the case in which the lender’s information acquisition decision is contractible. For information acquisition to be efficient, the value from acquiring information (i.e. the avoiding financing the bad project) must offset its cost. Formally this occurs when

\[ k(1 - \theta)(1 - \pi_h R - \pi_l \mu R) \geq c. \]  

Assumption 2 and \( k \leq 1 \) imply that (1) does not hold. Therefore, information acquisition is inefficient. Because information acquisition is contractible, the firm can induce the lender to not acquire information by offering sufficiently low payments if the lender acquires information.\(^\text{20}\) The firm’s problem is

\[
\max_c \sum_z \pi_z \left[ q_z p^0_z - d_{1z} + \phi_z ((k - q_z) R - d_{2z}) \right] \\
\text{s.t.} \\
k \leq 1, \\
k \leq \sum_z \pi_z (d_{1h} + \phi_z d_{2h}), \\
q_z \in [0, k], \quad d_{1z} \leq q_z p^0_z, \quad d_{2z} \leq (k - q_z) R \quad z = h, l, \\
p^0_z = (1 - \gamma^0_z) \phi_z R \quad z = h, l.
\]

The firm chooses a contract to maximize its expected profits subject to investment not exceeding the maximum scale (3), the lender’s participation constraint (4), which states that the expected payments the lender receives when it does not acquire information must be at least as large as the firm’s initial investment, and the promised payments at \( t = 1 \)

\(^{20}\)More specifically, the firm could offer a contract in which the lender breaks even from financing the good project if \( a = 1 \). If \( a = 1 \) the lender’s profits would be \(-c\), so the lender would never acquire information.
and \( t = 2 \) not exceeding the available funds from liquidation and the project’s output (5). Finally, (6) reflects the asset prices in each state when the lender does not acquire information.

**Proposition 1.** When information acquisition is contractible, the lender does not acquire information and the optimal contract \( C^{FB} \) is

\[
C^{FB} = \{k^{FB}, q_h^{FB}, q_l^{FB}, q_{1h}^{FB}, q_{1l}^{FB}, d_2^{FB} \} = \{1, 0, 0, 0, d_{2h}^{FB}, d_{2l}^{FB} \},
\]

where

\[
\sum_z \pi_z \phi_z d_{2z}^{FB} = 1,
\]

\[
d_{2z}^{FB} \in [0, R] \quad z = h, l,
\]

and the firm’s expected profits are

\[
V^{FB} = (\pi_h + \pi_l \phi_l)R - 1.
\]

Because the asset price in both states is always less than the expected output of the project \( p_z^0 = (1 - \gamma_z^0)\phi_z R \leq \phi_z R \), liquidations reduce the firm’s expected profits. Hence there are no liquidations or payments at \( t = 1 \). The firm also invests at full scale because investment is NPV positive. Since the firm has all of the bargaining power, any feasible combination of \( d_{2h} \) and \( d_{2l} \) that leads (4) to bind constitutes an optimal benchmark contract. The firm’s profits \( V^{FB} \) equal the expected value of the ex-ante, average project at the full investment scale, which I henceforth refer to as the first-best level of surplus.

### 3.2 Information Acquisition Non-Contractible

In this section, I show that when information acquisition is non-contractible, if the firm offers the lender \( C^{FB} \), the lender acquires information. In order for the lender to not acquire information, the lender’s payoff from acquiring information must be less than its
cost. Formally,

\[(1 - \theta) [k - \pi_h(d_{1h} + d_{2h}) - \pi_l(d_{1l} + \mu d_{2l})] \leq c. \quad (7)\]

If we insert the terms of $C^{FB}$ into (7) we have

\[
\frac{\theta(1 - \phi_l)(1 - \pi_h d_{2h}^{FB})}{\phi_l} \leq c. \quad (8)
\]

The LHS of (8) is at least as large as $\bar{c}$ because $d_{2h}^{FB} \leq R$. However, this implies that (8) is violated because Assumption 2 states that $c$ is less than $\bar{c}$. Thus, the lender would acquire information if the firm offered the lender $C^{FB}$.

**Lemma 1.** When information acquisition is non-contractible, if the firm offers the lender the optimal benchmark contract $C^{FB}$, the lender acquires information and accepts $C^{FB}$ if the project is good ($v = g$) and rejects it otherwise. The firm earns profits strictly less than $V^{FB}$.

To gain more intuition for why the lender acquires information if offered $C^{FB}$, note that the lender’s benefits of information acquisition are from avoiding financing the bad project. Compare the lender’s private benefits to the social benefits of information acquisition for any contract in which there are no $t = 1$ payments $d_{1h} = d_{1l} = 0$

\[
\underbrace{(1 - \theta)(k - \pi_h d_{2h} - \pi_l \mu d_{2l})} \geq \underbrace{k(1 - \theta)(1 - \pi_h R - \pi_l \mu R)}.
\]

Because of limited liability, the contract must pay the lender less than the full output of the project when it succeeds $d_{2z} \leq kR$. Intuitively, when deciding whether to produce information, the lender does not internalize the loss in the firm’s expected profits from the bad project which can be seen from subtracting the social benefits of information
from the lender’s benefits

\[
(1 - \theta)(k - \pi_h d_{2h} - \pi_l \mu d_{2l}) - k(1 - \theta)(1 - \pi_h R - \pi_l \mu R)
\]

Lender’s benefits

\[
= (1 - \theta)[\pi_h(kR - d_{2h}) + \pi_l \mu(kR - d_{2l})].
\]

Social benefits

Firm’s profits from bad project

Given that the project yields \(R\) when it succeeds regardless of its type, the lender’s private benefits of information only coincides with the social benefits of information when the firm earns zero profits. If \(c\) is sufficiently high, the lender will never find it privately optimal to acquire information; however, Assumption 2 ensures that \(c\) is small enough so that the misalignment of incentives materially affects the financial contracting problem. As shown below, contracts with payments at \(t = 1\) can be a way to improve the incentives of the lender because they reduce the lender’s expected loss from financing the bad project.

### 3.3 Second-Best Financial Contract

In this section, I characterize the optimal contract when information acquisition is non-contractible. I separate the search for the optimal contract into two cases i) the optimal contract in which the lender finds it optimal to not acquire information \(C^0^*\) and ii) the optimal contract in which the lender finds it optimal to acquire information \(C^1^*\). I then compare the profits between \(C^0^*\) and \(C^1^*\) to find the optimal contract \(C^*\). Contracts which include payments at \(t = 1\), I refer to as “short-term”, while contracts that do not I refer to as “long-term”.

#### 3.3.1 Optimal Contract That Deters Information Acquisition

To find the optimal contract that deters information acquisition \(C^0^*\), the firm faces the benchmark problem (2) with the addition of the lender’s incentive compatibility constraint (7). It is useful to first establish the following lemma.

**Lemma 2.** In the optimal contract that deters information acquisition,

\[21\]This definition is consistent with regulatory standards where the maturity is tied to when the lender can demand repayment versus the unconditional repayment date (see SEC (2019b)).
\( \text{i) } d_{h}^{0} = d_{1h}^{0} = 0 \)

\( \text{ii) } d_{2h}^{0} = k^{0} R \)

\( \text{iii) } d_{1l}^{0} = q_{1l}^{0} p_{l}^{0} \)

iv) The incentive compatibility constraint (7) binds.

Liquidations and payments at \( t = 1 \) when \( z = h \) lead to liquidation costs but do not affect the lender’s incentives (given that the project succeeds regardless of its type). The reason that all output is paid to the lender in the high state, \( d_{2h}^{0} = k^{0} R \) can be seen from the LHS of (8). Fixing the expected payments to the lender at \( t = 2 \), the private benefits from the lender acquiring information are decreasing in \( d_{2h}^{0} \). Hence, the optimal contract includes as large a value of \( d_{2h}^{0} \) as possible to minimize risky payments in the low state.

Finally, the firm only liquidates enough of the project to meet \( t = 1 \) payments in the low state because the incentives of the lender do not improve if the firm keeps the proceeds from liquidation. The following proposition characterizes \( C^{0*} \).

**Proposition 2.** In the optimal contract that deters information acquisition the participation constraint (4) binds and the contract and respective profits take two forms depending on parameter values:

\[
C^{0*} = C^{0L} \equiv \left\{ k^{0L}, q_{h}^{0L}, q_{l}^{0L}, d_{1h}^{0L}, d_{1l}^{0L}, d_{2h}^{0L}, d_{2l}^{0L} \right\} = \left\{ \frac{c \phi l}{\theta (1 - \phi l)(1 - \pi h R)}, 0, 0, 0, 0, k^{0L} R, c \right\}, \quad V^{0*} = V^{0L} = k^{0L} (\pi h R + \pi l \phi l R - 1), \]

or

\[
C^{0*} = C^{0S} \equiv \left\{ k^{0S}, q_{h}^{0S}, q_{l}^{0S}, d_{1h}^{0S}, d_{1l}^{0S}, d_{2h}^{0S}, d_{2l}^{0S} \right\} = \left\{ 1, 0, \frac{d_{1l}^{0S}}{p_{l}^{0S}}, 0, 1 - \pi h R - \frac{c \phi l}{\pi (1 - \phi l)}, R, c \right\}, \quad V^{0*} = V^{0S} = \pi l \left( \phi l \left( R - d_{2l}^{0S} \right) - \frac{d_{1l}^{0S}}{1 - \gamma l} \right). \]

\[\text{22Since the bad project is NPV negative it must be the case that } \pi h R < 1. \text{ Therefore, the contract must include payments in the low state for the lender to break-even.}\]
There are two potential channels to deter the lender from acquiring information. First, reducing investment \( k \) lowers the expected payments required for the lender to break-even. This makes it more difficult for the lender to recoup \( c \) through avoiding financing the bad project. Hence, when \( C^0^* = C^0^L \) investment is reduced just enough, \( k^0L < 1 \), so that the incentive compatibility constraint (7) binds.

More centrally to the paper, holding the expected payments to the lender constant, shifting payments from \( t = 2 \) to \( t = 1 \) in the low state, deters information production. Because payments at \( t = 1 \) are independent of the project’s quality, shifting payments to \( t = 1 \) decreases the lender’s expected loss from financing the bad project, which in turn lowers the lender’s private value of information. Hence, for parameters in which \( C^0^* = C^0^S \), the firm fully invests and the contract includes the minimum payment \( d_{1^L} \) so that (7) binds.

In summary, the optimal contract that deters information acquisition either includes reduced investment or interim liquidations and payments.

### 3.3.2 Optimal Contract That Induces Information Acquisition

To find the optimal contract that induces information acquisition \( C^{1^*} \), the firm faces the following problem

\[
\max_c \theta \sum_z \pi_z (q_z p_z^{1^L} - d_{1^L} + (k - q_z) R - d_{2^L})
\]

\[
\text{s.t.}
\]

\[
k \leq 1,
\]

\[
c \leq \theta \left( \sum_z \pi_z (d_{1^L} + d_{2^L}) - k \right),
\]

\[
c \leq (1 - \theta) \left[ k - \pi_h (d_{1^h} + d_{2^h}) - \pi_l (d_{1^l} + \mu d_{2^l}) \right],
\]

\[
q_z \in [0, k], \quad d_{1^L} \leq q_z p_z^{1^L}, \quad d_{2^L} \leq (k - q_z) R \quad z = h, l,
\]

\[
p_z^{1^L} = (1 - \gamma_z^{1^L}) R \quad z = h, l.
\]
The main differences between (9) and the problem that deters information acquisition are i) the participation constraint (10) which reflects the lender’s payoff if it acquires information, ii) the incentive compatibility constraint (11) which states that the lender must prefer to acquire information and iii) asset prices (12) because the lender only finances the good project when \( a = 1 \). As in the benchmark case, there are no benefits of liquidations, demanding payments at \( t = 1 \) or reducing investment. Hence, (11) is slack (i.e. the lender will always acquire information) and (10) binds and the firm captures the full surplus.

**Proposition 3.** The optimal contract that induces information acquisition takes the following form:

\[
C^{1*} = C^{1L} = \{ k^{1L}, q^{1L}, d^{1L}_h, d^{1L}_{1h}, d^{1L}_{2h}, d^{1L}_{2l} \} = \{ 1, 0, 0, 0, d^{1L}_{2h}, d^{1L}_{2l} \},
\]

where

\[
\theta \left( \sum_z \pi_z d^{1L}_{zz} - 1 \right) = c,
\]

\[
d^{1L}_{zz} \in [0, R] \quad z = h, l.
\]

The firm’s expected profits \( V^{1*} = V^{1L} \) where:

\[
V^{1L} = \theta(R - 1) - c.
\]

The firm ultimately bears the cost of the lender’s inefficient information production and its profits are strictly less than the first-best \( V^{1L} < V^{FB} \).

### 3.3.3 Optimal Contract

The optimal contract can be found by comparing the expected profits between the three classes of contracts (\( C^{0S} \), \( C^{0L} \) and \( C^{1L} \)).
Figure 4: Optimal Contract. This figure depicts regions of the parameter space in which each of the candidate contracts is optimal (\(C^{0S}, C^{0L}\) and \(C^{1L}\)) for the example parameters: \(\theta = \mu = 0.5, R = 1.2, c = 0.05\), varying \(\pi_l\) and \(\gamma_0^l\).

Proposition 4. Let \(V^* = \max\{V^{0S}, V^{0L}, V^{1L}\}\). The optimal contract \(C^*\) is:

\[
C^* = \begin{cases} 
C^{0S} & \text{if } V^* = V^{0S} \\
C^{0L} & \text{if } V^* = V^{0L} \\
C^{1L} & \text{if } V^* = V^{1L} 
\end{cases}
\]

Figure 4 depicts example regions of the parameter space in which each of the candidate contracts is optimal, varying the probability of the low state \(\pi_l\) and the liquidation cost in the low state when the lender does not acquire information \(\gamma_0^l\). Henceforth, I refer to \(C^{0S}\) as the short-term contract and \(C^{0L}\) and \(C^{1L}\) as long-term contracts.

3.4 Comparative Statics and Discussion

In this section, I discuss comparative statics and particular features of the short-term contract.

Proposition 5. The lower the liquidation cost in the low state when the lender does not
acquire information $\gamma^0_l$, the more likely the short-term contract is optimal $C^* = C^{0S}$.

The profits from the short-term contract $V^{0S}$ are decreasing in $\gamma^0_l$, while the profits of both of the long-term contracts are unaffected by $\gamma^0_l$. Hence, the lower $\gamma^0_l$ the more likely the firm chooses the short-term contract. In reality, financial assets likely have lower liquidation costs than real assets which makes short-term debt a cost-effective method to deter inefficient information production for financial firms. This result will also play an important role in market equilibrium where certain shocks can cause an endogenous increase in the liquidation cost, which then affects firms’ decisions to use short-term financing.

I now analyze the maturity of the short-term contract $C^{0S}$ where I refer to its maturity being “shorter” if $d^{0S}_{01}$ is larger. A higher probability of the low state $\pi_l$ leads to a shorter maturity of the short-term contract.\(^{23}\)

**Proposition 6.** The maturity of the short-term contract is decreasing in the probability of the low state, i.e. $d^{0S}_{01}$ is increasing in $\pi_l$.

There is only uncertainty in payoffs across project types in the low state; thus, as $\pi_l$ increases, the lender’s value of information increases. In order to induce the lender not to acquire information, the interim payment in the low state must increase.\(^{24}\) Because firms must liquidate more assets as the interim payment increases, a higher probability of the low state also makes the short-term contract less likely to be optimal as can be see in Figure 4. This result also plays a role in the market equilibrium as the aggregate maturity structure will endogenously affect liquidation costs.

The payment from the firm to the lender at the $t = 1$ in the low state resembles the variation margins used by financial firms which require counterparties to post cash collateral when the value of their assets drops. This form of short-term debt is distinct from standard short-term debt contracts that can be rolled over by any party (e.g. Flannery (1986) and Diamond (1991)). In my setting it is key that the initial lender does not

\(^{23}\text{This is also true if maturity is defined as the relative ratio of payments in the low state } \frac{d^{0S}_{01}}{\pi_h + \pi_l}\phi_l.\)

\(^{24}\text{To isolate the effect from higher uncertainty, one can easily show that this result holds if the NPV of the project } (\pi_h + \pi_l\phi_l)R - 1 \text{ is held constant while } \pi_l \text{ varies.}\)
refinance the interim payment, otherwise the lender would anticipate this and acquire information at $t = 0$. Hence, the particular form of short-term financing that arises in this setting shares the feature of short-term loans used by financial firms in practice. In addition, if higher asset volatility increase the value of information for lenders, then Proposition 6 can also shed light on the positive relationship between margins and and volatility (e.g. Adrian and Shin (2010)).

4 Market Equilibrium

In this section I incorporate information acquisition in the outside financial market to endogenize liquidation costs. Since there is no uncertainty in payoffs across project types in the high state, I focus the analysis on information production in the low state at $t = 1$.

4.1 Market Equilibrium Setup

There is a unit mass of firms indexed by $i$ that are distributed uniformly in the interval $[0, 1]$. Firms’ project qualities $\nu(i)$ are iid and have the same distribution as in the baseline model. Each firm makes an offer to a single lender at $t = 0$ where $a(i)$ refers to firm $i$’s lender’s information acquisition decision at $t = 0$. The outside financial market is composed of an infinite number of deep-pocketed investors. The timing is the same as the baseline model; however the investors in the outside financial market can acquire information at $t = 1$, which affects the endogenously determined liquidation costs.

After the low state has been realized at $t = 1$, each investor can incur a cost $\kappa$ to become informed, where $\eta \geq 0$ is the mass of investors that become informed. Investors that do not incur $\kappa$ compose a competitive pool of uninformed investors. Firms and informed investors are randomly matched via a technology described below. If firm $i$ matches with an informed investor, both the firm and investor learn the firm’s project type $\nu(i)$. The informed investor within a match makes an offer to buy $q_l(i)$ for $q_l(i)p_l(i)$. Matching and offers are anonymous so other investors cannot observe which firms previously received offers from informed investors. Therefore, a firm that does not sell its asset to an informed
investor can sell its assets to the uninformed investors for the competitively determined market price $p^a_i$, where there can be different prices received by firms whose lenders have acquired information and those that have not (i.e. $p^0_i$ and $p^1_i$). Figure 5 displays the timing in the liquidation stage.\footnote{The discussed mechanisms are a stylized representation of how trading occurs in reality. Financial assets trade in several different ways. For example most stocks trade in organized exchanges, convertible bonds trade in dealer markets and structured products may trade in even less transparent ways through bilateral agreements. The key ingredient is that the informed investors are able to distinguish good assets from bad when they buy them at the market price. In the Appendix, I show that an auction yields the same asset prices as the market mechanism in the main text.}

The total number of matches between firms and informed investors is $m(\eta)$. Hence, the probability each firm matches with an informed investor is $m(\eta)$ and the probability each informed investor matches with a firm is $\frac{m(\eta)}{\eta}$. I make the following assumptions regarding $m(\eta)$.

**Assumption 3** (Matching Function).

1. $\frac{m(\eta)}{\eta} \in [0, 1] \forall \eta$
2. $m'(\eta) \in \left(0, \frac{m(\eta)}{\eta} \left(1 - \frac{\theta m(\eta)}{\eta} \right)\right) \forall \eta$
3. $m(0) = 0$, \quad $\lim_{\eta \to \infty} m(\eta) \leq 1$

Assumption 3.1 says that the probability an investor matches with a firm is between 0 and 1. Assumption 3.2 ensures that i) the total number of matches $m(\eta)$ is increasing in $\eta$ and ii) $m(\eta)$ ensures investors’ decisions to become informed are strategic substitutes. Assumption 3.3 says that the total number of matches is between 0 and 1.\footnote{An example function that satisfies these conditions is $\eta^2 \frac{\eta}{1 + \eta}$.}

Let me briefly discuss the role of the informed investors and uninformed investors. Informed investors can be thought of as other financial firms with sufficient funds to purchase assets in the low state. For instance Mitchell, Pedersen, and Pulvino (2007) show that multi-strategy hedge funds become net buyers of convertible bonds when convertible arbitrage hedge funds become distressed. Uninformed investors can be thought of as less sophisticated institutional investors. For example Ben-David, Franzoni, and Moussawi (2012) find that insurance companies, pension funds and retail investors stepped in to buy...
1. State $z = l$ is realized
2. $\eta$ investors incur $\kappa$ to become informed
3. $m(\eta)$ firms and informed investors match
4. Within each match the informed investor makes an offer to buy the firm’s assets
5. Any unsold assets are sold to uninformed for $p_l^a$

Figure 5: Liquidation Stage Timing at $t = 1$. 

assets sold by hedge funds during the 2008/2009 financial crisis. Although each firm has one project, it is best to think of firms liquidating individual assets within their portfolio to meet interim payments and the informed investors producing information about these individual assets rather than the portfolio as a whole.

4.2 Market Equilibrium Analysis

In this section I characterize equilibrium asset prices, investors’ decisions to become informed and firms’ financial contracts. In the high state both good and bad projects payoff $R$ with certainty; hence, there is no potential for adverse selection and $p_h^0 = p_h^1 = R$. Consider $\mathcal{I}^0$ the set of firms in which their lenders do not acquire information at $t = 0$ and $\mathcal{I}^1$ the set of firms in which their lenders do acquire information

$$
\mathcal{I}^0 \equiv \{i : a(i) = 0\}, \quad \mathcal{I}^1 \equiv \{i : a(i) = 1\}.
$$

Firms $i \in \mathcal{I}^1$ are financed only if the project is good, implying that the uninformed are willing to pay $p_l^1 = R$. Therefore, if an informed investor matches with a firm $i \in \mathcal{I}^1$ in the low state, the informed investor offers $p_l(i) = p_l^1 = R$ and the firm accepts. If a firm $i \in \mathcal{I}^1$ does not match with an informed investor, it sells its assets to the uninformed for $p_l^1 = R$. Hence, regardless of matching outcomes all firms $i \in \mathcal{I}^1$ receive $p_l^1 = R$.

The remaining price to characterize is $p_l^0$. Since informed investors’ matching and offers are anonymous, uninformed investors cannot distinguish the quality of individual assets in the pool sold by firms $i \in \mathcal{I}^0$. Therefore, $p_l^0 \in [pR, R]$ where $p_l^0$ depends on
the inferred proportion of good assets sold to the uninformed. Consider a firm $i \in I^0$ that matches with an informed investor. If its project is good its expected payoff $R$ is always greater than $p_l^0$. Since each firm’s outside option is $p_l^0$, the informed investor offers $p_l(i) = p_l^0$ and the firm accepts. In contrast, if the project is bad its expected payoff is $pR$ which is always less than $p_l^0$. Thus, the firm rejects any offer the informed investor makes and sells the asset to the uninformed investors for $p_l^0$. A firm that does not match with an informed investor also sells its assets to the uninformed for $p_l^0$. Summarizing,

Lemma 3.

1. An informed investor that matches with a firm $i \in I^1$ at $t = 1$ buys the asset at $p_l^1 = R$

2. An informed investor that matches with a firm $i \in I^0$ at $t = 1$,
   (a) buys the asset at $p_l^0$ if it is good
   (b) does not buy the asset otherwise.

3. Any assets that go unsold to the the informed are purchased at $p_l^a$ by the uninformed

Lemma 3 implies that the market price received by firms $i \in I^0$ is

$$p_l^0(\eta) = \left(1 - \frac{m(\eta)\theta(1 - \phi_l)}{(1 - m(\eta)\theta)\phi_l}\right) \phi_l R,$$  \hspace{1cm} (13)$$

where $p_l^0(\eta)$ reflects the lower quality of assets that flow to the uninformed due to the informed investors “cream skimming” good assets. Table 1 summarizes the liquidation costs in each state borne by firms whose lenders acquire and do not acquire information. Next, I turn to investors’ decisions to become informed taking firms’ contracts as given. Define the aggregate asset sales and payments made by firms $i \in I^0$

$$Q \equiv \int_{I^0} q_l(i)di, \hspace{1cm} D \equiv \int_{I^0} d_{1l}(i)di.$$  

\footnote{I confirm in equilibrium that the inequality is strict.}

\footnote{Note that even if the firm does not keep any of the proceeds itself, it would default if $pRq_l(i) < d_{1l}(i)$ which means it always prefers selling the assets for a higher price.}
Table 1: Liquidation Costs

<table>
<thead>
<tr>
<th></th>
<th>( a = 1 )</th>
<th>( a = 0 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( z = h )</td>
<td>( \gamma_h^1 = 0 )</td>
<td>( \gamma_h^0 = 0 )</td>
</tr>
<tr>
<td>( z = l )</td>
<td>( \gamma_l^1 = 0 )</td>
<td>( \gamma_l^0 = \frac{m(\eta)\theta(1-\phi_l)}{(1-m(\eta)\theta)\phi_l} \geq 0 )</td>
</tr>
</tbody>
</table>

The expected payoff from becoming informed is

\[
\Pi(\eta) = \left( \frac{m(\eta)}{\eta} \right) \theta Q \left[ R - p_l^0(\eta) \right] - \kappa. \tag{14}
\]

Upon incurring the cost \( \kappa \) to become informed, each informed investor is matched with a firm with probability \( \frac{m(\eta)}{\eta} \). If the informed investors matches with a firm \( i \in \mathcal{I}^1 \) it pays \( p_l^1 = R \) for \( q_l(i) \) units of the asset and earns zero profits. If the informed investors matches with a firm \( i \in \mathcal{I}^0 \) there is a \( \theta \) probability the firm’s asset is good in which case the investor pays \( p_l^0(\eta) \) for \( q_l(i) \) units of the asset that yield \( R \) with certainty where (14) integrates over all firms \( i \in \mathcal{I}^0 \). From Lemma 2, \( d_l^{0*} = q_l^{0*} p_l^0 \), so for convenience (14) can be written as

\[
\Pi(\eta, D) = \left( \frac{m(\eta)}{\eta} \right) \theta D \left( \frac{R}{p_l^0(\eta)} - 1 \right) - \kappa. \tag{15}
\]

Differentiating \( \Pi \) with respect to \( \eta \)

\[
\frac{\partial \Pi}{\partial \eta} = \frac{\theta D (1 - \phi_l) (\phi_l \eta m'(\eta) - m(\eta) [\phi_l - \theta m(\eta)])}{\eta^2 [\phi_l - \theta m(\eta)]^2}. \tag{16}
\]

By Assumption 3.2, (16) is negative meaning that as more investors become informed, the expected profits from becoming informed decreases. Hence, if \( \Pi(0, D) < 0 \) then \( \eta^* = 0 \). Otherwise, \( \eta^* \) solves \( \Pi(\eta^*, D) = 0 \).\(^{29}\) In words, either no investors become informed or a positive number become informed such that informed investors earn zero profits. To see the effect of shorter maturities on the equilibrium mass of informed investors we can

\(^{29}\) \( \eta^* \) is always finite because as \( \eta \) tends to infinity \( \Pi(\eta, D) \) tends to \( -\kappa \).
apply the implicit function theorem,

\[
\frac{d \eta^*}{d D} = \begin{cases} 
0 & \text{if } \Pi(0, D) < 0 \\
-\frac{\partial \Pi}{\partial D} & \text{if } \Pi(0, D) \geq 0,
\end{cases}
\]

(17)
since \(\frac{\partial \Pi}{\partial D} > 0\) and \(\frac{\partial \Pi}{\partial \eta^*} < 0\). Hence, when \(\eta^* > 0\), larger aggregate payments at \(t = 1\) in the low state lead to an increase in the number of informed investors. In turn, this affects equilibrium asset prices which can be seen by differentiating \(p^0_l(\eta^*)\) with respect to \(D\)

\[
\frac{dp^0_l(\eta^*)}{d D} = \frac{\partial p^0_l}{\partial \eta^*} \frac{d \eta^*}{d D} \leq 0.
\]

The first term is negative by Assumption 3.2 and \(\frac{d \eta^*}{d D}\) is positive when \(\eta^* > 0\) from (17).

In summary when \(\eta^* > 0\), as \(D\) increases, more investors become informed. As more investors become informed, \(p^0_l(\eta^*)\) drops. Thus, investors’ information production yields a downward sloping demand curve in the asset market.

Now that I have established the main properties of the liquidation stage, I can define the market equilibrium.

**Definition 2.** A market equilibrium consists of contracts \(C(i)\) for all \(i\), information acquisition decisions by each firm’s lender \(a(i)\) for all \(i\), a mass of investors \(\eta^*\) that become informed at \(t = 1\) when \(z = l\), and asset prices \(\{p^0_{z,a}\}_{z=h,l,a=0,1}\), such that:

1. Firms’ contracts are optimal \(C(i) = C^*\) for all \(i\)
2. Lenders information acquisition decisions are optimal given contracts
3. Investors decisions to become informed in the low state are optimal given contracts and asset prices
4. Asset markets clear in each state.

The following definitions will be useful for characterizing the equilibrium.

**Definition 3.** The long-term contract that yields the highest profits and its corresponding profits are
\[ C^{L*} = \begin{cases} 
C^{0L} & \text{if } V^{0L} \geq V^{1L} \\
C^{1L} & \text{otherwise}, 
\end{cases} \]

and

\[ V^{L*} = \max\{V^{0L}, V^{1L}\}. \]

I also define aggregate short-term debt \( \alpha \) as the mass of firms that borrow short-term which is equivalent to the amount of investment funded by short-term contracts since \( k^{0S} = 1 \) in the short-term contract. Formally,

**Definition 4.** Aggregate short-term debt \( \alpha \) is

\[ \alpha = \int_0^1 \mathbb{I}(C(i) = C^{0S}) di. \]

**Proposition 7.** The equilibrium mass of firms using short-term contracts \( \alpha^* \), the mass of informed investors \( \eta^* \) and liquidation costs in the low state \( \gamma_{i}^{0*} \) borne by firms \( i \in I^0 \) take one of the following types depending on the parameter values

- **Type 1:** \( \alpha^* = 1, \ \eta^* = 0 \) and \( \gamma_{i}^{0*} = 0 \)
- **Type 2:** \( \alpha^* = 1, \ \eta^* > 0 \) and \( \gamma_{i}^{0*} > 0 \)
- **Type 3:** \( \alpha^* \in (0, 1), \ \eta^* > 0 \) and \( \gamma_{i}^{0*} > 0 \),

where in all equilibrium types a mass \( 1 - \alpha^* \) of firms choose \( C^{L*} \).

In the Type 1 equilibrium all firms use short-term contracts and no investors have an incentive to become informed which results in a liquidation cost of zero in the asset market. This equilibrium type will occur if the cost of becoming informed \( \kappa \) is sufficiently large. In the Type 2 equilibrium all firms use short-term contracts and a positive mass of investors become informed, where all firms still find it optimal to use short-term contracts because liquidation costs are not too high. Finally, in the Type 3 equilibrium, if all firms
chose short-term contracts, liquidation costs would be so high that it would no longer
be optimal for any firms to use short-term contracts. When this is the case, a mass of
firms less than 1 choose short-term contracts such that firms are indifferent between the
short-term contract and the long-term contract that yields the highest profits.

When the long-term contract that deters information is more profitable than the long-
term contract that induces information acquisition $C^{L*} = C^{0L}$, there are infinitely many
equilibrria such that all firms’ profits equal $V^{0L}$.\(^{30}\) However, $D^*$ and $\gamma_0^*$ are the same
regardless of the equilibrium. Therefore, for convenience I focus on the case where firms
simply choose between $C^{0S}$ and $C^{0L}$. Nonetheless, I characterize the full set of equilibria
in the proof of Proposition 7.\(^{31}\)

To understand the real consequences of the market equilibrium, I define aggregate
investment as the sum of realized investment across firms accounting for i) firms that
choose $C^{0L}$ invest less than 1 and ii) firms that choose $C^{1L}$ are only financed when the
project is good which occurs with probability $\theta$. Formally,

**Definition 5.** Aggregate investment $K$ is:

$$
K = \begin{cases} 
\alpha + (1 - \alpha)I^{0L} & \text{if } C^{L*} = C^{0L} \\
\alpha + (1 - \alpha)\theta & \text{otherwise.}
\end{cases}
$$

Therefore, aggregate investment can be characterized in the follow corollary.

**Corollary 1.** The equilibrium aggregate investment $K^*$ equals 1 if the equilibrium is Type
1 or Type 2 and $K^*$ is less than 1 if the equilibrium is Type 3.

Hence, if the adverse selection in the asset market is severe enough aggregate investment
becomes impaired through a portion of firms resorting to long-term financing.

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\(^{30}\)For example there is also a symmetric equilibrium in which all firms choose $d_{1t} > 0$ and reduce their
investment $k < 1$.

\(^{31}\)The notion of aggregate short-term debt can potentially vary based on the choice of equilibrium (i.e.
the amount of investment funded by contracts with payments at $t = 1$ in the low state); however, the
comparative statics are directionally the same across equilibria.
4.3 The Effect of Uncertainty on Aggregate Short-Term Debt and Investment

In this section I show how an increase in uncertainty can lead to a reduction in aggregate short-term debt and investment. Recall that the only uncertainty in payoffs across project types occurs in the low state and from Proposition 6, the maturity of the short-term contract is decreasing in the probability of the low state, i.e. \( d_{01}^{0S} \) is increasing in \( \pi_l \). Hence, in the market equilibrium whenever \( \alpha^* = 1 \) (i.e. Type 1 or Type 2 equilibrium) an increase in \( \pi_l \) leads to an increase in \( D^* \). In the Type 2 equilibrium, higher aggregate payments at \( t = 1 \) in the low state lead to an increase in the mass of investors that become informed causing \( \gamma^0_l \) to increase. If \( \pi_l \) becomes large enough the equilibrium can switch from Type 2 to Type 3 where some firms must use long-term contracts, resulting in a drop in aggregate investment and short-term debt. This is summarized in the following proposition.\(^{32}\)

**Proposition 8.** Aggregate investment \( K^* \) and short-term debt \( \alpha^* \) are decreasing in \( \pi_l \).

Figure 6 displays an example. Although I have only considered exogenous changes in \( \pi_l \), other changes in parameters that increases the value of information for lenders lead to an increase in \( d_{01}^{0S} \) which in turn increases adverse selection in the asset market.

Proposition 8 can help explain why short-term funding markets periodically become impaired. These episodes are often associated with increases in uncertainty and reduced maturities of short-term debt (e.g. the 2008/2009 financial crisis). My analysis suggests that increases in uncertainty not only affect firms’ initial financing decisions directly, but also indirectly through higher liquidation costs.

4.4 Welfare

In this section I consider a concept of constrained efficiency in which a planner chooses the mass of firms who use short-term contracts \( \alpha \) to maximize the sum of firms’ total

\(^{32}\)This is true even if the NPV of the project \( (\pi_h + \pi_l \phi_l)R - 1 \) is held constant while \( \pi_l \) varies.
Figure 6: The Effect of Uncertainty on Debt Maturity, Liquidation Costs and Investment. This figure depicts example equilibria for parameter values $\theta = 0.5$, $\mu = 0.5$, $c = 0.01$, $\kappa = 0.02$, where $m(\eta) = \frac{\eta}{1+\eta}$, while varying $\pi_l$.

profits $W(\alpha)$. Let $V^{0S}(\alpha)$ denote the profits from the short-term contract as a function of $\alpha$, then the planner’s problem is

$$\max_{\alpha \in [0,1]} W(\alpha) = \alpha V^{0S}(\alpha) + (1 - \alpha)V^{L*}. \quad (18)$$

Differentiating $W(\alpha)$ with respect to $\alpha$

$$\frac{dW(\alpha)}{d\alpha} = V^{0S}(\alpha) - V^{L*} + \alpha \frac{dV^{0S}(\alpha)}{d\alpha}. \quad (19)$$

At the Type 3 equilibrium point $V^{0S}(\alpha^*) = V^{L*}$ so (19) becomes

$$\frac{dW(\alpha^*)}{d\alpha^*} = \alpha^* \frac{dV^{0S}(\alpha^*)}{d\alpha^*} < 0,$$

because $\frac{dV^{0S}(\alpha^*)}{d\alpha^*} < 0$ in the Type 3 equilibrium. Therefore, there is always too much short-term debt in the Type 3 equilibrium and the planner would reduce $\alpha$ below $\alpha^*$ and raise asset prices and total welfare. Because $V^{0S}(\alpha^*) > V^{L*}$ in the Type 2 equilibrium,
the efficiency of the equilibrium depends on the parameters and \( m(\eta) \); however, in the Appendix, I fully characterize the planner’s solution for a particular form of the matching function.\(^{33}\) In the Type 1 equilibrium there is no information production at any point and the first-best is achieved \( W(\alpha^*) = V^{FB} \). Finally, there can never be too little short-term debt because the only equilibrium type in which \( \alpha^* < 1 \) is the Type 3 in which there is always too much short-term debt.

**Proposition 9** (Excessive Short-Term Debt). The Type 1 equilibrium is always constrained efficient. In some cases, the planner can raise welfare in the Type 2 equilibrium by reducing \( \alpha \) below \( \alpha^* = 1 \). The planner can always raise welfare in the Type 3 equilibrium by reducing \( \alpha \) below \( \alpha^* < 1 \).

The economic logic behind Proposition 9 is that while firms internalize the cost of reduced investment and inefficient information production by their lenders they fail to internalize the cost short-term financing imposes on other firms through information production in the asset market because asset prices are market-determined. Hence, this can create situations in which firms defer too much information production to the asset market.

### 4.5 Implementation

In this section I discuss implementation and policies that can restore constrained efficiency if there is too much short-term debt. First an exogenous limit on the mass of firms using short-term debt \( \bar{\alpha} \) can implement the planner’s solution \( \alpha^{**} \).

**Proposition 10.** A limit on the mass of firms using short-term debt \( \bar{\alpha} = \alpha^{**} \) where \( \alpha^* \leq \bar{\alpha} \) can achieve constrained efficiency

While a limit on short-term debt leads to a Pareto improvement in the Type 3 equilibrium, it necessary leaves firms that are unable to use short-term debt in the Type 2 equilibrium worse off. To implement the planner’s solution \( \alpha^{**} \) while attaining a Pareto improvement, the planner can impose a contingent transfer \( \tau_{2l}(\tilde{R}) \) at \( t = 2 \) in the low state between firms using short-term contracts and those using long-term contracts.

\(^{33}\)Knowing the marginal change in welfare is not enough because in principle, welfare could be increasing at \( \alpha = 1 \) but still achieve its maximum at an interior point \( \alpha \in (0, 1) \).
Proposition 11. In a Type 2 equilibrium in which $\alpha^{**} < \alpha^*$, a $t = 2$ transfer $\tau_2(\tilde{R})$ from firms that choose contracts in which $d_{UU} > 0$ to firms that choose $C^{L*}$ achieves a Pareto improvement.

The transfer leads to a reduction in firms using short-term financing so that the market determined $\alpha^*$ coincides with the planner’s solution $\alpha^{**}$. The transfer must apply to any contract in which $d_{UU} > 0$ to avoid firms manipulating their short-term contracts to avoid paying the transfer. In practice, this could be implemented with a tax on short-term debt (i.e. a tax on repo contracts or margin loans).

A caveat to my normative analysis is that I have only considered the inefficiency that may arise from short-term debt through pecuniary externalities in asset markets. There may also be coordination problems that arise between creditors (e.g. He and Xiong (2012) and Brunnermeier and Oehmke (2013)). In addition, when regulating debt maturity and choosing monetary policy, policymakers must distinguish between short-term debt demanded by investors with liquidity needs (e.g. Diamond and Dybvig (1983), Stein (2012) and Diamond (2016)) and short-term debt being used to prevent inefficient information production by lenders. In Stein (2012), the government can reduce the incentives of financial institutions to issue safe securities by issuing them itself. This policy would not have an effect in the context of my model because firms borrow short-term for reasons unrelated to the demand for safe assets.

In practice, regulators can also directly intervene in asset markets. For example if the a regulator committed to buying all assets at $t = 1$ in the low state at $R$, there would be no incentive for investors to become informed and the first-best would be achieved. However, asset market interventions may have other costs such as moral hazard (e.g. Farhi and Tirole (2012a) and Lee and Neuhann (2017)) or direct costs of intervention. Therefore, I leave the consideration of these types of interventions for future work.

Finally, the only source of asset sales comes from firms’ short-term debt contracts. However, if other agents traded in the same asset markets for different reasons, the adverse selection problem could become severe enough such that it leads to a complete
shutdown in short-term debt markets.\textsuperscript{34} If this occurs, short-term debt subsidies can raise welfare. For example during the 2008/2009 financial crisis, the Federal Reserve took several actions to support short-term debt markets when they became impaired.\textsuperscript{35}

5 Conclusion

In this paper, I propose a new rationale for the widespread use of short-term debt by non-bank financial firms. In particular, I argue that short-term financing allows financial firms to avoid excessive information production by their financiers. This problem may be particularly severe for financial firms that borrow heavily from financial institutions, such as banks, that have expertise in the same types of assets.

Although short-term financing deters information production at origination, it leads to excessive information production when firms liquidate to repay their initial lenders following a negative shock. This delay in information production endogenously raises the cost of short-term financing through information-based fire sales. Moreover, when market conditions deteriorate, short-term funding markets can become impaired, i.e. short-term debt maturities shorten, while the volume of total credit decreases. These implications are consistent with the behavior of numerous short-term debt markets in the 2008/2009 financial crisis.

From a welfare perspective, firms’ may defer too much information production from origination to the asset market. This implication echoes the concerns of policymakers that financial firms are overly reliant on short-term financing as opposed to detailed credit analysis (Basel Committee on Banking Supervision (1999)). Hence, by shifting information production from the asset market to financing, regulations that limit or tax financial firms’ use of short-term debt can raise welfare.

\textsuperscript{34}Gorton and Metrick (2012a) document shutdowns in certain bilateral repo markets during the financial crisis.

\textsuperscript{35}For instance, the Term Auction Facility, Term Securities Lending Facility and the Primary Dealer Credit Facility offered short-term financing during the financial crisis (see Gorton, Laarits, and Metrick (2018) for more details). The Troubled Asset Relief Program, TARP, likely indirectly supported repo markets by boosting asset prices.
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A Appendix
A.1 Data Description for Figure 1

The hedge fund data is from SEC (2019a) where short-term debt is defined as debt with a maturity under 365 days (Table 48) and Debt/Assets is derived from Borrowing/NAV (Figure 4a). The mortgage REIT data is from Pellerin, Sabol, and Walter (2013a) where short-term debt is defined as repo agreements. The mortgage originator debt maturity data comes from Kim et al. (2018) where they define short-term debt as warehouse loans (typically under a year maturity) and “other forms of short-term”. Mortgage originator leverage is defined as secured debt to tangible assets and is taken from a poll of 10 firms by Moody’s (Moody’s Investor Service, 2016). Industrial firms are from Compustat fiscal year-end 2018 and short-term debt is defined as debt with maturity under one year. I remove any financial firms within the SIC range of 6000-6999 and exclude firms with leverage greater than 1.
A.2 Proofs

Proof of Proposition 1. Denote $C_{FB} \equiv \{k_{FB}^h, q_{FB}^h, q_{FB}^l, d_{1h}^{FB}, d_{2h}^{FB}, d_{2l}^{FB}\}$ the optimal benchmark contract. To show $q_{FB}^h = 0$, suppose to the contrary that $q_{FB}^h > 0$. First suppose that $d_{1h}^{FB} = 0$. If the firm reduces $q_{FB}^h$ by any $\epsilon > 0$ where $q_{FB}^h - \epsilon \geq 0$, (4) and (5) would not be violated while the firm’s profits (2) would increase because $\gamma_0^h \geq 0$, which contradicts that $C_{FB}$ is optimal. Next suppose that $d_{1h}^{FB} > 0$. If the firm reduces $q_{FB}^h$ by any $\epsilon > 0$ where $q_{FB}^h - \epsilon \geq 0$, decreases $d_{1h}^{FB}$ by $\epsilon \phi_h$ and increase $d_{2h}^{FB}$ by $\epsilon$, (4) and (5) would not be violated and (2) would increase. The same steps can be used to show that $q_{FB}^l = 0$. Since $q_{FB}^h = q_{FB}^l = 0$, (5) implies that $d_{1h}^{FB} = d_{1l}^{FB} = 0$.

To show that $k_{FB} = 1$, suppose to the contrary $k_{FB} < 1$. If the firm increases $k_{FB}$ by any $\epsilon > 0$ where $k_{FB} + \epsilon \leq 1$, increases $d_{2h}^{FB}$ by $\epsilon R$ and increases $d_{2l}^{FB}$ by $\frac{1-\pi_h R}{\pi_l \phi_l}$, (4) and (5) would not be violated and the firm’s profits (2) would increase. Therefore $k_{FB} = 1$.

We can rewrite the problem as follows

$$\max \sum_z \pi_z \phi_z (R - d_{2z}),$$

s.t.

$$1 \leq \sum_z \pi_z \phi_z d_{2z},$$

$$d_{2z} \in [0, R] \quad z = h, l.$$  \hspace{1cm} (20)

(21)

Since the firm has all of the bargaining power (20) binds with equality. Thus any contract that leads (20) to bind and satisfies (21) constitutes an optimal benchmark contract and the firm earns profits

$$V_{FB} = (\pi_h + \pi_l \phi_l) R - 1.$$

Proof of Lemma 1. From (8) the lender would produce information if offered $C_{FB}$. The firm’s profits would be

$$\theta \left( \sum_z \pi_z (R - d_{2z}) \right).$$  \hspace{1cm} (22)

Note that the benchmark optimal contract that makes (22) largest while satisfying (20) is $d_{2h} = R$ and $d_{2l} = \frac{1-\pi_h R}{\pi_l \phi_l}$ which yields

$$\frac{\theta (\pi_h R + \pi_l \phi_l R - 1)}{\phi_l}.$$  \hspace{1cm} (23)
However, (23) is strictly less than $V^{FB}$ because $\frac{\theta}{\varphi} < 1$.

**Proof of Lemma 2.** Denote $C_{0}^{*} \equiv \{ k_{0}^{*}, q_{0}^{h*}, q_{0}^{l*}, d_{1h}^{0*}, d_{2h}^{0*}, d_{2l}^{0*}, d_{2l}^{0*} \}$ the optimal contract that deters information acquisition. The same steps from the proof of Proposition 1 can be used to show that $q_{0}^{h*} = d_{1h}^{0*} = 0$. To show that $d_{1l}^{0*} = q_{0}^{l*} p_{l}^{0}$, suppose to the contrary $q_{0}^{l*} > d_{1l}^{0*}$. If the firm reduces $q_{0}^{l*}$ by an $\epsilon > 0$ where $(q_{0}^{l*} - \epsilon)p_{l}^{0} \geq d_{1l}^{0*}$, (5) would not be violated while the firm’s profits (2) would increase because $\gamma_{l}^{0} \geq 0$. Therefore $d_{1l}^{0*} = q_{0}^{l*} p_{l}^{0}$.

The problem can then be rewritten as

$$\max_{c} \pi_{h}(kR - d_{2h}) + \pi_{l}\phi_{l} \left( \frac{k - d_{1l}}{p_{l}^{0}} R - d_{2l} \right),$$

s.t.

$$k \leq 1,$$

$$k \leq \pi_{h}d_{2h} + \pi_{l}(d_{1l} + \phi_{l}d_{2l}), \quad (24)$$

$$(1 - \theta)(k - \pi_{h}d_{2h} - \pi_{l}(d_{1l} + \mu d_{2l})) \leq c, \quad (25)$$

$$d_{2h} \leq kR, \quad (26)$$

$$d_{2l} \leq \left( k - \frac{d_{1l}}{p_{l}^{0}} \right) R. \quad (27)$$

Next we can prove the incentive compatibility constraint (25) binds. By Lemma 1, (25) is violated if the following three conditions are true: i) $d_{1l} = 0$, ii) $k = 1$ and iii) the participation constraint (24) binds; hence at least one of the above conditions do not hold. I then prove by contradiction that (25) binds in each of these three cases.

**Case 1.** $d_{1l}^{0*} > 0$

Suppose to the contrary that $d_{1l}^{0*} > 0$ and (25) is slack. There exists a small enough $\epsilon > 0$ such that if the firm decreases $d_{1l}^{0*}$ by $\epsilon$ and increases $d_{2l}^{0*}$ by $\frac{\epsilon}{\phi_{l}}$, then (24), (25) and (27) would not be violated. This would reduce $q_{l}^{0*}$ which causes the firm’s profits to increase because $\gamma_{l}^{0} \geq 0$.

**Case 2.** $k^{0*} < 1$

Suppose to the contrary that $k^{0*} < 1$ and (25) is slack. There exists a small enough $\epsilon > 0$ such that if the firm increases $k^{0*}$ by $\epsilon$ and increases $d_{2l}^{0*}$ by $\epsilon R$ and increases $d_{2h}^{0*}$ by $\frac{1 - \pi_{h}R}{\pi_{l}p_{l}^{0}}$, then (24), (25), (26) and (27) would not be violated, while the firm’s profits would increase.

**Case 3. The participation constraint (24) is slack**

Suppose to the contrary (24) and (25) are slack. There exists a small enough $\epsilon > 0$ such that if the firm decreased $d_{2h}^{0*}$, $d_{1l}^{0*}$, or $d_{2l}^{0*}$ by $\epsilon$, then (24), (25), (26) and (27) would not be violated, while the firm’s profits would increase. These three cases imply that the incentive compatibility constraint must bind.
Finally to prove $d_{2h}^0 = k^{0*}R$, suppose to the contrary $d_{2h}^0 < k^{0*}R$. If the firm increases $d_{2h}^0$ by $\epsilon > 0$ where $d_{2h}^0 + \epsilon \leq k^{0*}R$ and decreases $d_{2l}^0$ by $\frac{\epsilon}{\phi_{l1}}$, then (24), (26) and (27) would not be violated and (25) would slacken. However, as just shown (25) must bind at the optimum, which contradicts $C^{0*}$ being optimal. ■

Proof of Proposition 2. Following Lemma 2 and ignoring (27) for now, the problem can be written as

$$\max_{C} \pi_{l1} \phi_{l1} \left[ \left( k - \frac{d_{1l}}{p_{l1}} \right) R - d_{2l} \right],$$

s.t.

$$k \leq 1,$$  \hspace{1cm} (28)

$$k(1 - \pi_{h}R) \leq \pi_{l}(d_{1l} + \phi_{l}d_{2l}),$$  \hspace{1cm} (29)

$$(1 - \theta) [k(1 - \pi_{h}R) - \pi_{l}(d_{1l} + \mu d_{2l})] = c.$$  \hspace{1cm} (30)

The Lagrangian is

$$\mathcal{L} = \pi_{l1} \phi_{l1} \left[ \left( k - \frac{d_{1l}}{p_{l1}} \right) R - d_{2l} \right] - \lambda_{1} \left[ k(1 - \pi_{h}R) - \pi_{l}(d_{1l} + \phi_{l}d_{2l}) \right] -$$

$$\lambda_{2} \left[ (1 - \theta) \left( k(1 - \pi_{h}R) - \pi_{l}(d_{1l} + \mu d_{2l}) \right) - c \right] - \lambda_{3} (k - 1).$$

The Kuhn-Tucker necessary conditions are

$$\mathcal{L}_{d_{1l}} = \pi_{l1} \phi_{l1} \left( \frac{p_{l1} \left( \lambda_{1} + (1 - \theta) \lambda_{2} \right) - \phi_{l1} R}{p_{l1}} \right) \leq 0,$$

$$\mathcal{L}_{d_{2l}} = \pi_{l1} \left[ \phi_{l1} (1 - \lambda_{1}) - \mu (1 - \theta) \lambda_{2} \right] \leq 0,$$

$$\mathcal{L}_{k} = \pi_{l1} \phi_{l1} R - (1 - \pi_{h}R) \left( \lambda_{1} + (1 - \theta) \lambda_{2} \right) \lambda_{3} \leq 0,$$

$$\mathcal{L}_{d_{1l}} d_{1l} = 0, \quad \mathcal{L}_{d_{2l}} d_{2l} = 0, \quad \mathcal{L}_{k} k = 0,$$

$$\lambda_{1} \left[ k(1 - \pi_{h}R) - \pi_{l}(d_{1l} + \phi_{l}d_{2l}) \right] = 0,$$

$$\lambda_{2} \left[ (1 - \theta) \left( k(1 - \pi_{h}R) - \pi_{l}(d_{1l} + \mu d_{2l}) \right) - c \right] = 0,$$

$$\lambda_{3} (k - 1) = 0,$$

$$\lambda_{1} \geq 0, \quad \lambda_{2} > 0, \quad \lambda_{3} \geq 0,$$

(29), (30), (28).

There are many potential solutions to the system of equations; however, several can be eliminated immediately upon inspection. After doing so we are left with three potential
First, (33) can be ruled out because $\lambda_3 < 0$ from Assumption 1.1. In order for (31) to be a solution, it must be the case that $\gamma_0 \leq 1 - \frac{1}{\pi_l} \frac{\phi_l}{R}$ so that $\lambda_3 \geq 0$. (32) is a potential solution because $\lambda_1 > 0$ by Assumption 1.1. However, $L_{d_{1l}} > 0$, only if $\gamma_0 > 1 - \frac{1}{\pi_l} \frac{\phi_l}{R}$. Therefore, if $\gamma_0 \leq 1 - \frac{1}{\pi_l} \frac{\phi_l}{R}$ (31) is the solution while (32) is the solution otherwise. Also, note that (27) is not violated in any of the candidate solutions.

Proof of Proposition 3. Denote $C^{1*} \equiv \{ k^{1*}, q_{1h}^{1*}, q_{1l}^{1*}, d_{11}^{1*}, d_{12}^{1*}, d_{21}^{1*}, d_{22}^{1*} \}$ the optimal contract that induces information acquisition. The same steps from the proof of Proposition 1 can be used to show there are no liquidations or payments at $t = 1$ and $k^{1*} = 1$; however, in all cases (11) must remain slack which is always true because of Assumption 2. We can then rewrite the problem as follows

$$\max_{\theta} \theta \sum_z \pi_z (R - d_{2z}),$$

s.t.

$$\theta \left( \sum_z \pi_z d_{2z} - 1 \right) \geq c,$$

$$d_{2z} \in [0, R] \quad z = h, l.$$  \hspace{1cm} (34)

Since the firm has all of the bargaining power (35) binds. Therefore any contract that leads (35) to bind and satisfies (36) constitutes an optimal contract. The expected profits can be found by plugging the terms of $C^{1*}$ into (34).

Proof of Proposition 4. The proof comes immediately from comparing the profits
from \( C^{0*} \) and \( C^{1*} \) from Propositions 2 and 3.

**Proof of Proposition 5.** Differentiating \( V^{0S} \) with respect to \( \gamma_0^l \) we have

\[
\frac{c\phi_l}{\theta (1-\phi_l)} + \pi_h R - \frac{1}{(1 - \gamma_0^l)^2} < 0.
\]

\( V^{0L} \) and \( V^{1L} \) do not vary with \( \gamma_0^l \), hence the lower \( \gamma_0^l \), the more likely \( C^* = C^{0S} \).

**Proof of Proposition 6.** Differentiating \( d_{1l}^{0S} \) with respect to \( \pi_l \) we have

\[
\frac{R - 1 + \frac{c\phi_l}{\theta (1-\phi_l)}}{\pi_l^2} > 0.
\]

Notice this also true if we define maturity as

\[
\frac{d_{1l}^{0S}}{d_{1l}^{0S} + d_{2l}^{0S}}
\]

\[
\frac{\partial}{\partial \pi_l} \left( \frac{d_{1l}^{0S}}{d_{1l}^{0S} + d_{2l}^{0S}} \right) = \frac{c\theta R}{(1 - \phi_l) (c + \theta (1 - \pi_h R))} > 0.
\]

**Proof of Lemma 3.** See text.

**Proof of Proposition 7.** For convenience, define the set of contracts that deter the lender from producing information.

\[
C^0 \equiv \{ C : a = 0 \}.
\]

Let \( \gamma_0^l(\eta^*(D)) \) denote the liquidation cost in the low state received by firms \( i \in I^0 \) as a function of the equilibrium mass of informed investors given \( D \) and \( V^{0S}(D) \) the profits from the short-term contract as a function of \( D \). I break the proof into three cases.

**Case 1.** \( \Pi \left( 0, d_{1l}^{0S} \right) < 0 \)

If \( \alpha = 1 \) no investors would find it optimal to become informed \( \eta = 0 \). Hence, \( \eta^* = 0 \), \( \gamma_0^{0*} = 0 \) and \( \alpha^* = 1 \) (from Proposition 4).

**Case 2.** \( \Pi \left( 0, d_{1l}^{0S} \right) \geq 0 \) and \( V^{0S}(d_{1l}^{0S}) \geq V^{L*} \)

If \( \alpha = 1 \) then a positive mass of investors \( \eta > 0 \) would find it optimal to become informed. However, the resulting \( V^{0S}(d_{1l}^{0S}) \) is sufficiently high enough such that all firms still find it optimal to choose \( C^{0S} \) by Proposition 4. Hence \( \alpha^* = 1 \), \( \eta^* > 0 \), and \( \gamma_0^{0*} > 0 \).

**Case 3.** \( V^{0S}(d_{1l}^{0S}) < V^{L*} \)
If \( \alpha = 1 \), \( \gamma_0^0 \) would be so high that no firms would find it optimal to choose \( C^{0S} \). However, if \( \alpha = 0 \), then \( \gamma_0^0 = 0 \) and all firms would find it optimal to choose \( C^{0S} \). Thus, all firms must choose contracts \( C(i) \) such that they are indifferent between \( C(i) \) and the most profitable long-term contract \( V(i) = V^{L*} \) for all \( i \).

**Lemma A.1.** In Case 3 \( V(i) = V^{L*} \) for all \( i \).

**Proof.** Suppose to the contrary there is some contract \( C' \) used in equilibrium in which \( V' \neq V^{L*} \). First it can never be the case that \( V' < V^{L*} \) by Proposition 4. Now suppose that \( V' > V^{L*} \). Since, \( C^{1L} = C^{1*} \), if \( V' > V^{L*} \) then \( C' \in C^0 \). Since \( V' > V^{0L} \) it must be that \( C' = C^{0S} \) by Proposition 2. However, if \( V^{0S} > V^{L*} \), then all firms would choose \( C(i) = C^{0S} \), which is a contradiction because \( V^{0S}(d_{1i}^{0S}) < V^{L*} \). Therefore, \( V(i) = V^{L*} \) for all \( i \) in Case 3.

There are two sub-cases within Case 3.

**Subcase 1.** \( C^{L*} = C^{1L} \)

First note that it cannot be that \( C(i) = C^{1L} \) for all \( i \) because if this were true \( \gamma_i^0(\eta^*(0)) = 0 \) which would induce all firms to choose \( C^{0S} \). Therefore there must be some contract \( C' \in C^0 \) used in equilibrium with profits \( V' \) where from Lemma A.1, \( V' = V^{1L} \). From Proposition 2, it must be the case that \( C' = C^{0S} \). Thus, the only contracts that are used in equilibrium are \( C^{0S} \) and \( C^{1L} \) where \( \alpha \) is the fraction of firms that choose \( C^{0S} \). Hence, the following equation characterizes \( \alpha^* \)

\[
G(\alpha^* d_{1i}^{0S}) = V^{0S}(\alpha^* d_{1i}^{0S}) - V^{1L} = 0.
\]

First note that \( \alpha^* \neq 1 \) because \( V^{0S}(d_{1i}^{0S}) < V^{1L} \). Define \( \bar{\alpha} \) as the largest \( \alpha \) such that no investors become informed \( \eta^* = 0 \)

\[
\bar{\alpha} = \arg \max_{\alpha} \alpha \text{ s.t. } \eta^*(\alpha d_{1i}^{0S}) = 0.
\]

Since \( V^{0S}(\alpha d_{1i}^{0S}) = V^{FB} > V^{1L} \), it must be that \( \alpha^* \in (0,1) \). In this region \( \gamma_{i}^0(\eta^*(\alpha d_{1i}^{0S})) \) is strictly increasing in \( \alpha \) from (17). Hence, \( V^{0S}(\alpha d_{1i}^{0S}) \) is strictly decreasing in \( \alpha \) and there exists a unique \( \alpha^* \in (0,1) \) such that \( G(\alpha^* d_{1i}^{0S}) = 0 \).

**Subcase 2.** \( C^{L*} = C^{0L} \)

From Lemma A.1 \( V(i) = V^{0L} \) for all \( i \). It will be useful to establish the following lemma

**Lemma A.2.** In Case 3 when \( C^{L*} = C^{0L} \), \( V^{0S}(D^*) = V^{0L} \).
Proof. Suppose $V^{0S}(D^*) < V^{0L}$ then from Proposition 2 all firms to choose $C^* = C^{0L}$. However, if this is the case $\gamma_0 = 0$ which is a contradiction. Suppose $V^{0S}(D^*) > V^{0L}$ then from Proposition 2 all firms would choose $C^* = C^{0L}$. However, if this is the case $V^{0S}(D^*) < V^{0L}$ which is also a contradiction. ■

Lemma A.2 implies that the Lagrange multiplier ($\lambda_3$) on the constraint $k \leq 1$ for the candidate solution (31) equals zero. Hence, there can potentially be other contracts $C \in C^{0}$ other than $C_0S$ and $C_0L$ used in equilibrium. The following conditions characterize the equilibrium

$$k(i)(1 - \pi_R) = \pi_l (d_{II}(i) + \phi_l d_{II}(i)) \quad \forall i,$$

$$(1 - \theta) [k(i)(1 - \pi_R) - \pi_l (d_{II}(i) + \mu d_{II}(i))] = c \quad \forall i,$$

$$d_{II}(i) \geq 0 \quad \forall i,$$

$$V (i; D^*) = V^{0L} \quad \forall i.$$

Each firm’s participation constraint and incentive compatibility constraint bind and all firms must earn profits equal to the long-term contract with reduced investment given $D^*$. Further simplifying,

$$d_{II}(i) = \frac{c}{\theta \pi_l (1 - \phi_l)} \quad \forall i,$$

$$k(i) = \frac{c \phi_l + d_{II}(i)(1 - \phi_l) \theta \pi_l}{(1 - \phi_l) \theta (1 - \pi_R)} \quad \forall i,$$

$$d_{II}(i) \geq 0 \quad \forall i,$$

$$V (i; D^*) = V^{0L} \quad \forall i.$$

Integrating (37) over $i$,

$$K^* = \int_0^1 k(i) di = \frac{c \phi_l + D^*(1 - \phi_l) \theta \pi_l}{(1 - \phi_l) \theta (1 - \pi_R)}.$$

Since $K^*$ and $D^*$ do not depend on the exact distribution of firms’ contracts, I focus on the case where firms choose between $C^{0S}$ and $C^{0L}$. Therefore, the following equation characterizes the equilibrium

$$G(\alpha^* d_{II}^{0S}) = V^{0S}(\alpha^* d_{II}^{0S}) - V^{0L} = 0.$$

As in the previous sub-case, $V^{0S}(\alpha d_{II}^{0S})$ is strictly decreasing in $\alpha$ when $\alpha \in [\alpha, 1]$. Therefore, there exists a unique $\alpha^* \in (0, 1)$ such that $G(\alpha^* d_{II}^{0S}) = 0$. ■

Proof of Corollary 1. From Proposition 7 in the Type 1 and 2 equilibria $\alpha^* = 1$. Therefore $K^* = 1$ because $k^{0S} = 1$. In the Type 3 equilibrium $\alpha^* < 1$ which implies

50
\[ K^* < 1 \text{ because } \theta < 1 \text{ and } k^0_L < 1. \]

**Proof of Proposition 8.** Recall in the Type 3 equilibrium, \( \alpha^* \) solves

\[
G(\alpha^* d_{ii}^{OS}) = V^{OS}(\alpha^* d_{ii}^{OS}) - V^{L*} = 0.
\]

Applying the implicit function theorem

\[
\frac{d\alpha^*}{d\pi_l} = -\frac{\partial G}{\partial \pi_l} \frac{\partial G}{\partial \theta} \frac{d\theta}{d\pi_l} = -\left(\frac{(-)}{(-)(+)(+)}\right) < 0.
\]

(38)

Differentiating \( K^* \) with respect to \( \pi_l \) when \( C_L^* = C^0_L \)

\[
\frac{dK^*}{d\pi_l} \bigg|_{C^{L*} = C^0_L} = (1 - \alpha^*) \frac{\partial k^0_L}{\partial \pi_l} + (1 - k^0_L) \frac{d\alpha^*}{d\pi_l} < 0.
\]

and when \( C^{L*} = C^1_L \)

\[
\frac{dK^*}{d\pi_l} \bigg|_{C^{L*} = C^1_L} = (1 - \theta) \frac{d\alpha^*}{d\pi_l} < 0.
\]

Next we need to show that \( K^* \) is decreasing in \( \pi_l \) at the point where \( V^{0L} = V^{1L} \). First note that \( V^{0L} - V^{1L} \) is decreasing in \( \pi_l \)

\[
\frac{\partial (V^{0L} - V^{1L})}{\partial \pi_l} = \frac{c(R - 1)R\phi_l^2}{(1 - \phi_l)(1 - \pi_l R)^2} < 0.
\]

This implies that as \( \pi_l \) increases it becomes more likely that \( C^{L*} = C^1_L \). Finally we need to show that the realized investment level for \( C^1_L \) is lower than \( C^0_L \) when the profits from those contracts are equal i.e. \( \theta < k^0_L \) when \( V^{1L} = V^{0L} \)

\[
k^0_L - \theta = \frac{c\phi_l}{\theta(1 - \phi_l)(1 - \pi_l R)} - \theta,
\]

which is negative when \( V^{1L} = V^{0L} \). Hence, when the equilibrium is Type 3, both \( K^* \) and \( \alpha^* \) are decreasing in \( \pi_l \). The last step is to show that as \( \pi_l \) increases the equilibrium moves from Type 1 to Type 2 to Type 3. When the equilibrium is Type 1 the following condition holds

\[
\Pi (0, d_{ii}^{OS}) < 0.
\]

(39)

Since \( d_{ii}^{OS} \) is increasing in \( \pi_l \), an increase in \( \pi_l \) tightens (39). When the equilibrium is
Type 2, the following conditions are true

\[ \Pi(0, s_{il}^0) > 0, \quad V^{0S}(s_{il}^0) \geq V^{L*} \]  

(40) \hspace{1cm} (41)

An increase in \( \pi_l \) relaxes (40) and from (38) tightens (41). Therefore, as \( \pi_l \) increases the equilibrium moves from Type 1 to Type 2. When the equilibrium is Type 3, the following condition is true:

\[ V^{0S}(s_{il}^0) < V^{L*}. \]  

(42)

An increase in \( \pi_l \) relaxes (42). Therefore, as \( \pi_l \) increases the equilibrium moves from Type 2 to Type 3. Note that the equilibrium cannot jump from Type 1 to Type 3 from increasing \( \pi_l \) continuously because (39) implies (41). Summarizing, if an increase in \( \pi_l \) causes the equilibrium to switch types, the new equilibrium type results in a lower \( K^* \) and \( \alpha^* \). Together all of these pieces imply that \( \alpha^* \) and \( K^* \) are decreasing in \( \pi_l \).  

**Proof of Proposition 9**. When \( \Pi(0, s_{il}^0) > 0 \), i.e. Type 2 or Type 3 equilibrium, the planners solution \( \alpha^{**} \) must be at least as large as \( \overline{\alpha} \) (the largest fraction of firms using short-term financing such that no investors become informed) because otherwise it could costlessly raise \( W(\alpha^{**}) \) by increasing \( \alpha^{**} \) since \( V^{0S}(\alpha s_{il}^{0S}) = V^{FB} \) when \( \alpha \leq \overline{\alpha} \). Since (18) is continuous in the interval \( \alpha \in [\overline{\alpha}, 1] \), \( W(\alpha) \) obtains its maximum in this interval by the extreme value theorem. I refer to the text for the proof that the Type 3 equilibrium always has an excessive amount of short-term debt. To fully characterize the efficiency of the Type 2 equilibrium more assumptions are needed regarding \( m(\eta) \). However, there can never be too little short-term debt because the only equilibrium in which \( \alpha^* < 1 \) is the Type 3 equilibrium in which there is always too much short-term debt.  

**Proof of Proposition 10**. If a limit on the mass of firms that can use short-term debt \( \bar{\alpha} = \alpha^{**} < 1 \) is imposed when \( \alpha^* = 1 \), then necessarily all firms will still prefer short-term contracts because \( V^{0S}(d_{il}^{0S}) < V^{0S}(\alpha^* d_{il}^{0S}) \). Thus, as many firms as possible will use short-term contracts \( \alpha^* = \bar{\alpha} \) which coincides with the planner’s solution. If \( \alpha^* < 1 \) (Type 3 equilibrium), then \( V^{0S}(\alpha^* d_{il}^{0S}) = V^{L*} \) and since decreasing \( \alpha^{**} < \alpha^* \) implies that \( V^{0S}(\alpha^{**}) > V^{0S}(\alpha^*) \). Therefore, all firms will prefer short-term contracts and \( \alpha^* = \bar{\alpha} \).  

**Proof of Proposition 11**. Define \( \tau_{2z}(\hat{R}) \) as a transfer in state \( z \) contingent on \( \hat{R} \) from firms that choose contracts in which \( d_{il}(i) > 0 \) to firms with \( d_{il}(i) = 0 \). For simplicity assume the transfers have priority over payments to lenders so that firms cannot default on payments. Then the feasibility constraints on \( d_{2z} \) become

\[ d_{2z} \leq (k - q_z) R - \tau_{2z}(R) \quad z = h, l. \]  

(43)
Since \( d_{2L}^{0S} = k^{0S} R \) we can restrict focus to transfers in the low state at \( t = 2 \). Notice, that because the transfer affects all contracts in which \( d_{U1} > 0 \) equally, firms will still choose between \( C^{0S} \) and \( C^{L*} \). The optimal transfer \( \tau_{2L}^{*}(R) \) must make firms indifferent between \( C^{0S} \) and \( C^{L*} \) at the planner’s solution \( \alpha^{**} \).

\[
V^{0S}(\alpha^{**} d_{U1}^{0S}) - \pi_{1} \theta \tau_{2L}^{*}(R) = V^{L*} + \pi_{1} \left( \frac{\alpha^{**}}{1 - \alpha^{**}} \right) \tau_{2L}^{*}(R).
\] (44)

When (43) binds the firm earns zero profits from short-term contracts which implies (44) is violated. Therefore, there always exists a \( \tau_{2L}^{*}(R) \) that solves (44) while satisfying (43).
B Online Appendix

In the Online Appendix I include various robustness checks and extensions. To avoid overburdensome notation, for each individual section I will refer to $C^0\ast$, $C^1\ast$ and $C\ast$ as the revised versions of the optimal contract without information acquisition, with information acquisition and overall optimal contract for that particular section. I will be explicit when referring to the specific versions of these contracts in the main text.

B.1 Firm Can Raise Additional Funds at $t = 0$ and Store Funds Across Dates

In the main text I do not allow the firm to raise additional funds beyond $k$ at $t = 0$ or store funds across dates. In this section I show that this is without loss of generality. Consider the following revised definition of a financial contract.

$$C \equiv \{ k, q_z, d_0, d_{1z}, d_{2z}(\tilde{R}), e_0, e_{1z}, e_{2z}(\tilde{R}) \}_{z=h,l, \tilde{R}=R,0} \tag{45}$$

The differences between Definition 1 and (45) are i) $d_0$ which is the funds the firm raises at $t = 0$ which can potentially exceed $k$ and ii) the payment at $t = 2$ $d_{2z}(\tilde{R})$ can be conditioned on the project’s success or failure, and iii) $e$ is the firm’s consumption that may depend on the state and project output. The revised definition of the contract will only be relevant for the optimal contract without information acquisition $C^0\ast$. For the optimal contract with information production $C^1\ast$ as long as the firm captures the full surplus and the lender acquires information its profits will always be $V^1\ast = \theta(R - 1) - c$. The timing of the firm’s consumption is irrelevant because the firm is risk-neutral and there is no discounting. Hence, it is without loss of generality to assume the firm stores any excess funds raised at $t = 0$ to $t = 1$. The firm’s problem can be written as

$$\max_C d_0 - k + \sum_z \pi_z \left[ q_z p_z^0 - d_{1z} + \phi_z [(k - q_z) R - d_{2z}(R)] - (1 - \phi_z) d_{2z}(0) \right],$$

s.t.

- $k \leq d_0, \quad k \leq 1$,
- $d_0 \leq \pi_h (d_{1h} + d_{2h}) + \pi_l [d_{1l} + \phi d_{2l}(R) + (1 - \phi) d_{2l}(0)]$,
- $(1 - \theta) (d_0 - \pi_h (d_{1h} + d_{2h}) - \pi_l [d_{1l} + p d_{2l}(R) + (1 - p) d_{2l}(0)]) \leq c, \tag{46}$
- $q_z \in [0, k]$, \quad $d_{1z} \leq q_z p_z^0 + d_0 - k$ \quad $z = h, l$,
- $d_{2h}(R) \leq d_0 - k + q_h p_h^0 - d_{1h} + (k - q_h) R$,
- $d_{2l}(\tilde{R}) \leq d_0 - k + q_l p_l^0 - d_{1l} + (k - q_l) \tilde{R}$ \quad $\tilde{R} = R, 0$,
- $p_z^0 = (1 - \gamma_z) \phi_z R$, \quad $z = h, l.$
Using the same steps from Proposition 1 we can show \( q_0^0 = 0 \). Since there is no difference in the lender’s expected payments or the firm’s profits if the lender receives payments in the high state at \( t = 1 \) or \( t = 2 \) it is w.l.o.g to set \( d_{2h}^0 = 0 \). In addition, using the same steps from Lemma 2 we can show the incentive compatibility constraint (46) binds and \( d_{2h}^0 = k^0(R - 1) + d_0^0 \). Define \( \delta_1 \) as the firm’s cash at the beginning of \( t = 1 \)

\[
\delta_1 \equiv d_0 - k,
\]

and \( \delta_2 \) as the firm’s cash at the beginning of \( t = 2 \):

\[
\delta_2 \equiv d_0 - k + q_z p_0^0 - d_{1z}^0 \quad z = h, l.
\]

We can then rewrite the problem as follows

\[
\max_C \pi_l \left[ \phi_l \left[ \delta_2 + (k - q_l) R - d_2(R) \right] + (1 - \phi_l) \left[ \delta_2 - d_2(0) \right] \right], \quad (47)
\]

s.t.

\[
k \leq d_0, \quad k \leq 1,
\]

\[
d_0 \leq \pi_h (\delta_1 + k R) + \pi_l \left[ d_{1l} + \phi_l d_2(R) + (1 - \phi_l) d_2(0) \right], \quad (48)
\]

\[
(1 - \theta) (d_0 - \pi_h (\delta_1 + k R) - \pi_l \left[ d_{1l} + \mu d_2(R) + (1 - \mu) d_2(0) \right]) = c, \quad (49)
\]

\[
q_l \in [0, k], \quad d_{1l} \leq q_l p_l^0 + \delta_1
\]

\[
d_2(R) \leq \delta_2 + (k - q_l) R \quad R = R, 0,
\]

\[
p_z^0 = (1 - \phi_z^0) \phi_z R, \quad z = h, l.
\]

It will be useful to establish the following lemma.

**Lemma B.1.** \( d_{2l}(0)^{0*} = \delta_{2l}^{0*} \)

**Proof.** Suppose to the contrary \( d_{2l}(0)^{0*} < \delta_{2l}^{0*} \). First consider the case in which \( d_{2l}^{0*}(R) > 0 \). If the firm increases \( d_{2l}(0)^{0*} \) by \( \epsilon > 0 \) where \( d_{2l}(0)^{0*} + \epsilon \leq \delta_{2l}^{0*} \) and reduces \( d_{2l}^{0*}(R) \) by \( \left( \frac{1 - \phi_l}{\phi_l} \right) \epsilon \), (48) would not be violated while (49) would slacken which contradicts \( C^{0*} \) being optimal. Next consider the case in which \( d_{2l}^{0*}(R) = 0 \). Since \( \pi_h R < 1 \), it must be that \( q_l^{0*} > 0 \) in order for (48) to not be violated. To see this, suppose that \( q_l^{0*} = 0 \), and insert the largest value of \( d_{2l}(0)^{0*} = d_0 - k - d_{1l} \) into (48) and we have

\[
k (1 - \pi_l R) - \pi_l \phi_l (d_0 - k - d_{1l}) \leq 0 \quad (50)
\]

Inserting the largest possible value of \( d_{1l}^{0*} = d_0 - k \) into (50) we have

\[
k (1 - \pi_l R) \leq 0
\]
Which is violated so long as $k > 0$. Hence $q_l^0 > 0$. The firm can then reduce $q_l^0$ by $\epsilon$ and no constraints are violated while the firm’s profits (47) increase since $\gamma_l^0 \geq 0$. ■

Once again rewriting the problem following Lemma B.1

$$
\max_c \pi_l \phi_l [\delta_{2t} + (k - q_l) R - d_{2t}(R)],
$$

s.t.

$$
k \leq d_0, \quad k \leq 1,
$$

$$
d_0 \leq \pi_h (\delta_{1} + kR) + \pi_l [d_{1l} + \phi_l d_{2t}(R) + (1 - \phi_l)\delta_{2t}],
$$

$$
(1 - \theta) (d_0 - \pi_h (\delta_{1} + kR) - \pi_l [d_{1l} + \mu d_{2t}(R) + (1 - \mu)\delta_{2t}]) = c,
$$

$$
q_l \in [0, k], \quad d_{1l} \leq q_l p_l^0 + \delta_{1},
$$

$$
d_{2t}(R) \leq \delta_{2t} + (k - q_l) R,
$$

$$
p_l^0 = (1 - \gamma_l^0)\phi_l R.
$$

Expanding (51) and (52),

$$
d_0 \leq \pi_h (\delta_{1} + kR) + \pi_l [\phi_l (d_{1l} + d_{2t}(R)) + (1 - \phi_l)q_l p_l^0],
$$

$$
(1 - \theta) (d_0 - \pi_h (\delta_{1} + kR) - \pi_l [\mu (d_{1l} + d_{2t}(R)) + (1 - \mu)q_l p_l^0]) = c.
$$

Upon inspection, we can see the lender’s incentives to acquire information and the firm’s profits are invariant between $d_{1l}$ and $d_{2t}(R)$, i.e. storing funds from $t = 1$ to $t = 2$. Hence, it is without loss of generality to set $\delta_{0t}^2 = 0$ and rewrite the problem as

$$
\max_c \pi_l \phi_l [\delta_{1} + (k - q_l) R - d_{2t}(R)],
$$

s.t.

$$
k \leq d_0, \quad k \leq 1,
$$

$$
d_0 \leq \pi_h (\delta_{1} + kR) + \pi_l [d_{1l} + \phi_l d_{2t}(R)],
$$

$$
(1 - \theta) (d_0 - \pi_h (\delta_{1} + kR) - \pi_l [d_{1l} + \mu d_{2t}(R)]) = c,
$$

$$
q_l \in [0, k], \quad d_{1l} \leq q_l p_l^0 + \delta_{1}, \quad d_{2t}(R) \leq (k - q_l) R,
$$

$$
p_l^0 = (1 - \gamma_l^0)\phi_l R.
$$

We can use the same steps from Lemma 2 to show that $d_{0t}^0 = q_l^0 p_l^0 + \delta_{1}^0$. The problem
can be written as

$$\max_c \pi_l \phi_l \left[ (k - q_l) R - d_{2l}(R) \right],$$

s.t.

$$k \leq 1,$$

$$k \leq \pi_h k R + \pi_l \left( q_l p^0_l + \phi_l d_{2l}(R) \right),$$

$$\left( 1 - \theta \right) \left( k - \pi_h k R - \pi_l (q_l p^0_l + \mu d_{2l}(R)) \right) = c,$$

$$q_l \in [0, k], \quad \text{d}_{2l}(R) \leq (k - q_l) R,$$

$$p^0_l = (1 - \gamma^0_l) \phi_l R,$$

where \(d_0\) simply drops out. Hence, it is without loss of generality that the firm only raises \(k\) initially and does not store funds across periods.

**B.2 Firm Knows Project Type and Lender Cannot Acquire Information**

In this section, I analyze the case in which the firm knows \(\upsilon\) and the lender cannot acquire information. This is useful to show that exogenous asymmetric information alone will not lead to firms’ using short-term financing.

Because the firm knows its project type, its contract offer may be a signal about its type. First note that there can never be a separating equilibrium because the bad project is NPV negative. Depending on off-equilibrium beliefs, there can be a multiplicity of equilibria. To narrow down the potential equilibria, I apply undefeated equilibrium refinement from Mailath, Okuno-Fujiwara, and Postlewaite (1993).

This refinement allows the firm with the good project to choose a contract that yields the highest profits subject to being mimicked by the firm with the bad project. The problem can be written as

$$\max_c \sum_z \pi_z \left( q_z p^0_z - d_{1z} + (k - q_z) R - d_{2z} \right)$$

s.t.

$$k \leq 1,$$

$$k \leq \sum_z \pi_z (d_{1z} + \phi_z d_{2z}),$$

$$q_z \in [0, k], \quad d_{1z} \leq q_z p^0_z, \quad d_{2z} \leq (k - q_z) R \quad z = h, l,$$

$$p^0_z = (1 - \gamma^0_z) \phi_z R, \quad z = h, l.$$

The following lemma immediately follows.
Lemma B.2. In the optimal contract in which the firm knows its project type and the lender cannot acquire information,

\begin{align*}
  i) & \quad q_h^* = q_l^* = 0 \\
  ii) & \quad d_{2h}^* = d_{2l}^* = 0 \\
  iii) & \quad k^* = 1 \\
  iv) & \quad d_{2h}^* = R.
\end{align*}

Proof. i) and ii) follow from the same steps as Proposition 1. Suppose $k^* < 1$. If we increase $k^*$ by $\epsilon$ and increase $d_{2h}^*$ by $\epsilon R$ and increase $d_{2l}^*$ by $\frac{\epsilon(1-\pi_l R)}{\pi_l \phi_l}$ (53) is not violated and the objective increase which is a contradiction. Suppose that $d_{2h}^* < R$. If we increase $d_{2h}^*$ by $\epsilon$ and decrease $d_{2l}^*$ by $\frac{\pi_l R}{\pi_l \phi_l}$ (53) is not violated and the objective increase which is a contradiction. ■

After Lemma B.2, the problem reduces to

\[
\max_C \pi_l (R - d_{2l})
\]

s.t.

\[
(1 - \pi_h R) \leq \pi_l \phi_l d_{2l}. \tag{54}
\]

Since the firm has all of the bargaining power (54) binds and the optimal contract is

\[
C^* \equiv \{k^*, q_h^*, q_l^*, d_{1h}^*, d_{1l}^*, d_{2h}^*, d_{2l}^*\} = \left\{1, 0, 0, 0, 0, R, \frac{1 - \pi_h R}{\pi_l \phi_l}\right\}.
\]

B.3 Firm Knows Project Type and Lender Can Acquire Information

In this section, I analyze the case in which the firm knows $u$ and the lender has the same information acquisition technology as in the baseline model. I apply the same undefeated equilibrium refinement from Mailath, Okuno-Fujiwara, and Postlewaite (1993). Therefore, the firm with the good project chooses the contract that maximizes its profits subject to pooling with the firm with the bad project. Note that because the lender can acquire information, the lender may be able to distinguish the types after the contract offer. Similarly, when the firm knows its type the optimal contract without information production coincides with the optimal contract from the main text $C^{1*} = C^{1L}$. Since from Lemma 1, the lender will acquire information if the firm offers a contract in which $k = 1$
and \( q_l = d_{1L} = 0 \), the firm with the good project’s profits from \( C^{1L} \) is

\[
R - 1 - c.
\]  

(55)

For simplicity, assume information acquisition is contractible. As in the benchmark case there is no value to liquidations; therefore, the lender’s break-even condition is

\[
k \leq \sum_z \pi_z \phi_z d_{2z}.
\]  

(56)

To minimize pooling costs, the firm with the good project chooses \( d_{2h} = kR \) and (56) binds. Therefore, the firm with the good project’s profits are

\[
\pi_l R \left( \frac{1 - \frac{\pi_h R}{\pi_l \phi_l}}{\pi_l \phi_l} \right),
\]

which is strictly less than (55). Hence, the firm with the good project wants to induce the lender to acquire information to avoid the pooling cost with the firm with the bad project. This result is similar to Fulghieri and Lukin (2001). Therefore, the optimal contract is \( C^* = C^{1L} \).

### B.4 Both Firm and Lender Can Acquire Information

In this section I analyze the case in which the firm can also incur \( c \) to learn \( v \). Before the firm offers the lender a contract, the firm decides whether to acquire information or not. If the firm produces information the choice of producing information becomes immediately public, while \( v \) is revealed at the end of \( t = 0 \). I assume the firm’s information production choice becomes public to avoid the problem of the firm discovering it has a bad project then attempting to pool with a firm that does not produce information. The rest of the timing is exactly the same as in the baseline model in Section 2.

From Section B.3, the optimal contract conditional on the firm knowing its project type is \( C^{1L} \). If the firm acquires information then offers \( C^{1L} \), the firm with the good project’s expected profits will be \( V^{1L} - c \) which is strictly less than \( V^{1L} \), hence the firm would not acquire information. Summarizing,

**Proposition B.1.** If the firm has access to the same information technology as the lender at the beginning of \( t = 0 \), it does not acquire information and the optimal contract is the same as in the main text.

### B.5 Firm Receives Exogenous Information

In the baseline model, the firm and lender begin symmetrically uninformed; however in practice, it seems plausible firms have some form of information advantage over their
lenders. In this section I show that if the firm receives an exogenous noisy signal regarding its project type the optimal contract may still deter information production. Suppose that prior to offering the lender a contract the firm receives a signal \( s \in \{G, B\} \) regarding \( \nu \). Specifically, \( s = G \) with probability \( \frac{1}{2} \) and \( \Pr(\nu = g|s = G) = \theta + \epsilon \) and \( \Pr(\nu = b|s = B) = \theta - \epsilon \) otherwise where \( \epsilon \leq \max\{\theta, 1 - \theta\} \). The change in probability need not be symmetric, but this simplification makes the unconditional probability of the project succeeding the same as in the baseline model (i.e. \( \Pr(\nu = g|s = G)\Pr(s = G) + \Pr(\nu = g|s = B)\Pr(s = B) = \theta \)). The firm’s signal is private information and the lender has access to the same information acquisition technology in the baseline model.

Once again, I use the undefeated equilibrium refinement from Mailath, Okuno-Fujiwara, and Postlewaite (1993) so the problem amounts to the firm that receives the good signal \( s = G \) maximizing its profits subject to pooling with the firm that receives the bad signal \( s = B \). Define

\[
\phi_h(G) \equiv 1, \quad \phi_l(G) \equiv \theta + \epsilon + (1 - \theta - \epsilon)\mu.
\]

Then the firm that receives signal \( s = G \) faces the following problem to deter information production

\[
\max C \sum_z \pi_z \left[ q_z p_0^z - d_1z + \phi_z(G) ((k - q_z) R - d_2z) \right]
\]

s.t.

\[
k \leq 1,
\]

\[
k \leq \sum_z \pi_z (d_1z + \phi_z d_2z),
\]

\[
(1 - \theta) [k - \pi_h(d_{1h} + d_{2h}) - \pi_l(d_{1l} + \mu d_{2l})] \leq c,
\]

\[
q_z \in [0, k], \quad d_1z \leq q_z p_0^z, \quad d_2z \leq (k - q_z) R \quad z = h, l,
\]

\[
p_z^0 = (1 - \gamma_z) \phi_z R, \quad z = h, l.
\]

**Proposition B.2.** When the firm receives an exogenous private signal regarding the project type, the optimal contract that deters information production takes the form \( C^{0L} \) or \( C^{0S} \) depending on parameters.

The steps are the same as in the main text so I omit them. For the problem that induces information acquisition the firm that receives the good signal solves the following problem
\[
\max_c (\theta + \epsilon) \sum_z \pi_z (q_z p_z^1 - d_{1z} + (k - q_z)R - d_{2z}) \\
\text{s.t.} \\
k \leq 1,
\]
\[
c \leq \theta \left( \sum_z \pi_z (d_{1z} + d_{2z}) - k \right),
\]
\[
c \leq (1 - \theta) [k - \pi_h (d_{1h} + d_{2h}) - \pi_l (d_{1l} + \mu d_{2l})],
\]
\[
q_z \in [0, k], \quad d_{1z} \leq q_z p_z^1, \quad d_{2z} \leq (k - q_z) R \quad z = h, l,
\]
\[
p_z^1 = (1 - \gamma_z^1)R \quad z = h, l.
\]

The following proposition immediately follows

**Proposition B.3.** When the firm receives an exogenous private signal regarding the project type, the optimal contract that induces information production takes the form $C^{1L}$.

The firm that receives the good signal’s expected profits from the three classes of contracts are

\[
V^{0L}(G) = k^{0L}(\pi_h R + \pi_l \phi_l(G)R - 1),
\]
\[
V^{0S}(G) = \pi_l \phi_l(G) \left( R - d^{0S}_{2l} - \frac{d^{0S}_{3l}}{(1 - \gamma_l^0)\phi_l} \right),
\]
\[
V^{1L}(G) = (\theta + \epsilon)(R - 1) - c.
\]

Both $V^{1L}(G) - V^{0S}(G)$ and $V^{1L}(G) - V^{0S}(G)$ are increasing in $\epsilon$. Hence, when the firm begins with private information, it is more likely the optimal contract induces information production. However, there are still parameter ranges in which the optimal contract is short-term (e.g. when $\epsilon$ and $\gamma_l^0$ are small).

### B.6 NPV Positive Bad Project

In this section, I characterize the optimal contract when the bad project is NPV positive. Specifically,

\[
(\pi_h + \pi_l \mu)R > 1.
\]

Condition (57) implies that $c < 0$, therefore I impose the additional assumption that $c > 0$, i.e. $c \in (0, \bar{c})$. To keep the problem interesting, I also impose the following
\[ \pi_h R < 1 \] (58)

Condition (58) ensures the lender cannot breakeven by only receiving payments in the high state where there is no uncertainty across project types. The firm’s problem for the optimal contract without information acquisition \( C_0^* \) remains the same. However, if we inspect the potential solutions from Proposition (2), note that now (32) can be ruled out because of (57) and (33) is the solution when \( \gamma_l^0 \geq \frac{1 - \pi_h R}{\pi_h R} \) and (31), \( C_{0S}^* \), is the solution otherwise.

The optimal contract that induces information acquisition \( C_{1*}^* \) can differ from the case in which the bad project was NPV negative because the firm can offer a menu to induce the lender to accept different terms depending on \( \nu \). I use superscripts to refer to the contract terms intended for the specific project type. To keep notation manageable, I suppress the references to the optimality of the contract throughout the proofs. For instance if I state \( q_h^0 = 0 \) in a Lemma, this refers to the value of \( q_h^0 \) at the optimum unless otherwise stated. The firm’s problem that induces information acquisition is

\[
\max_{k^g, d_{2z}^g} \theta \left[ \pi_h ((k^g - q_{h}^g) R - d_{2h}^g) + \pi_l ((k^g - q_{l}^g) R - d_{2l}^g) \right] + \\
(1 - \theta) \left[ \pi_h ((k^b - q_{h}^b) R - d_{2h}^b) + \pi_l ((k^b - q_{l}^b) R - d_{2l}^b) \right],
\]

s.t.

\[ k^v \in [0, 1] \quad v = g, b, \]

\[ c \leq \theta \left( \sum_z \pi_z(d_{1z}^g + d_{2z}^g) - k^g \right) + (1 - \theta) \left( \pi_h(d_{1h}^b + d_{2h}^b) + \pi_l(d_{1l}^b + \mu d_{2l}^b) - k^b \right), \] (59)

\[ k^g \leq \sum_z \pi_z(d_{1z}^g + d_{2z}^g), \] (60)

\[ k^b \leq \pi_h(d_{1h}^b + d_{2h}^b) + \pi_l(d_{1l}^b + \mu d_{2l}^b), \] (61)

\[ \sum_z \pi_z(d_{1z}^b + d_{2z}^b) - k^b \leq \sum_z \pi_z(d_{1z}^g + d_{2z}^g) - k^g, \] (62)

\[ \pi_h(d_{1h}^g + d_{2h}^g) + \pi_l(d_{1l}^g + \mu d_{2l}^g) - k^g \leq \pi_h(d_{1h}^b + d_{2h}^b) + \pi_l(d_{1l}^b + \mu d_{2l}^b) - k^b, \] (63)

\[ q_z^v \in [0, k^v], \quad d_{1z}^v \leq q_z^v (1 - \gamma_z^1) \mathbb{E}[R|v, z], \quad d_{2z}^v \leq k^v R \quad z = h, l, \quad v = g, b, \]

where (59) is the lender’s ex-ante participation constraint, (60) and (61) are the lender’s participation constraints conditional on discovering the project is good (bad) and (62) says if the firm discovers the project is good it must be incentive compatible to accept the terms for the good project and vice versa for (63).

**Lemma B.3.** \( q_z^v = d_{1z}^v = 0, \quad v = g, b. \)
Proof. The proof is the same regardless of \( \upsilon \). Suppose that \( q^\upsilon_\mathcal{V} > 0 \) for any \( \upsilon \in \{ g, b \} \). First suppose that \( d^\upsilon_1 \mathcal{V} = 0 \), then the first can reduce \( q^\upsilon_\mathcal{V} \) by \( \epsilon \) and no constraints are violated and the firm’s profits increase because \( \gamma^1_1 \geq 0 \). Next suppose \( d^\upsilon_1 \mathcal{V} > 0 \), the firm can decrease \( q^\upsilon_\mathcal{V} \) by \( \epsilon \), decrease \( d^\upsilon_1 \mathcal{V} \) by \( \epsilon \) and increase \( d^\upsilon_2 \mathcal{V} \) by \( \epsilon \) and none of the constraints are affected and the firm’s profits increase because \( \gamma^1_1 \geq 0 \). Hence, \( q^\upsilon_\mathcal{V} = 0 \) and thereby \( d^\upsilon_1 \mathcal{V} = 0 \) for all \( \upsilon \).

To simplify the proof I make the following claim which I confirm is true at the conclusion of the proof

Claim B.1. (63) is slack.

I then establish the following lemma.

Lemma B.4. \( q^\upsilon_\mathcal{V} = d^\upsilon_1 \mathcal{V} = 0 \) \( \upsilon = g, b \).

Proof. The same steps from Lemma B.3 can be taken to show that \( q^g_\mathcal{V} = d^g_1 \mathcal{V} = 0 \). Next, suppose that \( q^b_\mathcal{V} > 0 \). There are two cases to consider. First suppose that \( d^b_1 \mathcal{V} = 0 \), then the first can reduce \( q^b_\mathcal{V} \) by \( \epsilon \) and no constraints are violated and the firm’s profits increase because \( \gamma^1_1 \geq 0 \). Next suppose \( d^b_1 \mathcal{V} > 0 \), the firm can decrease \( q^b_\mathcal{V} \) by \( \epsilon \), decrease \( d^b_1 \mathcal{V} \) by \( \epsilon \) and increase \( d^b_2 \mathcal{V} \) by \( \epsilon \) and (62) is relaxed while none of the other constraints are affected and the firm’s profits increase because \( \gamma^1_1 \geq 0 \).

Hence, the contract is long-term and we can rewrite the problem as

\[
\max_{k^\upsilon, d^\upsilon_z} \theta \left[ \pi_h(k^g R - d^g_2h) + \pi_l(k^g R - d^g_2l) \right] + \\
(1 - \theta) \left[ \pi_h(k^b R - d^b_2h) + \pi_l(k^b R - d^b_2l) \right],
\]

s.t.

\[
k^\upsilon \in [0, 1], \upsilon = g, b, \\
c \leq \theta(\pi_h d^g_{2h} + \pi_l d^g_{2l} - k^g) + (1 - \theta)(\pi_h d^b_{2h} + \pi_l d^b_{2l} - k^b), \\
k^g \leq \pi_h d^g_{2h} + \pi_l d^g_{2l}, \\
k^b \leq \pi_h d^b_{2h} + \pi_l d^b_{2l}, \\
\pi_h d^g_{2h} + \pi_l d^b_{2l} - k^b \leq \pi_h d^g_{2h} + \pi_l d^b_{2l} - k^g, \\
d^\upsilon_{2z} \leq k^\upsilon R \quad z = h, l, \upsilon = g, b.
\]

Lemma B.5. (60) is slack and \( k^g = 1 \)

63
Proof. Suppose (60) binds, then we can replace \( k^g = \pi_h d_{2h}^g + \pi_l d_{2l}^g \) into (62) which simplifies to \( k^b \geq \pi_h d_{2h}^b + \pi_l d_{2l}^b \); however, this violates (61). Suppose \( k^g < 1 \), then we can increase \( k^g \) by \( \epsilon \) such that \( k^g + \epsilon \leq 1 \) and increase \( d_{2h}^g \) by \( \pi_h \epsilon \) and \( d_{2l}^g \) by \( \pi_l \epsilon \) and (62) and (59) are not violated and the firm’s profits increase.

\[ \square \]

Lemma B.6. (59) is slack if \( k^b = 1 \)

Proof. Suppose to the contrary that (59) binds if \( k^b = 1 \), then we can rewrite (62) as

\[ \frac{\pi_h d_{2h}^b + \pi_l \phi d_{2l}^b - c}{\theta} \leq 0. \]

(64)

For (64) to hold, we need \( \pi_h d_{2h}^b + \pi_l \phi d_{2l}^b \) to be sufficiently small while not violating (60) and \( d_{2z}^b \leq R \) for all \( z \in \{h, l\} \). It easily shown that the LHS of (64) is smallest when (60) binds and \( d_{2h}^b = R \); however, even when this is the case (64) is violated.

\[ \square \]

Lemma B.7. (62) binds.

Proof. Suppose to the contrary (62) is slack. First consider the case in which \( k^b < 1 \), we can increase \( k^b \) by \( \epsilon \) and increase \( d_{2h}^b \) by \( \epsilon \) and \( d_{2l}^b \) by \( \frac{\pi_h}{\mu} \) such that remains (62) is not violated while (59) remains unchanged and the firm’s profits increase. Now consider the case in which \( k^b = 1 \). From Lemma B.6, (59) is slack. Hence we can decrease \( d_{2h}^b \) by a small enough \( \epsilon \) such that (59), (60) and (62) remain slack while increasing the firm’s profits.

\[ \square \]

Lemma B.8. (61) binds

Proof. Suppose to the contrary that (61) is slack. First consider the case in which \( k^b = 1 \). When this is the case (59) is slack from Lemma B.6. Hence we can decrease \( d_{2l}^b \) (note \( d_{2l}^b > 0 \) because otherwise (61) would be violated) by a small enough \( \epsilon \) such that (59) is not violated, (62) would not be violated and the firm’s profits would increase. Now consider the case in which \( k^b < 1 \) if we increase \( k^b \) by \( \epsilon \) and increase \( d_{2l}^b \) or \( d_{2h}^b \) by \( \epsilon \frac{\theta \pi_h}{(1-\theta)\mu} \) such that (61) remains slack, then (59) remains unchanged and (62) slackens while the firm’s profits increase.

\[ \square \]

Lemma B.9. \( d_{2h}^b = k^b R \)

Proof. Suppose to the contrary that \( d_{2h}^b < k^b R \), then we can increase \( d_{2h}^b \) by \( \epsilon \) and decrease \( d_{2l}^b \) by \( \frac{\pi_h \epsilon}{\pi_l \mu} \) (\( d_{2l}^b \) must be positive because otherwise (59) is violated) such that (59) and (61) remain unchanged; however, (62) slackens which leads to a contradiction.

\[ \square \]
Hence from we can rewrite the problem as

\[
\max_{k^b, d_{2h}^b, d_{2l}^b} \theta \left[ \pi_h (R - d_{2h}^b) + \pi_l (R - d_{2l}^b) \right] + (1 - \theta) \pi_l \mu \left( k^b R - d_{2l}^b \right),
\]

subject to

\[
k^b \leq 1
\]

\[
c \leq \theta(\pi_h d_{2h}^b + \pi_l d_{2l}^b - 1) + (1 - \theta)(\pi_h k^b R + \pi_l \mu d_{2l}^b - k^b),
\]

\[
k^b = \pi_h k^b R + \pi_l \mu d_{2l}^b,
\]

\[
\pi_h k^b R + \pi_l d_{2l}^b - k^b = \pi_h d_{2h}^b + \pi_l d_{2l}^b - 1,
\]

\[
d_{2h}^b \leq k^b R \quad z = h, l.
\]

Notice that (65), (67), (68) depend on the expected payments from the good project \(\pi_h d_{2h}^b + \pi_l d_{2l}^b\), but not the relative values of \(d_{2h}^b\) and \(d_{2l}^b\). Hence, we can set \(d_{2h}^b = R\) (which will ensure Claim B.1 holds). The Lagrangian is

\[
\mathcal{L} = \theta \left[ \pi_h (R - d_{2h}^b) + \pi_l (R - d_{2l}^b) \right] + (1 - \theta) \pi_l \mu \left( k^b R - d_{2l}^b \right) - \lambda_1 (k^b - 1) - \lambda_2 [c - \theta(\pi_h d_{2h}^b + \pi_l d_{2l}^b - 1) - (1 - \theta)(\pi_l \mu d_{2l}^b - k^b (1 - \pi_h R))] - \lambda_3 (k^b (1 - \pi_h R) - \pi_l \mu d_{2l}^b) - \lambda_4 \left( k^b \left( \frac{\pi_l R}{\mu} - 1 \right) - \pi_h d_{2h}^b - \pi_l R + 1 \right) - \lambda_5 (d_{2l}^b - R) - \lambda_6 (d_{2l}^b - k^b R).
\]

The Kuhn-Tucker necessary conditions are

\[
\mathcal{L}_{k^b} = \pi_l (1 - \theta) \mu R - \lambda_1 - (1 - \pi_h R) ((1 - \theta) \lambda_2 + \lambda_3 - \lambda_4) + \lambda_6 R \leq 0,
\]

\[
\mathcal{L}_{d_{2l}^b} = \pi_l \left[ (1 - \theta) \mu (\lambda_2 - 1) + \mu \lambda_3 - \lambda_4 \right] - \lambda_6 \leq 0,
\]

\[
\mathcal{L}_{d_{2l}^b} = \pi_l (r (\lambda_2 - 1) + \lambda_4) - \lambda_5 \leq 0,
\]

\[
\mathcal{L}_{k^b} k^b = 0, \quad \mathcal{L}_{d_{2l}^b} d_{2l}^b = 0, \quad \mathcal{L}_{d_{2l}^b} d_{2l}^b = 0,
\]

\[
\lambda_1 (k^b - 1) = 0,
\]

\[
\lambda_2 [c - \theta(\pi_h d_{2h}^b + \pi_l d_{2l}^b - 1) - (1 - \theta)(\pi_l \mu d_{2l}^b - (1 - \pi_h R) k^b)] = 0,
\]

\[
k^b (1 - \pi_h R) - \pi_l \mu d_{2l}^b = 0,
\]

\[
\pi_h k^b (R - d_{2h}^b) + k^b \left( \frac{1 - \pi_h R}{\mu} - 1 \right) - \pi_l R + 1 = 0,
\]

\[
\lambda_1 \geq 0, \quad \lambda_2 \geq 0, \quad \lambda_3 > 0, \quad \lambda_4 > 0, \quad \lambda_5 \geq 0, \quad \lambda_6 \geq 0,
\]

(66), (67).
There are two potential solutions

\[
\begin{align*}
    k^b &= \frac{c\mu}{\theta(1-\mu)(1-\pi_h R)}, \\
    d_{2l}^g &= \frac{c + \theta(1-\pi_h R)}{\theta\pi_l}, \\
    d_{2l}^b &= \frac{c}{\theta\pi_l(1-\mu)}, \\
    \lambda_1 &= 0, (69) \\
    \lambda_2 &= \frac{(\mu + \theta(1-2\mu))(1-\pi_h R) - R(1-\theta)\mu^2\pi_l}{\theta(1-\mu)(1-\pi_h R)}, \\
    \lambda_3 &= \frac{(1-\theta)\phi_l (\pi_h R + \pi_1 R - 1)}{\theta(1-\mu)(1-\pi_h R)}, \\
    \lambda_4 &= \frac{(1-\theta)\mu(\pi_h R + \pi_1 R - 1)}{(1-\mu)(1-\pi_h R)}, \\
    \lambda_5 &= 0, \quad \lambda_6 = 0,
\end{align*}
\]

and,

\[
\begin{align*}
    k^b &= 1, \\
    d_{2l}^g &= \frac{c + \theta(1-\pi_h R)}{\theta\pi_l}, \\
    d_{2l}^b &= \frac{c}{\theta\pi_l(1-\mu)}, \\
    \lambda_1 &= \pi_l (1-\theta)\mu R - \frac{(\mu + \theta(1-2\mu))(1-\pi_h R)}{\mu}, \\
    \lambda_2 &= 0, \quad \lambda_3 = 1 + \theta \left( \frac{1}{\mu} - 1 \right), \\
    \lambda_4 &= \theta, \quad \lambda_5 = 0, \quad \lambda_6 = 0,
\end{align*}
\]

where, (69) is the solution when \((\mu + \theta(1-2\mu))(1-\pi_h R) - R(1-\theta)\mu^2\pi_l \geq 0\) and (70) is the solution otherwise. We can also now confirm Claim B.1. When (69) is the solution (63) reduces to

\[
\begin{align*}
    \mu \left( 1 + \frac{c}{\theta} \right) + \pi_h (1-\mu) R - 1 \leq 0,
\end{align*}
\]

which holds. When (70) is the solution, the LHS of (63) reduces to 0, hence (63) holds.

The respective profits for (69) and (70) are

\[
\begin{align*}
    \theta(R - 1) - c + \frac{c(1-\theta)\mu(\pi_h R + \pi_1 R - 1)}{\theta(1-\mu)(1-\pi_h R)}, \\
    \frac{\phi_l (\pi_h R + \pi_1 R - 1)}{\mu}, \\
    \end{align*}
\]

Notice that (71) is strictly greater than \(V^{1L}\). Hence, the optimal contract with information acquisition is either (69) or (70). To find \(C^*\) we can simply compare the profits from the optimal contract with information acquisition and that without information acquisition.

Intuitively, the firm is able to finance the project regardless of its type; however, there is still a welfare loss relative to the first-best because the lender produces information. Hence, for \(\gamma_0\) sufficiently close to 0 the optimal contract is short-term \(C^* = C^{os}\).
B.7 Non-Zero Project Payoff in the Case of Failure

Because the project yields 0 in the case of failure, it is not possible to distinguish between equity and debt for payments at $t = 2$. In this section I show that state-contingent debt is the optimal contract when the project yields a positive payoff in the case of failure. Suppose that $\tilde{R} = r < 1$ when the project fails. To analyze the interesting case I revise Assumption 1 as follows.

**Assumption B.1.** The bad project is NPV negative:

$$\pi_h R + \pi_l (\mu R + (1 - \mu) r) < 1,$$

while the ex-ante, average project is NPV positive:

$$\pi_h R + \pi_l (\phi R + (1 - \phi) r) > 1,$$

and Assumption 2 as follows,

**Assumption B.2.** $c \in (\underline{c}, \bar{c})$, where

$$\underline{c} \equiv (1 - \theta)(1 - \pi_l ((1 - \mu) r + \mu R) - \pi_h R),$$

and

$$\bar{c} \equiv \frac{\theta(1 - \phi)((1 - \pi_h R - \pi_l r))}{\phi_l}.$$

Let $d_{2z}(r)$ denote the promised payment from the firm to the lender if the project fails in state $z$. Then consider the revised definition of a financial contract

$$C = \{k, q_h, q_l, d_{1h}, d_{1l}, d_{2h}, d_{2l}, d_2(r), d_{2l}, d_{2l}(r)\}$$

To find the optimal contract to induce the lender to not acquire information the firm
solves
\[
\max \sum \pi_z \left( q_z p^0_z - d_{1z} + \phi_z \left[ (k - q_z) R - d_{2z} \right] + (1 - \phi_z) \left[ (k - q_z) r - d_{2z}(r) \right] \right)
\]
\[
\text{s.t.}
\]
\[
k \leq 1,
\]
\[
k \leq \sum \pi_z (d_{1z} + \phi_z d_{2z} + (1 - \phi_z)d_{2z}(r)),
\]
\[
(1 - \theta) [k - \pi_h (d_{1h} + d_{2h} - \pi_l (d_{1l} + \mu d_{2l} + (1 - \mu)d_{2l}(r))] \leq c,
\]
\[
q_z \in [0, k], \quad d_{1z} \leq q_z p^0_z, \quad d_{2z} \leq (k - q_z) R, \quad d_{2z}(r) \leq (k - q_z) r \quad z = h, l,
\]
\[
p^0_z = (1 - \gamma^0_z)(\phi_z R + (1 - \phi_z)r) \quad z = h, l.
\]

The project never fails in the high state so we can ignore \(d_{2h}(r)\). Using the same arguments from Proposition 1 and Lemma 2, \(q^0_h = d^0_h = 0\), \(d^0_{2h} = k^0 R\), the incentive compatibility constraint binds and \(d^0_{1l} = q^0_l p^0_l\). We can rewrite the problem as follows
\[
\max \pi_l \left( q_l p^0_l - d_{1l} + \phi_l \left[ (k - q_l) R - d_{2l} \right] + (1 - \phi_l) \left[ (k - q_l) r - d_{2l}(r) \right] \right),
\]
\[
\text{s.t.}
\]
\[
k \leq 1,
\]
\[
k (1 - \pi_h R) \leq \pi_l (d_{1l} + \phi_l d_{2l} + (1 - \phi_l)d_{2l}(r)),
\]
(72)
\[
(1 - \theta) [k(1 - \pi_h R) - \pi_l (d_{1l} + \mu d_{2l} + (1 - \mu)d_{2l}(r))] = c,
\]
(73)
\[
d_{2l} \leq \left( k - \frac{d_{1l}}{p^0_l} \right) R,
\]
(74)
\[
d_{2l}(r) \leq \left( k - \frac{d_{1l}}{p^0_l} \right) r,
\]
(75)
\[
p^0_l = (1 - \gamma^0_l)(\phi_l R + (1 - \phi_l)r).
\]

We can then show that (75) binds implying the optimal contract is debt.

**Lemma B.10.** In the optimal contract (75) binds

**Proof.** Suppose to the contrary (75) is slack. If the firm increases \(d^0_{2l}(r)\) by any \(\epsilon > 0\) where \(d^0_{2l}(r) + \epsilon \leq \left( k^0 - \frac{d^0_{2l}}{p^0_l} \right) r\) and decreases \(d^0_{2l}\) by \(\frac{(1 - \mu)\epsilon}{\phi_l}\), then (72) and (74) would not be violated while (73) would slacken. However, because (73) binds at the optimum this is a contradiction.

Lemma B.10 implies that payments at \(t = 2\) are equivalent to debt because all of the cash flows from the project in the case of failure are paid to the lender. I omit the remaining steps to find the optimal contract that induces the lender to not acquire, however it follows from Proposition 2.
B.8 Auction for Market Equilibrium Mechanism

In the main text I assume that informed investors can make unobservable offers to firms to buy their assets before the firms sell to a pool of uninformed investors. In this section I show how a second-price auction yields the same price as the mechanism in the main text.

The matching process works exactly as in Section 4; however, informed investors simply learn project types and do not enter a bilateral bargaining game with the firm whose project they learn. Instead, each firm sells \( q(i) \) units of good in an auction after the low state has been realized and investors have decided to become informed. Uninformed investors do not observe whether or not they are bidding against an informed investor which leads to the winner’s curse. Uninformed investors are symmetric and have no private information so I can restrict focus to symmetric bidding strategies among the uninformed. Let \( b^U(i) \) denote each uninformed investors per unit bid for firm \( i \)'s project.

Because of matching, there can be at most one informed investor bidding in any auction. Let \( b^I(i) \) denote the informed investor’s bid. If \( b^I(i) \geq b^U(i) \) the informed investor wins the auction and pays \( b^U(i)q(i) \) for the \( q(i) \) units of the project and vice versa if \( b^I(i) < b^U(i) \). For simplicity I assume a random tiebreaker so that one investors pays \( b^U(i)q(i) \) for \( q(i) \) units of the project. If there is no informed investor bidding \( b^I(i) = 0 \), hence the uninformed problem for firm \( i \)'s asset is

\[
\max_{b^U(i)} \mathbb{E}[(\bar{R} - b^U(i))q(i)|b^I(i) < b^U(i)].
\]

When \( i \in \mathcal{I}^1 \), \( b^U(i) = b^I(i) = R \) since \( v(i) = g \). Henceforth, I restrict focus to auctions in which \( i \in \mathcal{I}^0 \) where the firm’s project type is not publicly known. The uninformed never bid \( b^U(i) < \mu R \) because even if the project is bad with certainty its expected payoff is \( \mu R \). In addition, \( b^U(i) > \mu R \) for all \( i \). Suppose to the contrary that \( b^U(i) = \mu R \) for some \( i \). Then, the informed investor’s best response would be to bid \( b^I(i) = \mu R \) and win the good. However, with probability \( 1 - m(\eta) \) there is no informed investor bidding for all \( i \). Therefore, an uninformed investor could always bid \( \epsilon \) more than \( \mu R \) and earn positive profits. Hence, \( b^U(i) > \mu R \) for all \( i \).

It is simple to show that the uninformed investor always bids \( b^U(i) < R \). Suppose to the contrary \( b^U(i) = R \), then the informed investor would bid \( b^I(i) = R \) when \( v(i) = g \) and win the asset and bid \( b^I(i) = \mu R \) when the asset is bad and lose the bid. Therefore, the uninformed would earn negative profits by bidding \( b^U(i) = R \). Since \( b^U(i) \in (\mu R, R) \) the informed bidder bids its valuation and earns profits \( R - b^U(i) \) when the \( v(i) = g \) and loses the bid when \( v(i) = b \). Hence, the uninformed optimal bid \( b^* \) must satisfy:

\[
(1 - \theta)m(\eta)(\mu R - b^*) + (1 - m(\eta))(\phi R - b^*) = 0.
\]
Solving for $b^*$,

$$b^* = \left(1 - \frac{m(\eta)\theta(1 - \phi_l)}{(1 - m(\eta)\theta)\phi_l}\right)\phi_l R. \tag{76}$$

Notice that the winning bid in each auction (76) is the same as the price in the main text (13). Therefore, the solution is identical to the bargaining process in Section 4 of the main text.

### B.9 Full Characterization of Planner’s Solution

In this section I consider a specific functional form for the matching function to fully characterize the planner’s solution to (18). In particular I assume that $m(\eta) = \frac{\eta}{1 + \rho \eta}$ where $\rho > \frac{\theta}{\phi_l}$. Hence, the expression for $p^0_l(\eta)$ can be written as

$$p^0_l(\eta) = \left(1 - \frac{\eta\theta(1 - \phi_l)}{1 - \eta(\theta - \rho)}\right) R. \tag{77}$$

Plugging (77) into the expected profits from investors becoming informed (15),

$$\Pi(\eta, D) = \frac{D\theta(1 - \phi_l)}{(1 + \eta\rho)\phi_l} - \kappa. \tag{78}$$

Since $\frac{\partial \Pi}{\partial \eta} < 0$ we have

$$\eta^* = \begin{cases} 0 & \text{if } \Pi(0, D) < 0 \\ \frac{D\theta(1 - \phi_l) - \kappa\phi_l}{\kappa(\rho\phi_l - \theta)} & \text{otherwise.} \end{cases}$$

Therefore,

$$\gamma^*_l = \begin{cases} 0 & \text{if } \Pi(0, D) < 0 \\ \frac{D\theta(1 - \phi_l) - \kappa\phi_l}{\phi_l(D(\theta - \rho) - \kappa)} & \text{otherwise.} \end{cases}$$

If $\Pi(0, d^0_{1l}) = \frac{d^0_{1l} \theta(1 - \phi_l)}{\phi_l} - \kappa < 0$, then the equilibrium is Type 1. Otherwise, the equilibrium is Type 2 or Type 3. Recall the profits from the short-term contract are

$$V^{0S} = \pi_l \left(\phi_l (R - d^0_{2l}) - \frac{d^0_{1l}}{1 - \gamma^*_l}\right). \tag{79}$$
Then when $\Pi(0, d_{1i}^{\text{FS}}) \geq 0$ we can plug $\gamma^0_i = \frac{d_{1i}^{\text{FS}} \theta (1 - \phi_i) - \kappa \phi_i}{\phi_i (d_{1i}^{\text{FS}} (\theta - \rho) - \kappa)}$ into (79) and the equilibrium is Type 2 if

$$V^{\text{FS}} (d_{1i}^{\text{FS}}) = \pi_i \left( \phi_i \left( R - d_{2i}^{\text{FS}} \right) - \frac{d_{1i}^{\text{FS}}}{1 - \frac{d_{1i}^{\text{FS}} (1 - \phi_i) - \kappa \phi_i}{\phi_i (d_{1i}^{\text{FS}} (\theta - \rho) - \kappa)}} \right) \geq V^L_*,$$

and Type 3 otherwise. Now to find the planner’s solution, we have

$$\max_{\alpha \in [0, 1]} \alpha V^{\text{FS}} (\alpha d_{1i}^{\text{FS}}) + (1 - \alpha) V^L_*.$$

The second-order condition is

$$\frac{2 \left( d_{1i}^{\text{FS}} \right)^2 \kappa \phi_i \left( \theta (1 - \pi_i R) (1 - \phi_i) - (c + \theta) \phi_i \right) (\rho \phi_i - \theta)}{(\alpha d_{1i}^{\text{FS}} \theta (1 - \phi_i) - \phi_i \kappa)^3} > 0,$$

where the numerator is positive, while the denominator is positive because $\alpha d_{1i}^{\text{FS}} \theta (1 - \phi_i) - \phi_i \kappa$ is equal to $\Pi(0, \alpha d_{1i}^{\text{FS}})$ which must be positive if the equilibrium is Type 2 or Type 3. Hence, the planners solution is a corner in which $\alpha^{**} = 1$ or $\alpha^{**} = \alpha$ where

$$\alpha = \arg \max_{\alpha} \alpha \quad \text{s.t.} \quad \eta^* (\alpha d_{1i}^{\text{FS}}) = 0.$$

In words, the planner’s solution is either all firms use short-term financing or largest fraction that induces no information production in the asset market. From (78), we have

$$\alpha = \frac{\phi_i \kappa}{\theta (1 - \phi_i) d_{1i}^{\text{FS}}}. $$

When $\alpha = \alpha$ welfare is

$$W(\alpha) = \frac{V^L_* \left( d_{1i}^{\text{FS}} \theta (1 - \phi_i) - \kappa \phi_i \right) + \kappa \phi_i \left( \pi_i R + \pi_i \phi_i R - 1 \right)}{d_{1i}^{\text{FS}} \theta (1 - \phi_i)},$$

and when $\alpha = 1$

$$W(1) = \phi_i \left( \frac{\pi_i \left( R (\rho \phi_i - \theta) + \kappa - \phi_i d_{1i}^{\text{FS}} (\rho - \theta) \right)}{\rho \phi_i - \theta} - \frac{c}{\theta (1 - \phi_i)} \right).$$

Differentiating $W(1)$ with respect to $\rho$,

$$\frac{\partial W(1)}{\partial \rho} = \frac{\pi_i \phi_i \left( d_{1i}^{\text{FS}} \theta (1 - \phi_i) - \phi_i \kappa \right)}{(\rho \phi_i - \theta)^3} > 0. \quad \text{(80)}$$
Where the numerator of (80) equals $\Pi(0, d_{it}^{0S})$ which must be positive if the equilibrium is Type 2 or Type 3. Also, notice that

$$\lim_{\rho \to \infty} W(1) = \pi_l(\phi_l R - d_{it}^{0S}) - \frac{c\phi_l}{\theta(1 - \phi_l)} = (\pi_h + \pi_l\phi_l)R - 1 = V^{FB}.$$ 

Hence, for a high enough value of $\rho$, the Type 2 market equilibrium achieves the first-best level of surplus and is efficient. We can then express the efficiency of the equilibrium in terms of $\rho$. Since $W(1) - W(\alpha)$ is increasing in $\rho$, $W(1) - W(\alpha) \geq 0$ when

$$\rho \geq \bar{\rho} \equiv \frac{\phi_l (\theta(R - 1) - c) - \theta V^{L*}}{\phi_l (\pi_h + \phi_l \pi_l R - 1 - V^{L*})}. $$

When $C^{L*} = C^{0L}$, $\bar{\rho}$ can be expressed as

$$\bar{\rho}_{C^{L*}=C^{0L}} \equiv \frac{\theta (R - 1)}{\pi_h R + \pi_l \phi_l R - 1}.$$ 

Recall that $\rho > \frac{\theta}{\phi_l}$ by assumption and note that $\frac{\theta (R - 1)}{\pi_h R + \pi_l \phi_l R - 1} > \frac{\theta}{\phi_l}$. Hence, there always exists a $\bar{\rho} > \frac{\theta}{\phi_l}$ such that the Type 2 equilibrium is efficient if $\rho \geq \bar{\rho}$ and inefficient if $\rho < \bar{\rho}$ when $C^{L*} = C^{0L}$. When $C^{L*} = C^{1L}$, $\bar{\rho}$ can be expressed as

$$\bar{\rho}_{C^{L*}=C^{1L}} \equiv \frac{(\theta (R - 1) - c)(\phi_l - \theta)}{\pi_h R + \pi_l \phi_l R - 1} > \frac{\theta}{\phi_l}.$$ 

Hence, there also always exists a $\bar{\rho} > \frac{\theta}{\phi_l}$ such that the Type 2 equilibrium is efficient if $\rho \geq \bar{\rho}$ and inefficient if $\rho < \bar{\rho}$ when $C^{L*} = C^{1L}$.