Information Dynamics and the Countercyclical Nature of Secured Debt

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Abstract

The countercyclical behavior of secured debt, a well-documented phenomenon, has raised questions about its underlying mechanisms. This paper shows that countercyclical nature of secured debt arises in an environment with information frictions. Unsecured debt necessitates costly firm monitoring and such action requires expertise. When the quality of collateral drops, high demand for monitoring pushes up the cost of such services and renders unsecured debt unprofitable. In response, firms switch to secured debt with active screening that is less costly. We show that the proportion of secured debt in the economy serves as an indicator of whether there is excess or insufficient information acquisition.

1 Introduction

This paper studies how information frictions contribute to explaining the countercyclical behavior of secured debt. The countercyclical nature of secured debt has been well documented in the literature (Nini et al., 2012; Bradley and Roberts, 2015; Benmelech et al., 2023). It is evident that information frictions play a crucial role in comprehending the dynamics of business cycles, as underscored by Gorton and Ordoñez (2014). Moreover, various empirical studies have demonstrated that the accuracy of bank's information exhibits countercyclical patterns (Becker et al., 2020; Howes and Weitzner, 2023).

A firm in need of financing can opt to raise capital either by issuing equity or by utilizing debt. This paper focuses on debt instruments. Debt can take the form of either secured or unsecured. We adopt the structure employed by Gorton and Ordoñez (2014) and further classify secured debt into two distinct categories: those with active collateral screening and those without. Unsecured debt is an option available exclusively to firms whose outputs have undergone a certification process, incurring monitoring expenses. Creditors have the option to allocate resources for collateral assessment or firm monitoring to secure certification. The use of secured debt without active screening is limited by creditors' incentives to covertly evaluate collateral quality and provide financing contingent on collateral quality.

Monitoring a firm's projects is challenging due to the varying structures employed by each firm, whereas collateral screening is a more cost-effective process as the assessment of collateral is more standardized. Consequently, the evaluation of a firm's outputs necessitates a greater level of expert involvement compared to collateral screening. Additionally, experts' skills are heterogeneous. This implies that the marginal cost associated with expert input rises in proportion to the overall demand for such expertise.

When collateral quality is high, the use of secured debt without active collateral screening enables firms to access a significant amount of credit. At the same time, the absence of secured debt with active screening leads to a limited demand for expert skills, resulting in a low marginal cost for such skills. This results in low total monitoring and makes unsecured debt an appealing option for firms. In the equilibrium, firms predominantly opt for these two contract types, with collateral remaining unscreened.

As the quality of collateral decreases, creditors become strongly motivated to secretly screen the collateral and extend funding based on the outcomes. This restriction limits the availability of funding through secured debt without active screening. In response, firms transition to secured debt with active screening, leading to a surge in the demand for expert skills. This heightened demand, in turn, pushes up the marginal cost of expert services.

Given that project monitoring entails a greater requirement for expert inputs, the cost of unsecured debt rises in comparison to the cost of secured debt with active screening. Consequently, all firms shift towards the adoption of secured debt with active screening. In cases where collateral quality demonstrates a procyclical pattern, secured debt exhibits countercyclical behavior.

Within this framework, both information frictions and information production exhibit a countercyclical nature. As firms transition from requiring project monitoring to collateral screening, information frictions diminish because evaluating the quality of collateral involves lower expert's inputs. Furthermore, as the majority of firms make the transition to secured debt with active screening, the overall information production rises. If the accuracy of information improves with increased effort, given a constant level of effort, creditors can generate more precise information as information frictions decrease.

This perspective offers the potential to reconcile what might initially appear to be contradictory findings in Becker et al. (2020) and Howes and Weitzner (2023). In Becker et al. (2020), based on data from a major Swedish bank, the authors demonstrate that the enhanced information accuracy observed during economic downturns is primarily attributed to exogenously reduced information frictions. However, Howes and Weitzner (2023), which utilizes loan-level data, reveal that a mere exogenous reduction in information frictions cannot account for the entirety of the improvement in banks' predictive capabilities for default during economic downturns. In this framework, banks that maintain a fixed budget for screening and monitoring witness an increase in information accuracy without augmenting their effort. In contrast, banks that adjust their screening efforts in response to demand experience heightened information production. Consequently, while individual banks may yield results in line with the former study, when considered collectively, banks tend to produce more information on average.

The optimal policy in this model demonstrates that the share of secured debt is a valuable indicator in determining whether there is either excessive or insufficient information acquisition. The cost of information increases with the rising demand for expert services, and it is particularly high when monitoring is ubiquitous. High information cost diminishes creditors' motivation to secretly screen collateral and provide funding based on collateral quality. If the share of secured debt is low, the direct advantage of reducing the overall information cost outweighs the drawbacks associated with exacerbating the creditors' incentive issue. In such a scenario, there is excessive information acquisition. Conversely, when the share of secured debt is high, relaxing the creditors' incentive constraint becomes the dominant force, leading to insufficient information acquisition.

This paper contributes to several areas of existing literature. The countercyclical nature of secured debt has been well-documented in prior research. Benmelech et al. (2023), for instance, utilized data from various sources to illustrate that secured bond issuance increases by approximately 3 percentage points during economic recessions. As indicated by Nini et al. (2012), creditors often request collateral when a debtor breaches covenants, and if covenant violations exhibit countercyclical patterns, the volume of outstanding secured debt would likewise demonstrate countercyclical behavior.

Numerous theoretical arguments have been advanced regarding the cyclical properties of secured debt. Some studies have highlighted that the use of unsecured debt can offer financial flexibility, preserving valuable collateral for challenging times (Holmstrom and Tirole, 1997; Rampini and Vishwanathan, 2010). Another strand of research focuses on operational flexibility, emphasizing that by not pledging assets, firms maintain the ability to make adjustments in the future (Mello and Ruckes, 2017). [1] In this paper, we propose an alternative explanation rooted in an information perspective.

Another area of literature centers on the role of information frictions in understanding business cycles (Gorton and Ordoñez, 2014; Abadi, 2021; Asriyan et al., 2022; Dong and Liu, 2023). For example, Gorton and Ordoñez (2014) demonstrate that information production can trigger a financial crisis by increasing the difficulty of accessing credit. In Asriyan et al. (2022), it is shown that declines in collateral values prompt firms to engage in information production related to their capital. In this paper, we explore how the acquisition of information regarding both capital and collateral influences the availability of credit and the debt selection of firms.

The paper proceeds as follows. Section 2 introduces a static model and studies the optimal policy. Section 3 presents a dynamic version of the model in Section 2. Section 4 concludes.

2 Static Model

There are two goods in the economy, numeraire and land. Numeraire can be used for either production or consumption. Land can only be used for consumption and its quality is imperfect. A unit of land has value C with probability α and 0 otherwise.

There are three types of agents, firms, households and an expert. All agents are risk-neutral. There is a continuum of firms. A firm is endowed with a unit of land and a

[1] Benmelech et al. (2023) offer a comprehensive survey of various theories that seek to elucidate the countercyclical nature of secured debt.

project. The project operates under a stochastic Leontief technology framework, which can be described as follows:

$$y = \begin{cases} A \min\{k, \bar{k}\}, & \text{with prob. } \theta, \\ 0, & \text{with prob. } 1-\theta, \end{cases}$$

where k is the numeraire input, $\bar{k}$ represents the maximum production capacity, A is the total factor productivity and θ is the probability of success. We assume that the expected net outcome of firm's technology, $\theta A - 1$ is positive. As a result, firm production is beneficial.

A project's output is not pledgeable prior to monitoring, and the expert provides such service and project certification. However, the pledgeability of the output is not guaranteed, and the probability of pledgeability is denoted as ω. Importantly, the pledgeability of a project is not known even to the owner before monitoring.

The number of households is equal to the number of firms, and each household is endowed with a numeraire of n, where n exceeds the maximum production capacity of a firm ($n > \bar{k}$).

The expert posses expertise in screening both lands and projects. Screening a piece of land reveals its true value, while monitoring a project provides information about its pledgeability. We denote the expert inputs required to monitor collateral and a project as γ^c and γ^p, respectively. The total monitoring efforts for collateral and projects are represented as Γ^c and Γ^p, and the total investigation effort is expressed as $\Gamma = \Gamma^c + \Gamma^p$.

The expert information production technology has decreasing return to scale. Consequently, the marginal cost of monitoring increases with the total demand for expert services. To capture this, we assume the presence of a marginal cost function $\Gamma \mapsto \varphi(\Gamma)$ that is increasing in the total investigation effort and $\varphi(0) = 0$. [2] The total costs for screening and monitoring, in terms of numeraire, are $\gamma^c \varphi(\Gamma)$ and $\gamma^p \varphi(\Gamma)$, respectively.

The distribution of resources is such that they are not optimally allocated, leading to the need for firms to acquire numeraires from households. In our model, we assume that a firm is randomly matched with a household. Subsequently, the firm presents a take-it-or-leave-it offer to the household, outlining the terms and conditions of the offer, which may involve screening or monitoring activities conducted by the expert, with the associated costs prepaid by households.

In this model, there exists a land market where land is traded, and the price of land is

[2] We do it in this way to simplify the planner's problem in the later subsection. Alternatively, we can assume that there is a continuum of experts and their skills are heterogeneous. This will result in the same structure for the marginal cost. In this alternative setup, however, we have to take into account the welfare of experts in the planner's problem. For a microfoundation, please refer to Asriyan et al. (2022).

contingent on its quality. Given that all agents in the model are risk-neutral, the price of land is equal to the expected intrinsic value of the land.

Additionally, we consider that there exists a brief period of time before production commences, during which basic checks, active screening of collateral, or monitoring a project's pledgeability can take place. Beyond this specific time frame, none of these actions can be executed. Each of these actions requires considerable attention, and a household can only manage one of the three tasks during this limited period. Furthermore, we assume that firms have no direct access to the expert services following Gorton and Ordoñez (2014). [3]

We specify a functional form for the marginal cost $\varphi(\Gamma) = \kappa\Gamma^{\psi}$, where κ determines the level and ψ represents the convexity of the marginal cost function. We now discuss the available contract options for firms.

2.1 Contracts

When a firm extends a take-it-or-leave-it offer to a household, it entails the presentation of a contract outlining the required returns, the specified collateral amount, and the conditions for screening or monitoring. In our model, limited attention of households restricts firms to offering one of three distinct contract types: information-insensitive (I), collateral-sensitive (C), or project-sensitive (P).

The information-insensitive contract is a form of secured debt that does not require active screening or project monitoring. In contrast, the collateral-sensitive contract is also a secured debt, but it necessitates the household's involvement in collateral screening, with funding contingent on the collateral's quality. The project-sensitive contract involves project monitoring and provides credit only when the firm's output is deemed pledgeable.

By assuming that household has limited attention, our model precludes the possibility of firms structuring offers that involve sequential actions. We do not permit a contract in which the household first screens the collateral, and if the collateral quality is found to be subpar, the household subsequently proceeds to monitor the project, providing funding only if the output is pledgeable. Similarly, we do not allow a contract in which the household first monitors the project, and if the project is determined to be non-pledgeable, the household proceeds to execute an information-sensitive or collateral-sensitive contract. This simplification streamlines the problem and facilitates the differentiation of all the information that can be derived by examining different debt utilization.

[3] Gorton and Ordoñez (2019) show that allowing firms' access to the expert services do not change their qualitative results.

We assume that the intraperiod risk free rate is 0. Given that households are risk neutral, they are willing to extend credits to firms if they break-even in expectation.

2.1.1 Information-insensitive Contract

Information-insensitive contract does not require screening of any type. A household's break-even constraint is

$$\theta R^I + (1-\theta)\chi^I \alpha C = k^I,$$

where R^I is the required gross return when the project succeeds, χ^I is the fraction of the collateral posted and k^I represents the numeraire extended. The expected return for the household equals the amount of credit extended. In this contract, with a probability of θ, the firm successfully produces, and the firm reimburses R^I to the household. In the scenario where production fails (with a probability of $1-\theta$), the firm surrenders the posted collateral to the household. Moreover, the contract satisfies

$$R^I = \chi^I \alpha C.$$

To understand this, suppose that $R^I > \chi^I \alpha C$, the firm will always hand over χ^I fraction of the land to the lender. Now suppose $R^I < \chi^I \alpha C$, the borrower will sell the collateral in the event of failure and pay R^I to the household. Hence, the contract must be risk free. It follows that

$$R^I = k^I,$$
$$\chi^I = \frac{k^I}{\alpha C}.$$

Since each firm owns a unit of land, this constrains the amount of credit that can be extended through an information-insensitive contract. The collateral constraint reads

$$\chi^I \leq 1 \iff k^I \leq \alpha C.$$

A household has the ability to secretly screen the land and offer funding contingent on the quality of the land. This results in an incentive compatibility constraint, stipulates that doing so results in negative return

$$\alpha \left[\theta R^I + (1-\theta)\chi^I C - k^I\right] - \gamma^c \varphi(\Gamma) \leq 0.$$

Rearranging, we get a limit on the credit

$$k^I \leq \frac{\gamma^c \varphi(\Gamma)}{(1-\theta)(1-\alpha)}.$$

Given that $\theta A > 1$ and the risk-free rate is 0, firms aim to acquire the maximum amount of credit. The optimal choice of k^I by the firm is

$$k^I = \min\left\{\frac{\gamma^c \varphi(\Gamma)}{(1-\theta)(1-\alpha)}, \alpha C, \bar{k}\right\}.$$

The firm's expected profit (net of the collateral pC) utilizing this contract is

$$\mathbb{E}\left[\pi^I\right] = (\theta A - 1)\min\left\{\frac{\gamma^c \varphi(\Gamma)}{(1-\theta)(1-\alpha)}, \alpha C, \bar{k}\right\}.$$

Note that when the incentive compatibility constraint is binding, the expected profit is increasing in the total monitoring cost $\gamma^c \varphi(\Gamma)$.

2.1.2 Collateral-sensitive Contract

The firm can require the household to first screen the collateral and to provide funding contingent on the quality. A household's break-even constraint is

$$\alpha\left[\theta R^C + (1-\theta)\chi^C C - k^C\right] = \gamma^c \varphi(\Gamma),$$

where R^C is the required gross return in the event of successful production, χ^C is the fraction of collateral posted and k^C is the numeraire extended. With probability α, the land is valuable, and only in this case, the household provides credit to the firm. The expected return is equal to the screening cost incurred. The debt in this contract must also be risk-free, following the same reasoning as discussed earlier. This requirement leads to

$$R^C = \chi^C C.$$

Substituting into the break-even constraint, we get

$$R^C = k^C + \frac{\gamma^c \varphi(\Gamma)}{\alpha}.$$

The required gross return is equal to the credit supplied and compensation for screening. Since each firm possesses only a single unit of land, the total amount of credit they can

access is constrained by the total value of this land. This results in a collateral constraint

$$\chi^C \leq 1 \iff k^C \leq C - \frac{\gamma^c \varphi(\Gamma)}{\alpha}.$$

As $\theta A - 1 > 0$, firms would like obtain as much credit as possible up to the production capacity $\bar{k}$. However, the collateral constraint limits the total funding. It follows that the optimal choice of numeraire by the firm is

$$k^C = \min\left\{C - \frac{\gamma^c \varphi(\Gamma)}{\alpha}, \bar{k}\right\}.$$

The expected profit of the firm utilizing this contract is

$$\begin{aligned}\mathbb{E}\left[\pi^C\right] &= \alpha\left[\theta A k^C - \left(k^C + \frac{\gamma^c \varphi(\Gamma)}{\alpha}\right)\right] \\ &= \alpha\left[(\theta A - 1)\min\left\{C - \frac{\gamma^c \varphi(\Gamma)}{\alpha}, \bar{k}\right\} - \frac{\gamma^c \varphi(\Gamma)}{\alpha}\right].\end{aligned}$$

The expected profit is decreasing in the total monitoring cost $\gamma^c \varphi(\Gamma)$.

2.1.3 Project-sensitive Contract

In this contract, the firm mandates the lender to perform a screening of the project and provide funding conditional on the project's pledgeability. The break-even requirement for the lender can be expressed as follows:

$$\omega\left(\theta R^P - k^P\right) = \gamma^p \varphi(\Gamma).$$

Here, R^P represents the demanded gross return when the project attains success, and k^P denotes the amount of numeraire to be supplied. In this contractual arrangement, the household commits to providing funding in the amount of k^P to the firm, contingent upon its classification as pledgeable with a probability of ω. The stipulated return on this funding, denoted as R^P, is to be delivered to the household only in the case of a successful project outcome. The break-even constraint states that the household's expected return is equal to the monitoring cost incurred. Rearranging this equation, we get

$$\theta R^P = \frac{\gamma^p \varphi(\Gamma)}{\omega} + k^P.$$

The expected gross return equals the credit provided and compensation for monitoring. Since $\theta A - 1 > 0$, the optimal choice of numeraire by the firm is to borrow up to the capacity

$$k^P = \bar{k}.$$

The expected profit of the firm in this contract is

$$\mathbb{E}\left[\pi^P\right] = \omega(\theta A - 1)\bar{k} - \gamma^p \varphi(\Gamma).$$

This equation reveals that the expected profit of the firm decreases as the monitoring cost, denoted as $\gamma^p \varphi(\Gamma)$, increases.

2.2 Equilibrium

We first introduce two assumptions.

Assumption 1. Monitoring a project is costly,

$$(\theta A - 1)\omega\bar{k} - \kappa(\gamma^p)^{1+\psi}.$$

Assumption 2. Monitoring a project requires more effort than screening a unit of land,

$$\frac{\gamma^p}{\gamma^c} > \theta A \frac{\omega\bar{k}}{C}.$$

Assumption 1 says that if all firms choose project-sensitive contract, the expected profit of that contract is negative. Hence, monitoring a project is costly if everyone does so. Assumption 2 states that monitoring a project requires more expert's services than screening a unit of land.

It's important to note that in equilibrium, there is always a positive demand for expert services. To understand why this is the case, consider that if the total demand for expert services were zero, it would imply that information-insensitive contracts yield zero profits. Given that $\theta A > 1$, firms would have a stronger incentive to choose either a collateral-sensitive or a project-sensitive contract.

In this model, firms are allowed to play mixed strategies, denoted by η and ν, representing the probabilities of a firm choosing a project-sensitive or collateral-sensitive contract, respectively.

The total demand for expert services is

$$\Gamma = \eta\gamma^p + \nu\gamma^c.$$

In our analysis, we will focus on symmetric equilibrium. A symmetric equilibrium is defined as a tuple (η, ν) where, given that $\varphi(\Gamma) = \varphi(\eta\gamma^p + \nu\gamma^c)$, each firm selects the contract that maximizes its expected profits and has no incentive to deviate from this choice when all other firms also employ the same strategy.

In the following subsection, we will present a sufficient condition that helps us understand when secured debt exhibits countercyclical behavior.

2.3 Countercyclical Secured Debt

We now provide a sufficient condition under which the secured debt exhibits countercyclicality.

Proposition 1. *Suppose that $\omega\bar{k} > C$ and Assumptions 1 and 2 hold. If γ^c is small enough, then there exists an $\alpha \in (0, 1)$ such that the share of secured debt jumps down from 1.*

Proof. See Appendix A. □

We will illustrate the intuition behind the proof with a numerical example. In this example, we assume that project monitoring necessitates six times more expert input compared to screening a unit of land. This example will help clarify the key ideas.

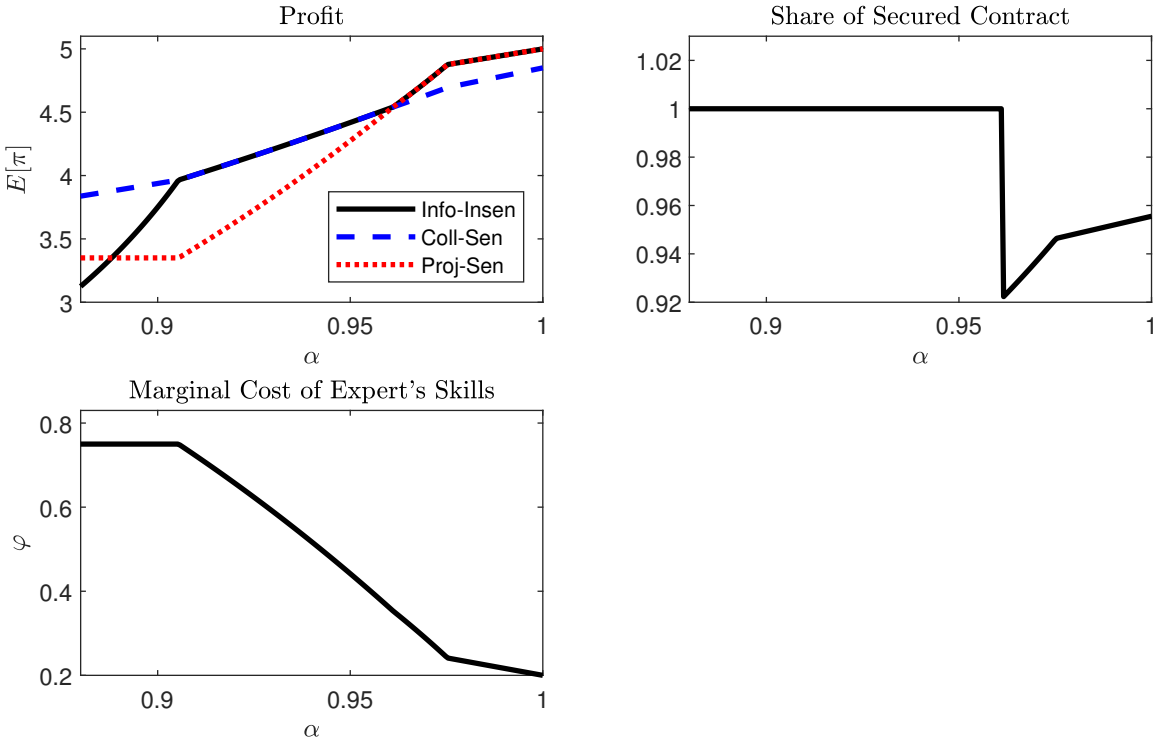

Figure 1: Parameters $A = 3, \theta = 0.5, \omega = 0.8, C = 10, \gamma^c = 0.5, \gamma^p = 6\gamma^c, \kappa = 1.5, \psi = 1$ and $\bar{k} = 14$. The top left panel shows the profits of contracts as α varies. The top right panel plots the utilization of secured debt. The bottom panel displays the marginal cost of expert skills φ.

In Figure 1, there is a transition point at around $\alpha = 0.96$, where the share of secured debt drops from 1 to 0.92. This transition aligns with the result outlined in Proposition 1. We now explain the underlying assumptions that lead to this outcome.

The condition $\omega\bar{k} > C$ implies that the firm's credit demand exceeds the value of the land even when the land quality is perfect ($\alpha = 1$). As α approaches one (i.e., land quality is almost always perfect), the household's incentive constraint does not bind. In this region, the expected profit of an information-insensitive contract is

$$\mathbb{E}\left[\pi^I\right] = (\theta A - 1)\min\left\{\frac{\gamma^c\varphi(\Gamma)}{(1-\theta)(1-\alpha)}, \alpha C, \bar{k}\right\} = (\theta A - 1)\alpha C.$$

This strictly dominates the collateral-sensitive contract as the latter incurs additional screening cost. Recall that the profit of project-sensitive contract is

$$\mathbb{E}\left[\pi^P\right] = \omega(\theta A - 1)\bar{k} - \gamma^p\varphi(\Gamma).$$

When the demand for expert skill is 0, the profit of the project-sensitive contract is the highest among all contracts. Clearly, this cannot be an equilibrium as firms have incentives to deviate. In equilibrium, firms adopt a mixed strategy, utilizing both information-insensitive and project-sensitive contracts to balance their profits.

As α decreases, the incentive compatibility constraint of the household starts to bind. The profit of an information-insensitive contract becomes

$$\mathbb{E}\left[\pi^I\right] = (\theta A - 1)\frac{\gamma^c \varphi(\Gamma)}{(1-\theta)(1-\alpha)}.$$

Note that $\varphi(\Gamma)$, in equilibrium, is an implicit function of α. As α decreases, more firms switch to project-sensitive contracts, leading to an increase in φ. Therefore, it may not be immediately apparent how this quantity changes with α. In equilibrium, as the information-insensitive contract tracks the profit of the project-sensitive contract, and φ increases as α drops, $\mathbb{E}\left[\pi^I\right]$ falls.

Recall that the profit of a collateral-sensitive contract is

$$\mathbb{E}\left[\pi^C\right] = (\theta A - 1)\alpha C - \theta A \gamma^c \varphi(\Gamma).$$

The condition in Proposition 1 emphasizes that monitoring a project is significantly more demanding than screening a collateral. Since the slopes of the profit curves for project-sensitive and collateral-sensitive contracts are influenced by the ratio γ^p/γ^c, it follows that when α decreases, the profit of the collateral-sensitive contract surpasses that of the project-sensitive contract. Consequently, firms abandon the project-sensitive contract and rely solely on secured debt when α falls below a certain threshold. Therefore, to the extent that business cycles are characterized by the value of collateral, our model is capable of explaining the countercyclical nature of secured debt through an endogenous information cost.

2.4 The Planner's Problem

In this section, we continue to impose the assumption that $\omega\bar{k} > C$. The planner maximizes total welfare of firms

$$\begin{aligned} &\max_{\eta,\nu} \eta\mathbb{E}\left[\pi^P\right] + \nu\mathbb{E}\left[\pi^C\right] + (1-\eta-\nu)\mathbb{E}\left[\pi^I\right], \\ \text{s.t.} \quad &\varphi(\Gamma) = \kappa\left(\eta\gamma^p + \nu\gamma^c\right)^\psi, \quad \eta \geq 0, \quad \nu \geq 0, \quad \eta + \nu \leq 1. \end{aligned}$$

We focus on the case where the average quality of collateral is high (big α), and in the equilibrium, firms exclusively adopt information-insensitive and project-sensitive contracts. The model exhibits a price externality. Firms individually select contracts to maximize their own profits, without considering that, collectively, their choices regarding the utilization frequency of project-sensitive contracts can influence the equilibrium monitoring costs.

Proposition 2. *Suppose that $\omega\bar{k} > C$ and firms mix between information-insensitive and project-sensitive contracts in the equilibrium. Then, there exists a threshold $\bar{\alpha}$ such that if $\alpha > \bar{\alpha}$, there is excessive monitoring. When $\alpha < \bar{\alpha}$, there exists a threshold $\bar{\eta}$ such that, if the equilibrium share of project-sensitive contracts $\eta^E > \bar{\eta}$, there is excessive monitoring; otherwise, there is insufficient monitoring.*

Proof. See Appendix B. □

The intuition is as follows. When α is high, the incentive compatibility constraint of households does not bind. In this scenario, the planner must balance the proportion of firms that benefit more from project-sensitive contracts with the overall monitoring cost. Since individual firms, when making their choices, don't consider the collective impact of their decisions on the total monitoring cost, the equilibrium share of project-sensitive contracts becomes excessively high. This is what leads to excessive monitoring in these situations.

As α decreases to a point where the incentive compatibility constraint of households starts to bind, a new trade-off emerges for the planner. In addition to balancing the share of firms using project-sensitive contracts and the overall monitoring cost, the planner now has to consider the impact of marginal cost (represented by φ) on relaxing the incentive compatibility constraint. A higher value of φ can ease this constraint, enabling firms to access more credit through information-sensitive contracts.

The derivative of φ w.r.t. η is

$$\frac{\partial \varphi}{\partial \eta} = \frac{\psi \varphi}{\eta},$$

which is decreasing in η. If the equilibrium share of firms opting for project-sensitive contract, η^E is high, the marginal cost of expert skills, φ is less sensitive to changes in η. In this case, the direct benefit of reducing the overall monitoring cost by decreasing η is more significant than the gain achieved by relaxing the incentive-compatibility constraint. As a result, there is excessive monitoring when η^E is large. Conversely, when η^E is small, the effect on the incentive compatibility constraint dominates. In such situations, there is insufficient monitoring.

The key takeaway is that the equilibrium share of firms using project-sensitive contracts (unsecured debt) plays a crucial role in determining whether there is excessive or insufficient monitoring.

3 Dynamic Model

In the static model, we do not consider information persistence and the impact of firm distribution on information acquisition. We will now extend the model to incorporate these elements.

We consider a discrete time infinite horizon model. Each period t consists of two sub-periods: morning and evening. The economy still features two types of goods: numeraire, which must be consumed within the same period, and land, which is storable and can be consumed over multiple periods. The quality of land is variable, represented by the parameter α, and consuming land can yield a return (in numeraire) based on this quality. Consuming an α-land yields numeraire C with probability α and 0 otherwise. The three types of agents, firms, households, and the expert, retain their risk-neutral characteristics from the static model.

Households live for one period and have limited attention. Each household is endowed with n numeraires at the beginning of the period.

The expert lives for one period and has the skills to screen both projects and lands. Her investigation technology exhibits decreasing to scale. We assume the same parametric form for the marginal cost of expert service $\varphi(\Gamma_t) = \kappa\Gamma_t^{\psi}$.

Firms have discount factor β. Each firm is equipped with a project. This project requires at least one unit of land to operate. With the help of a unit of land, a firm can initiate its project by investing numeraire in the morning, and this investment results in an output generated in the evening. The production process follows a stochastic Leontief technology framework

$$\tilde{y}_t = \begin{cases} A\min\{k_t, \bar{k}\}, & \text{with prob. } \theta, \\ 0, & \text{with prob. } 1-\theta, \end{cases}$$

where $\tilde{y}_t$ represents the output in the evening. A firm that chooses to engage in production and invests in its project is at risk of failure. The probability of a firm that enrolls in production failing to produce successfully is given by $(1-\theta)$. When a firm fails to produce, it dies and exits the model. Similarly, a firm that does not participate in production and remains inactive also faces a similar probability of dying.

We assume that owning a second unit of land is associated with a prohibitively high stamp duty cost. This implies that all firms own a unit of land in equilibrium. [4]

Firms are heterogeneous. Each firm possesses both a project and a unit of land, and this heterogeneity is manifested in the various types of projects and land qualities that firms can have. For projects, the output can fall into one of three categories: pledgeable (g), unknown pledgeability (u), or not pledgeable (b). Similarly, land quality is characterized by three possible types, denoted as $\alpha \in \{0, \hat{\alpha}, 1\}$, where $\hat{\alpha}$ takes on values between 0 and 1.

In the morning, a firm is randomly matched with a household, and the firm has the opportunity to present a take-it-or-leave-it offer. Firms, as in the static model, have the choice of offering one of three types of contracts: information-insensitive, collateral-sensitive, and project-sensitive.

The morning interactions result in the revelation of information after screening or monitoring. Based on the chosen contract type, households extend credits to the firm in accordance with the contract's specifications. A project-sensitive contract can impact the pledgeability of the project, converting it from an unknown state to either pledgeable or not pledgeable. The probability of converting to pledgeable is denoted as ω, while the probability of becoming not pledgeable is $(1-\omega)$. Likewise, a collateral-sensitive contract reveals the true quality of an α-land. After screening, an α-land can transition into a 1-land or a 0-land, with probabilities α and $(1-\alpha)$, respectively.

A firm is labelled by the state (s, α) in the morning and $(\tilde{s}, \tilde{\alpha})$ in the evening, where $s, \tilde{s} \in \{g, u, b\}$ and $\alpha, \tilde{\alpha} \in \{0, \hat{\alpha}, 1\}$ represent the project pledgeability and land quality, respectively. Firms with an α-land can choose to consume the land or save the land for future consumption.

In the evening, a new firm randomly matches with a dying firm and presents a take-it-or-leave-it offer for the land held by the dying firm. A new firm starts with a project with an unknown pledgeability status.

The information about both the projects and land is persistent, and these characteristics are represented as Markov processes. Let

$$B^{\rho} = \begin{pmatrix} \rho_{gg} & \rho_{gu} & \rho_{gb} \\ \rho_{ug} & \rho_{uu} & \rho_{ub} \\ \rho_{bg} & \rho_{bu} & \rho_{bb} \end{pmatrix}, \quad B^{\varrho} = \begin{pmatrix} \varrho_{00} & \varrho_{0\hat{\alpha}} & \varrho_{01} \\ \varrho_{\hat{\alpha}0} & \varrho_{\hat{\alpha}\hat{\alpha}} & \varrho_{\hat{\alpha}1} \\ \varrho_{10} & \varrho_{1\hat{\alpha}} & \varrho_{11} \end{pmatrix},$$

where B^{ρ} is the transition matrix of project pledgeability, B^{ϱ} is the transition matrix of

[4] This assumption eliminates the need to account for the number of land units that each firm owns. This simplification ensures that the distribution of firms has finite supports.

land quality, ρ_{xy} represents the probability of a project with $\tilde{s}_t = x$ transition into $s_{t+1} = y$ and ϱ_{xy} is the probability of an x-land at the end of time t transition into y-land in the beginning of time $t + 1$.

The quality of the land carries over when the land changes hands. However, the new firm does not inherit the project pldegeability of the dying firm. The sequence of actions within a period is summarized here.

- Morning
    1. Firms learn about their asset types.
    2. A firm is randomly matched with a household.
    3. Firms choose one of the three contracts.
    4. Firms learn about their new types and start to produce if possible.
- Evening
    1. Firms that produce receive the stochastic outputs.
    2. Firms learn whether they will survive or die.
    3. A dying firm is randomly matched with a new firm. The new firm makes a take-it-or-leave-it offer for the land held by the dying firm.

We now solve the model, starting from the evening.

3.1 Evening

In the evening, an exiting firm is randomly matched with a new firm who makes a take-it-or-leave-it offer. It follows that the price of $\tilde{\alpha}$-land $q(\tilde{\alpha}) = \tilde{\alpha}C$ under which a dying firm with that land is indifferent between consuming or selling the land. If a firm dies, her terminal value is

$$W^q(\tilde{s}, \tilde{\alpha}) = \tilde{\alpha}C.$$

A surviving firm's continuation value is

$$W^s(\tilde{s}, \tilde{\alpha}) = J(\tilde{s}, \tilde{\alpha})$$

where

$$J(\tilde{s}, \tilde{\alpha}) = \beta\Big\{\rho_{\tilde{s}g}\mathbb{E}\left[U(g, \alpha') \mid \tilde{\alpha}\right] + \rho_{\tilde{s}u}\mathbb{E}\left[U(u, \alpha') \mid \tilde{\alpha}\right] + \rho_{\tilde{s}b}\mathbb{E}\left[U(b, \alpha') \mid \tilde{\alpha}\right]\Big\}.$$

Here, $U(s,\alpha)$ is the continuation value of a firm with state (s,α) at the beginning of the period and $J(\tilde{s},\tilde{\alpha})$ is the discounted expected value of a firm with evening state $(\tilde{s},\tilde{\alpha})$. The expectation is over next-period α' conditional on $\tilde{\alpha}$ in the evening. Let $\vec{U}$ and $\vec{J}$ be the stacked vectors of U and J, respectively, that is

$$\vec{U} = \begin{pmatrix} U(g,0) \\ U(g,\hat{\alpha}) \\ U(g,1) \\ U(u,0) \\ U(u,\hat{\alpha}) \\ U(u,1) \\ U(b,0) \\ U(b,\hat{\alpha}) \\ U(b,1) \end{pmatrix}, \quad \vec{J} = \begin{pmatrix} J(g,0) \\ J(g,\hat{\alpha}) \\ J(g,1) \\ J(u,0) \\ J(u,\hat{\alpha}) \\ J(u,1) \\ J(b,0) \\ J(b,\hat{\alpha}) \\ J(b,1) \end{pmatrix}.$$

Then J and U are related by

$$\vec{J} = \beta(B^{\rho} \otimes B^{\varrho})\vec{U}.$$

3.2 Morning

Since there is no storage device for numeraire across periods, firms need to obtain numeraires from households in the morning. A firm is randomly matched with a household and the firm presents a take-it-or-leave-it offer for the numeraire. We allow the matched firm and household to trade land. Since household only lives for one period, the maximum price they can offer is αC. If a firm decides to purchases the land from the matched household, the firm makes a take-it-or-leave-it offer. This allows us to maintain the result that debts under information-insensitive and collateral-sensitive contracts are risk free.

Under an information-insensitive contract, a firm's state in the evening remains the same as in the morning. The value of an information-insensitive contract is

$$V^I(s,\alpha) = \overbrace{\theta(A-1)\min\left\{\frac{\gamma^c\varphi(\Gamma)}{\alpha(1-\theta)(q(1)/q(\alpha)-1)}, q(\alpha), \bar{k}\right\} + \theta W^s(s,\alpha)}^{\text{Successful production}}$$
$$\underbrace{-(1-\theta)\min\left\{\frac{\gamma^c\varphi(\Gamma)}{\alpha(1-\theta)(q(1)/q(\alpha)-1)}, q(\alpha), \bar{k}\right\} + (1-\theta)W^q(s,\alpha)}_{\text{Failed production and forced quit}}.$$

The first term is the flow utility from consuming when the production is successful. The second term represents the continuation value of a surviving firm. The third term represents the loss of posted collateral after a failed production attempt. The last term is the terminal value of a dying firm.

A collateral-sensitive contract reveals information about the land. The value of a collateral-sensitive contract with $\alpha \in (0,1)$ is

$$V^C(s,\alpha) = \overbrace{\alpha\theta\left[(A-1)\min\left\{q(1)-\frac{\gamma^c\varphi(\Gamma)}{\alpha},\bar{k}\right\}-\frac{\gamma^c\varphi(\Gamma)}{\alpha}+W^s(s,1)\right]}^{\text{High quality collateral and successful production}}$$
$$\underbrace{+\alpha(1-\theta)\left[-\min\left\{q(1)-\frac{\gamma^c\varphi(\Gamma)}{\alpha},\bar{k}\right\}-\frac{\gamma^c\varphi(\Gamma)}{\alpha}+W^q(s,1)\right]}_{\text{High quality collateral, failed production and forced quit}}$$
$$\underbrace{+(1-\alpha)\left[\theta W^s(s,0)+(1-\theta)W^q(s,0)\right]}_{\text{Low quality collateral}}.$$

The first term accounts for the utility flow and continuation value in the scenario where the land is of high quality, and production is successful. The second term represents the loss in collateral and the terminal value when the land is of high quality, but production fails, leading to the demise of the firm. The final term captures the anticipated continuation value when the land quality is low. Note that firms with either bad or perfect quality land are not permitted to employ collateral-sensitive contracts. We set

$$V^C(s,0) = -\infty, \quad V^C(s,1) = -\infty.$$

The value of a project-sensitive contract hinges on the pledgeability status in the morning. When the project's pledgeability is unknown ($s = u$), the contract reveals information about the project's pledgeability. In this case, the value of a project-sensitive contract is

$$V^P(u,\alpha) = \overbrace{\omega\theta\left[\left(A-\frac{1}{\theta}\right)\bar{k}-\frac{\gamma^p\varphi(\Gamma)}{\omega\theta}+W^s(g,\alpha)\right]}^{\text{Good project and successful production}}$$
$$\underbrace{+\omega(1-\theta)W^q(g,\alpha)}_{\text{Good project, failed production and forced quit}} \qquad \underbrace{+(1-\omega)\left[\theta W^s(b,\alpha)+(1-\theta)W^q(b,\alpha)\right]}_{\text{Bad project}}.$$

The first term corresponds to the flow utility and continuation value when the project's output is pledgeable, and production is successful. Because project-sensitive contracts are

unsecured, in cases of production failure, the firm is not obligated to make any payments, which explains why the second term only includes the terminal value of a firm that is going out of business. The last term represents the expected continuation value for a firm with a non-pledgeable project. Note that when a firm knows its project is pledgeable, it can opt for a project-sensitive contract without incurring monitoring costs. Hence in the case with $s = g$, we have

$$V^P(g,\alpha) = \underbrace{\theta\left[\left(A - \frac{1}{\theta}\right)\bar{k} + W^s(g,\alpha)\right]}_{\text{Successful production}} \underbrace{+(1-\theta)W^q(g,\alpha)}_{\text{Failed production and forced quit}} .$$

If $s = b$, then this contract is not available. In this case, we simply define

$$V^P(b,\alpha) = -\infty.$$

A firm chooses the contract with the highest expected profit. Her value function is

$$U(s,\alpha) = \max\left\{V^I(s,\alpha), V^C(s,\alpha), V^P(s,\alpha)\right\}.$$

3.3 Stationary Distribution

Let $f(s,\alpha)$, $\tilde{f}(s,\alpha)$, and $\bar{f}(s,\alpha)$ represent the stationary probability mass functions of firms with state (s,α) in the morning, at the beginning of the evening, and at the end of the evening, respectively. Additionally, denote $\eta(s,\alpha)$ and $\nu(s,\alpha)$ as the probabilities that a firm with state (s,α) chooses a project-sensitive and collateral-sensitive contract, respectively.

The distribution at the beginning of the evening is determined by the morning distribution and the contract choices of firms. When $\eta(u,\cdot)$ is high, more firms with both good and bad quality projects will be present in the evening, with the distribution among these groups influenced by ω. Similarly, if $\nu(\cdot,\alpha)$ is high, the distribution of firms with high and low quality in the evening will increase, with the ratio governed by α.

The end-of-evening distribution relies on the survival probability of firms. When θ is low, the proportion of firms with unknown pledgeability increases, as dying firms are replaced by new firms with projects of unknown pledgeability. The Markov transition matrices enable us to derive the morning distribution from the end-of-evening distribution. In equilibrium, if the distribution is stationary, we return to the initial morning distribution. Detailed expressions for the stationary distribution can be found in Appendix C.

3.4 Land Quality Aggregate Shock

We investigate the impact of a one-time unexpected aggregate land quality shock, where an α-land transforms into a $\zeta\alpha$-land. Following this shock, absence of screening, the land quality gradually reverts to $\hat{\alpha}$, according to a Markov process with the following transition matrix

$$B^{\varrho} = \begin{pmatrix} \varrho_{0,0} & \varrho_{0,\zeta\hat{\alpha}} & \varrho_{0,\hat{\alpha}} & \varrho_{0,\zeta} & \varrho_{0,1} \\ \varrho_{\zeta\hat{\alpha},0} & \varrho_{\zeta\hat{\alpha},\zeta\hat{\alpha}} & \varrho_{\zeta\hat{\alpha},\hat{\alpha}} & \varrho_{\zeta\hat{\alpha},\zeta} & \varrho_{\zeta\hat{\alpha},1} \\ \varrho_{\hat{\alpha},0} & \varrho_{\hat{\alpha},\zeta\hat{\alpha}} & \varrho_{\hat{\alpha},\hat{\alpha}} & \varrho_{\hat{\alpha},\zeta} & \varrho_{\hat{\alpha},1} \\ \varrho_{\zeta,0} & \varrho_{\zeta,\zeta\hat{\alpha}} & \varrho_{\zeta,\hat{\alpha}} & \varrho_{\zeta,\zeta} & \varrho_{\zeta,1} \\ \varrho_{1,0} & \varrho_{1,\zeta\hat{\alpha}} & \varrho_{1,\hat{\alpha}} & \varrho_{1,\zeta} & \varrho_{1,1} \end{pmatrix}.$$

We derive the distribution dynamics in Appendix C and provide an algorithm for solving the model in Appendix D.

3.5 Numerical Illustration

3.5.1 Calibration

We set $\theta = 0.98$ which implies a default rate of 2%. We set θA to be 1.1 which implies a profitability of 10% without monitoring. The discount factor β is set to be 0.96, which translates to a risk free rate of 4%. We follow Gorton and Ordoñez (2014) and set the persistence of pledgeability and quality to be 0.9. We let $\psi = 1$, so that the expert's skill marginal cost is linear in the total demand. The collateral to credit demand ratio $C/\bar{k}$ is set to be 0.9. We set $\hat{\alpha} = 0.98$, so that the average quality of land is high. [5] We choose κ, γ^c and γ^p to achieve a secured debt share (in terms of values) of 40%, a 7% information cost to credit demand ratio and no land screening in the steady state. The choice of the last target aligns with the theme of little information revelation about collateral when the value of collateral is high.

3.5.2 Results

We study the outcomes of both small ($\zeta = 0.99$) and large ($\zeta = 0.9$) land quality aggregate shocks. Figure 2 displays the results.

[5] We vary $\hat{\alpha}$ in the robustness check to ensure that our results are not sensitive to the choice of $\hat{\alpha}$.

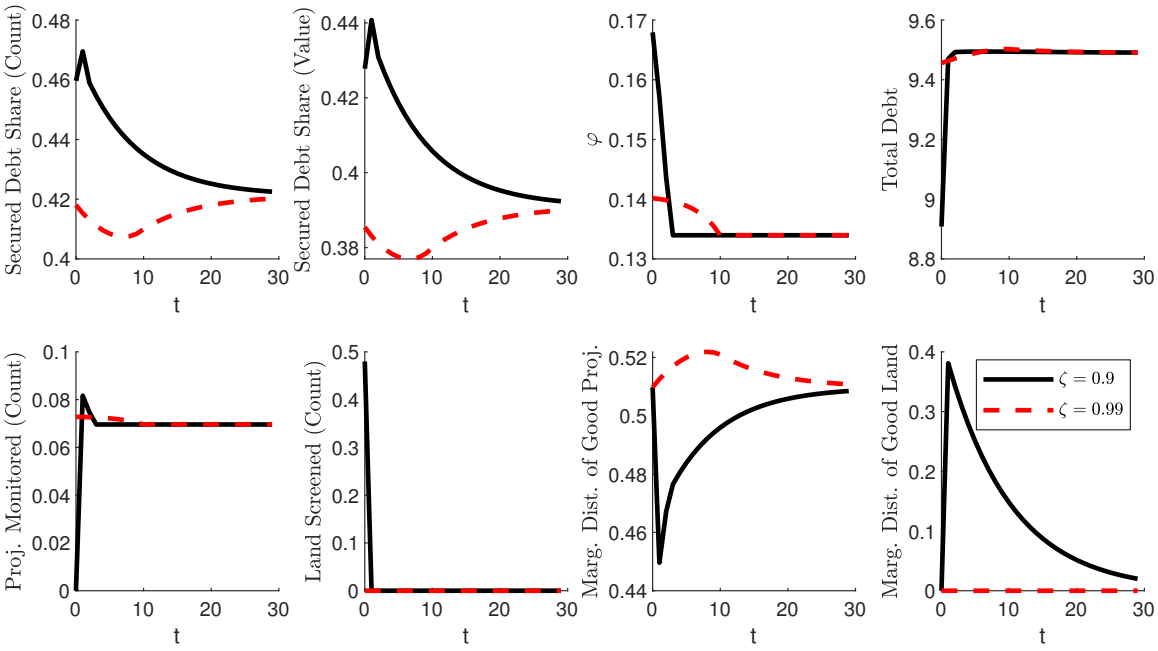

Figure 2: Impulse responses of a one-time unexpected land quality aggregate shock. The black curves and red dashed curves show the effects of a large $\zeta = 0.9$ and a small $\zeta = 0.99$ shock, respectively. The first two panels display the evolution of secured debt share in terms of total loan count and total loan value. The third panel at top shows the expert skill marginal cost. The top right panel plots the impulse response of total debt value. The first two bottom panels show the number of projects being monitored and piece of lands being screened. The last two bottom panels display marginal distributions of pledgeable projects and high quality land, respectively.

In the case of a large land quality shock (black curves), despite the fact that around 51% of the projects are pledgeable in the steady state, the intuition developed in the static case still holds. When the economy experiences a significant drop in the price of collateral, the project-sensitive contract becomes much more attractive if monitoring costs remain constant. However, in equilibrium, the marginal cost of expert skill, denoted as φ, surges in response to the high demand for project monitoring. Since monitoring a project requires a significant input from the expert, this reduces the attractiveness of the project-sensitive contract.

In fact, the second force, which is the increase in φ is so substantial that firms switch to collateral-sensitive contracts. This results in no projects being monitored, and only a fraction of lands are screened at the impact of the shock (as shown in the first two plots in the bottom panel of Figure 2). Consequently, the secured debt share, both in terms of

dollar values and count, rises immediately after the shock. Since information is persistent, firms continue to utilize secured debt after the shock. The increase in the secured debt's dollar share at the impact is approximately 3 percentage points, which is consistent with the numbers reported in Benmelech et al. (2023).

In the case of a small land quality aggregate shock, where the price of collateral falls by only 1%, the marginal cost of expert skill does increase, but not significantly enough to make the project-sensitive contract unattractive. Consequently, firms continue to utilize project-sensitive contracts. As land qualities are not revealed, the price of collateral remains low after the shock's impact. Firms persist in choosing project-sensitive contracts, and the marginal cost of expert skill stays high for an extended period. As a result, the secured debt share continues to decrease. However, as the effect of the land quality aggregate shock diminishes over time, the secured debt share slowly recovers back to its steady-state level.

It's worth noting from the top right panel that the recovery is faster with a large land-quality aggregate shock. This can be explained by the fact that the cost of revealing land quality is relatively low, and the choice of collateral-sensitive contracts by firms introduces a large fraction of high-quality collateral into the economy. This, in turn, allows firms to obtain credit by posting high-quality collateral. As a result, the economy experiences a rapid recovery after a large shock.

This result poses another challenge to the financial crisis literature. In a standard macro-finance model (Kiyotaki and Moore (1997), Bernanke et al. (1999), Brunnermeier and Sannikov (2014)), the speed of recovery after a financial crisis is too high in the absence of behavioral frictions. The introduction of information frictions, such as those studied in this paper, further exacerbates this problem.

The phenomenon of endogenous contract switching can offer a potential resolution to the seemingly contradictory findings in Becker et al. (2020) and Howes and Weitzner (2023). In the former, the authors conclude using Swedish's bank data that information frictions are countercyclical while monitoring effort is acyclical. In the latter, the authors, using Federal Reserve's Y-14Q Schedule H.1 data, demonstrate that countercyclical exogenous information frictions alone are insufficient to explain banks' ability to predict defaults over the business cycle. They conclude that information production is countercyclical.

In this model, firms exhibit varying preferences for contract choices throughout the business cycle. The process of switching contracts, which relies less on expert assessment to determine land quality, inherently mitigates information frictions during economic downturns. Despite an increasing marginal cost associated with expert skills, the overall information cost per contract, denoted as $\gamma^c \varphi_{\text{bust}}$, decreases when firms transition to collateral-sensitive

contracts during recessionary periods, as compared to $\gamma^p \varphi_{\text{boom}}$. Consequently, creditors can attain higher information accuracy while adhering to a fixed screening budget. Furthermore, the aggregate information production by creditors increases when firms with unknown pledgeability exclusively adopt collateral-sensitive contracts, rather than mix between project-sensitive and information-insensitive contracts. These results align with the empirical findings presented in the two papers cited above that, at first glance, appear to present contrasting viewpoints.

4 Conclusion

Our paper introduces a fresh perspective on the interaction between debt choice and information frictions. We illustrate how information frictions arising from screening and monitoring mechanisms can naturally lead to the countercyclical nature of secured debt. Moreover, our model aligns with the idea that information frictions tend to be less severe during economic downturns. Additionally, we show that the level of secured debt utilization in equilibrium can serve as a valuable indicator of whether there is an excess or insufficiency in information acquisition. This sheds new light on the dynamics of secured debt and its relationship with information imperfections in the financial system.

Future work will involve empirically testing the information type switching as outlined in the model. We also plan to extend the model to incorporate firm investment decisions and explore the interaction between investment and information frictions.

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Appendix

A Proof of Proposition 1

We separate the proof into 4 lemmas.

Lemma 1. *Suppose that $\omega\bar{k} > C$, pure strategy of selecting only information-insensitive contract is not possible.*

Proof. We proceed by contradiction. Suppose that all firms choose information-insensitive contract. Then, the marginal cost of monitoring is $\varphi(0) = 0$. This implies that the profit of information-insensitive contract is zero. Since project-sensitive and collateral-sensitive contract yield positive profit, firms have incentives to deviate. We have a contradiction. □

Lemma 2. *Suppose that $\omega\bar{k} > C$, Assumption 1 and 2 hold. There exists a threshold α^{IP} such that $\forall\alpha > \alpha^{IP}$, firms are indifferent between information-insensitive and project-sensitive contracts in equilibrium.*

Proof. We proceed by first showing that if α is large enough, pure strategy is not possible. Then, we show all the other combinations of contracts are not possible.

Assumption 1 precludes the possibility of pure project-sensitive contract at $\alpha = 1$. Moreover, pure collateral-sensitive contract at $\alpha = 1$ is not possible as information-insensitive contract dominates when $\varphi(\Gamma) > 0$. Holding fix the value of $\varphi(\Gamma)$, the profit of information-insensitive contract is continuous at $\alpha = 1$. It follows that there exists some neighbourhood around $\alpha = 1$ such that pure strategy is not possible.

We now show that mixing between information-insensitive and collateral-sensitive contracts is not possible for α large enough. We proceed by contradiction. Suppose that mixing between information-insensitive and collateral-sensitive contracts is an equilibrium. Then, the incentive compatibility constraint of household must bind and $k^I = \frac{\gamma^c\varphi(\Gamma)}{(1-\alpha)(1-\theta)}$. Equalizing profit between both contracts yields

$$\varphi(\Gamma) = \frac{(\theta A - 1)pC(1-\alpha)(1-\theta)}{\gamma^c\left[(\theta A - 1) + \theta A(1-\alpha)(1-\theta)\right]}.$$

Using the expression for $\varphi(\Gamma)$, we show that the profit of project-sensitive contract is strictly

higher when α is large enough, that is,

$$\begin{aligned}
\mathbb{E}\left[\pi^P\right] - \mathbb{E}\left[\pi^C\right] &= (\theta A - 1)\omega\bar{k} - \gamma^p\varphi(\Gamma) - (\theta A - 1)\alpha C - \theta A\gamma^c\varphi(\Gamma) \\
&= (\theta A - 1)(\omega\bar{k} - \alpha C) - (\gamma^p - \theta A\gamma^c)\varphi(\Gamma) \\
&= (\theta A - 1)\left[\omega\bar{k} - \alpha C - \left(\frac{\gamma^p}{\gamma^c} - \theta A\right)\frac{\alpha C(1-\alpha)(1-\theta)}{(\theta A - 1) + \theta A(1-\alpha)(1-\theta)}\right] \\
&\xrightarrow{\alpha\to 1} (\theta A - 1)(\omega\bar{k} - C) > 0.
\end{aligned}$$

Similarly, we show that mixing between collateral-sensitive contract and project-sensitive contract is not possible for α large enough. We again prove this by contradiction. Equalizing profit between both contracts yields

$$\varphi(\Gamma) = \frac{(\theta A - 1)(\omega\bar{k} - \alpha C)}{\gamma^p - \theta A\gamma^c},$$

which is greater than 0 by assumption. Since $\frac{\gamma^c\varphi(\Gamma)}{(1-\alpha)(1-\theta)} \to \infty$ when $\alpha \to 1$, the incentive compatibility constraint of information-insensitive contract is not biding and $k^I = \alpha C$ when α is large. It follows that information-sensitive contract yields strictly higher profit than collateral-sensitive contract and we have a contradiction.

We now show that mixing between information-insensitive and project-sensitive contracts is indeed an equilibrium. We guess and verify that the incentive compatibility constraint is not binding when α is large enough. Equalizing profit yields

$$\varphi(\Gamma) = \frac{(\theta A - 1)(\omega\bar{k} - \alpha C)}{\gamma^p}.$$

Note that

$$\frac{\gamma^c\varphi(\Gamma)}{(1-\alpha)(1-\theta)} \xrightarrow{\alpha\to 1} \infty,$$

the incentive compatibility constraint is indeed not binding when α is large. Since $\varphi(\Gamma) > 0$ and IC constraint is not binding, information-insensitive contract dominates collateral-sensitive contract. We have completed the proof. □

We now give conditions under which secured debt is counter-cyclical. Suppose α^{IP} is defined as the α such that profits of all contracts are equalized. Then, eliminating marginal cost yields

$$\frac{\omega\bar{k} - \alpha^{IP}C}{\frac{\gamma^p}{\gamma^c} - \theta A} = \frac{\omega\bar{k}}{\frac{\theta A - 1}{(1-\alpha^{IP})(1-\theta)} + \frac{\gamma^p}{\gamma^c}} = \frac{\alpha^{IP}C}{\frac{\theta A - 1}{(1-\alpha^{IP})(1-\theta)} + \theta A}. \tag{A.1}$$

Note that the any one of the equality implies the other. We will use both expressions in the later proof. We now show that under assumptions 1 and 2, α^{IP} exists. Rewrite the second equality as

$$\frac{\theta A-1}{(1-\alpha^{IP})(1-\theta)}+\theta A=\frac{\alpha^{IP}C}{\omega\bar{k}}\left[\frac{\theta A-1}{(1-\alpha^{IP})(1-\theta)}+\frac{\gamma^p}{\gamma^c}\right]$$
$$\left(1-\frac{\alpha^{IP}C}{\omega\bar{k}}\right)\frac{\theta A-1}{(1-\alpha^{IP})(1-\theta)}-\left(\frac{\alpha^{IP}C}{\omega\bar{k}}\frac{\gamma^p}{\gamma^c}-\theta A\right)=0.$$

Define

$$h(\alpha)\equiv\left(1-\frac{\alpha C}{\omega\bar{k}}\right)\frac{\theta A-1}{(1-\alpha)(1-\theta)}-\left(\frac{\alpha C}{\omega\bar{k}}\frac{\gamma^p}{\gamma^c}-\theta A\right).$$

We note that

$$\lim_{\alpha\to 1}h(\alpha)=-\left(\frac{C}{\omega\bar{k}}\frac{\gamma^p}{\gamma^c}-\theta A\right)<0,\quad h(0)=\frac{\theta A-1}{1-\theta}+\theta A>0.$$

Since h is continuous, by intermediate value theorem, α^{IP} is well-defined. We also need to ensure that at $\alpha=\alpha^{IP}$, the fraction of firms that use project-sensitive contract, η^{IP} is bounded by 1. The η^{IP} satisfies

$$\kappa\left(\eta^{IP}\gamma^p\right)^{\psi}=\frac{(\theta A-1)\omega\bar{k}}{\gamma^c\left[\frac{\theta A-1}{(1-\alpha^{IP})(1-\theta)}+\frac{\gamma^p}{\gamma^c}\right]}.$$

Notice that κ and ψ do not enter the equation that defines α^{IP}. We assume that κ and ψ are such that η^{IP} is smaller than 1.

We now identify conditions under which firms abandon project-sensitive contract at α slightly smaller than α^{IP}. If this can be done, we have a sufficient condition for secured debt to be countercyclical. First, we need to ensure that the marginal cost is sustainable with only collateral screening, that is,

$$\kappa\left(\gamma^c\right)^{\psi}>\frac{(\theta A-1)\alpha^{IP}C}{\gamma^c\left[\frac{\theta A-1}{(1-\alpha^{IP})(1-\theta)}+\theta A\right]}.$$

This holds if κ is large enough. Next, we compare the profit of collateral-sensitive contract with project-sensitive contract around the left neighbourhood of α^{IP}, using marginal cost that equalizes profits of collateral-sensitive and information-insensitive. The profit of the

collateral-sensitive contract is

$$\mathbb{E}\left[\pi^C\right] = (\theta A - 1)\alpha C - \theta A \frac{(\theta A - 1)\alpha C}{\frac{\theta A - 1}{(1-\alpha)(1-\theta)} + \theta A}.$$

The profit of the project-sensitive contract is

$$\mathbb{E}\left[\pi^P\right] = (\theta A - 1)\omega\bar{k} - \frac{\gamma^p}{\gamma^c}\frac{(\theta A - 1)\alpha C}{\frac{\theta A - 1}{(1-\alpha)(1-\theta)} + \theta A}.$$

Note that the profit is equalized at $\alpha = \alpha^{IP}$. A sufficient condition is

$$\left.\frac{\partial \mathbb{E}\left[\pi^C\right]}{\partial \alpha}\right|_{\alpha=\alpha^{IP}} < \left.\frac{\partial \mathbb{E}\left[\pi^P\right]}{\partial \alpha}\right|_{\alpha=\alpha^{IP}}.$$

Computing the derivatives yields

$$\frac{\theta A - 1}{(1-\alpha^{IP})(1-\theta)} + \theta A < \left(\frac{\gamma^p}{\gamma^c} - \theta A\right)\left[\frac{\frac{\theta A - 1}{(1-\alpha^{IP})(1-\theta)}}{\frac{\theta A - 1}{(1-\alpha^{IP})(1-\theta)} + \theta A}\frac{\alpha^{IP}}{1-\alpha^{IP}} - 1\right]. \tag{A.2}$$

We now provide a sufficient condition under which the above inequality holds. We need the following lemma.

Lemma 3. *Suppose that $\omega\bar{k} > C$ and Assumption 1 and 2 hold. Then, $\lim_{\gamma^c \to 0} \alpha^{IP} = 1$ and for γ^c small enough the indifferent point α^{IP} is decreasing in the screening cost γ^c.*

Proof. We first show that α^{IP} is converging to 1 when $\gamma^c \to 0$. We start with the equation that defines α^{IP}

$$\frac{\omega\bar{k} - \alpha^{IP}C}{\frac{\gamma^p}{\gamma^c} - \theta A} = \frac{\alpha^{IP}C}{\frac{\theta A - 1}{(1-\alpha^{IP})(1-\theta)} + \theta A}.$$

Rearranging yields

$$\alpha^{IP}(1-\alpha^{IP})C(1-\theta) = \frac{\left(\omega\bar{k} - \alpha^{IP}C\right)\left(\theta A - 1 + \theta A(1-\alpha^{IP})(1-\theta)\right)}{\left(\frac{\gamma^p}{\gamma^c} - \theta A\right)}.$$

When $\gamma^c \to 0$, α^{IP} is either 0 or 1. We can rule out $\alpha^{IP} = 0$ as profits of I and C are 0 but profit of P is strictly negative by Assumption 1. Thus,

$$\lim_{\gamma^c \to 0} \alpha^{IP} = 1.$$

We now take derivative of α^{IP} w.r.t. γ^c

$$\begin{aligned}
&\left[(1-\alpha^{IP})-\alpha^{IP}\right]C(1-\theta)\left(\frac{\gamma^p}{\gamma^c}-\theta A\right)\frac{\partial\alpha^{IP}}{\partial\gamma^c}-\alpha^{IP}(1-\alpha^{IP})C(1-\theta)\frac{\gamma^p}{(\gamma^c)^2}\\
&=-C\left(\theta A-1+\theta A(1-\alpha^{IP})(1-\theta)\right)\frac{\partial\alpha^{IP}}{\partial\gamma^c}-\left(\omega\bar{k}-\alpha^{IP}C\right)\theta A(1-\theta)\frac{\partial\alpha^{IP}}{\partial\gamma^c}.
\end{aligned}$$

Rearrange, we obtain

$$\frac{\partial\alpha^{IP}}{\partial\gamma^c}=\frac{\alpha^{IP}(1-\alpha^{IP})C(1-\theta)\frac{\gamma^p}{(\gamma^c)^2}}{(1-2\alpha^{IP})C(1-\theta)\left(\frac{\gamma^p}{\gamma^c}-\theta A\right)+C\left[\theta A-1+\theta A(1-\alpha^{IP})(1-\theta)\right]+(\omega\bar{k}-\alpha^{IP}C)\theta A(1-\theta)}.$$

The numerator is non-negative. When $\gamma^c\to 0$, we have $\alpha^{IP}\to 1$ and the first term in the denominator converges to $-\infty$. Since the remaining terms are bounded, we have

$$\lim_{\gamma^c\to 0}\frac{\partial\alpha^{IP}}{\partial\gamma^c}\leq 0.$$

□

Lemma 4. *Suppose that $\omega\bar{k}>C$ and Assumption 1 and 2 hold. Then, the sufficient condition* (A.2) *is satisfied if γ^c is small enough.*

Proof. We want to show that

$$1<\left(\frac{\gamma^p}{\gamma^c}-\theta A\right)\left\{\frac{\frac{\theta A-1}{1-\theta}\alpha^{IP}}{\left[\frac{\theta A-1}{1-\theta}+\theta A(1-\alpha^{IP})\right]^2}-\frac{1-\alpha^{IP}}{\frac{\theta A-1}{1-\theta}+\theta A(1-\alpha^{IP})}\right\}$$

We first note that the big fraction converges to a constant when $\alpha^{IP}\to 1$,

$$\lim_{\alpha^{IP}\to 1}\frac{\frac{\theta A-1}{1-\theta}\alpha^{IP}}{\left[\frac{\theta A-1}{1-\theta}+\theta A(1-\alpha^{IP})\right]^2}-\frac{1-\alpha^{IP}}{\frac{\theta A-1}{1-\theta}+\theta A(1-\alpha^{IP})}=\frac{1-\theta}{\theta A-1}.$$

From lemma 3, we have $\lim_{\gamma^c\to 0}\alpha^{IP}=1$. Then,

$$\lim_{\gamma^c\to 0}\left(\frac{\gamma^p}{\gamma^c}-\theta A\right)\left\{\frac{\frac{\theta A-1}{1-\theta}\alpha^{IP}}{\left[\frac{\theta A-1}{1-\theta}+\theta A(1-\alpha^{IP})\right]^2}-\frac{1-\alpha^{IP}}{\frac{\theta A-1}{1-\theta}+\theta A(1-\alpha^{IP})}\right\}=\infty.$$

We have completed the proof. □

B The Planner's Problem

Substituting the profits into the objective yields

$$\begin{aligned}\max_{\eta,\nu}\Bigg\{&\eta\left[(\theta A-1)\omega\bar{k}-\gamma^p\varphi(\Gamma)\right]+\nu\left[(\theta A-1)\alpha C-\theta A\gamma^c\varphi(\Gamma)\right]\\&+(1-\eta-\nu)\left[(\theta A-1)\min\left\{\frac{\gamma^c\varphi(\Gamma)}{(1-\alpha)(1-\theta)},\alpha C\right\}\right]\Bigg\},\\\text{s.t.}\quad&\varphi(\Gamma)=\kappa\left(\eta\gamma^p+\nu\gamma^c\right)^{\psi},\quad \eta\geq 0,\quad \nu\geq 0,\quad \eta+\nu\leq 1.\end{aligned}$$

We proceed by guess and verify. Suppose that at the optimal (η^*,ν^*), the IC constraint of household does not bind. In this case, the information-insensitive contract dominates collateral-sensitive contract and we have $\nu^*=0$. The objective function is simplified to

$$\max_{\eta\in[0,1]}\ \eta\left[(\theta A-1)\omega\bar{k}-\gamma^p\kappa\left(\eta\gamma^p\right)^{\psi}\right]+(1-\eta)\left[(\theta A-1)\alpha C\right].$$

The first order condition is

$$(\theta A-1)\omega\bar{k}-\gamma^p\kappa\left(\eta^*\gamma^p\right)^{\psi}-\psi\gamma^p\kappa\left(\eta^*\gamma^p\right)^{\psi}-(\theta A-1)\alpha C=0.$$

Solving for η^* gives

$$\eta^*=\left[\frac{(\theta A-1)(\omega\bar{k}-\alpha C)}{(1+\psi)\kappa(\gamma^p)^{1+\psi}}\right]^{1/\psi}.$$

Recall that the equilibrium η^E is

$$\eta^E=\left[\frac{(\theta A-1)(\omega\bar{k}-\alpha C)}{\kappa(\gamma^p)^{1+\psi}}\right]^{1/\psi}.$$

Note that

$$\eta^*<\eta^E,$$

the equilibrium fraction of project-sensitive contract is too high as firms experience expert cost externalities in the case where the η^* does not trigger IC constraint to be binding. We have to verify that under η^*, the IC constraint is not binding. The φ under η^* is

$$\varphi^*=\frac{(\theta A-1)(\omega\bar{k}-\alpha C)}{(1+\psi)\gamma^p}.$$

The IC constraint is not binding iff

$$\frac{\gamma^c}{\gamma^p}\frac{(\theta A-1)(\omega\bar{k}-\alpha C)}{1+\psi}\geq\alpha(1-\alpha)(1-\theta)C.$$

This holds if α is close to either 0 or 1.

Suppose that the IC constraint is binding at the optimal policy. We first study the case where, in equilibrium, IC constraint is binding and firms are indifferent between information-insensitive and project-sensitive contracts. We now identify conditions where there is excessive project monitoring. We consider a simpler problem where the planner maximizes

$$\begin{aligned}V^{\text{Planner}}&=\max_{\eta}\eta\mathbb{E}\left[\pi^P\right]+(1-\eta)\mathbb{E}\left[\pi^I\right],\\ \text{s.t.}\quad&\varphi(\Gamma)=\kappa\left(\eta\gamma^p\right)^{\psi},\quad\eta\geq0,\quad\eta\leq1.\end{aligned}$$

The derivative of φ w.r.t. η is

$$\frac{\partial\varphi}{\partial\eta}=\frac{\psi\varphi}{\eta}. \tag{B.1}$$

The first order derivative reads

$$\frac{\partial V^{\text{planner}}}{\partial\eta}=\mathbb{E}\left[\pi^P\right]-\mathbb{E}\left[\pi^I\right]+\left(\frac{1-\eta}{\eta}\frac{(\theta A-1)\gamma^c}{(1-\alpha)(1-\theta)}-\gamma^p\right)\psi\varphi.$$

Under the equilibrium $\varphi^E=\frac{(\theta A-1)\omega\bar{k}}{\frac{\theta A-1}{(1-\alpha)(1-\theta)}\gamma^c+\gamma^p}$, profits of both information-insensitive and project-sensitive contracts are equalized. Substituting φ^E into the above expression yields

$$\frac{\partial V^{\text{planner}}}{\partial\eta}=\left(\frac{1-\eta^E}{\eta^E}\frac{(\theta A-1)\gamma^c}{(1-\alpha)(1-\theta)}-\gamma^p\right)\psi\varphi^E.$$

The equilibrium η^E is too high if the first order derivative is negative, that is

$$\frac{1-\eta^E}{\eta^E}\frac{(\theta A-1)\gamma^c}{(1-\alpha)(1-\theta)}-\gamma^p<0. \tag{B.2}$$

Rearranging, we obtain

$$\eta^E>\frac{\frac{\theta A-1}{(1-\alpha)(1-\theta)}\gamma^c}{\frac{\theta A-1}{(1-\alpha)(1-\theta)}\gamma^c+\gamma^p}.$$

Converting the left hand side to φ^E yields

$$\varphi^E > \kappa \left[\frac{\frac{\theta A-1}{(1-\alpha)(1-\theta)}\gamma^c}{\frac{\theta A-1}{(1-\alpha)(1-\theta)}\frac{\gamma^c}{\gamma^p}+1} \right]^{\psi}.$$

Substituting the expression for φ^E results in

$$\frac{(\theta A-1)\omega\bar{k}}{\frac{\theta A-1}{(1-\alpha)(1-\theta)}\gamma^c+\gamma^p} > \kappa \left[\frac{\frac{\theta A-1}{(1-\alpha)(1-\theta)}\gamma^c}{\frac{\theta A-1}{(1-\alpha)(1-\theta)}\frac{\gamma^c}{\gamma^p}+1} \right]^{\psi}.$$

This holds if κ is small. The intuition is as follows. On the one hand, reducing the amount of project-sensitive contracts decreases the total monitoring cost which improves welfare. On the other hand, this lowers the credit obtainable through information-insensitive contracts. When κ is small, the equilibrium η^E is large. From (B.1), the sensitivity of φ to η is low when η^E is large. In this case, the direct improvement of welfare through reduction of information cost dominates and the optimal monitoring is lower than the equilibrium η^E. The other force dominates when κ is large as φ is highly sensitive to to η as only a small fraction of firms utilize project-sensitive contracts. In that case, the optimal policy is to increase the amount of monitoring.

Suppose the IC constraint is binding at optimal policy. We now study the case where, in equilibrium, IC constraint is not binding and firms are indifferent between information-insensitive and project-sensitive contracts. In this case, there is excessive monitoring as setting $\eta^E > \eta = \frac{1}{\gamma^p}\left[\frac{1}{\kappa}\frac{(\theta A-1)\omega\bar{k}}{\frac{\theta A-1}{(1-\alpha)(1-\theta)}\gamma^c+\gamma^p}\right]^{1/\psi}$ that equalizes the profits of information-insensitive and project-sensitive contracts with IC constraint binding improves welfare.

C Distribution

C.1 Stationary Distribution

The beginning-of-evening stationary distribution satisfies

$$\begin{aligned}
\tilde{f}(g,0) &= f(g,0) + f(u,0)\eta(u,0)\omega + f(g,\hat{\alpha})\nu(g,\hat{\alpha})(1-\hat{\alpha}),\\
\tilde{f}(g,\hat{\alpha}) &= f(g,\hat{\alpha})(1-\nu(g,\hat{\alpha})) + f(u,\hat{\alpha})\eta(u,\hat{\alpha})\omega,\\
\tilde{f}(g,1) &= f(g,1) + f(u,1)\eta(u,1)\omega + f(g,\hat{\alpha})\nu(g,\hat{\alpha})\hat{\alpha},\\
\tilde{f}(u,0) &= f(u,0)(1-\eta(u,0)) + f(u,\hat{\alpha})\nu(u,\hat{\alpha})(1-\hat{\alpha}),\\
\tilde{f}(u,\hat{\alpha}) &= f(u,\hat{\alpha})(1-\eta(u,\hat{\alpha})-\nu(u,\hat{\alpha})),\\
\tilde{f}(u,1) &= f(u,1)(1-\eta(u,1)) + f(u,\hat{\alpha})\nu(u,\hat{\alpha})\hat{\alpha},\\
\tilde{f}(b,0) &= f(b,0) + f(u,0)\eta(u,0)(1-\omega) + f(b,\hat{\alpha})\nu(b,\hat{\alpha})(1-\hat{\alpha}),\\
\tilde{f}(b,\hat{\alpha}) &= f(b,\hat{\alpha})(1-\nu(b,\hat{\alpha})) + f(u,\hat{\alpha})\eta(u,\hat{\alpha})(1-\omega),\\
\tilde{f}(b,1) &= f(b,1) + f(u,1)\eta(u,1)(1-\omega) + f(b,\hat{\alpha})\nu(b,\hat{\alpha})\hat{\alpha}.
\end{aligned}$$

The end-of-evening stationary distribution satisfies

$$\begin{aligned}
\bar{f}(g,0) &= \theta\tilde{f}(g,0),\\
\bar{f}(g,\hat{\alpha}) &= \theta\tilde{f}(g,\hat{\alpha}),\\
\bar{f}(g,1) &= \theta\tilde{f}(g,1),\\
\bar{f}(u,0) &= \tilde{f}(u,0) + [1-\theta]\,\tilde{f}(g,0) + [1-\theta]\,\tilde{f}(b,0),\\
\bar{f}(u,\hat{\alpha}) &= \tilde{f}(u,\hat{\alpha}) + [1-\theta]\,\tilde{f}(g,\hat{\alpha}) + [1-\theta]\,\tilde{f}(b,\hat{\alpha}),\\
\bar{f}(u,1) &= \tilde{f}(u,1) + [1-\theta]\,\tilde{f}(g,1) + [1-\theta]\,\tilde{f}(b,1),\\
\bar{f}(b,0) &= \theta\tilde{f}(b,0),\\
\bar{f}(b,\hat{\alpha}) &= \theta\tilde{f}(b,\hat{\alpha}),\\
\bar{f}(b,1) &= \theta\tilde{f}(b,1).
\end{aligned}$$

Finally, the morning stationary distribution satisfies

$$\begin{pmatrix} f(g,0) \\ f(g,\hat{\alpha}) \\ f(g,1) \\ f(u,0) \\ f(u,\hat{\alpha}) \\ f(u,1) \\ f(b,0) \\ f(b,\hat{\alpha}) \\ f(b,1) \end{pmatrix} = (B^{\rho})' \otimes (B^{\varrho})' \begin{pmatrix} \bar{f}(g,0) \\ \bar{f}(g,\hat{\alpha}) \\ \bar{f}(g,1) \\ \bar{f}(u,0) \\ \bar{f}(u,\hat{\alpha}) \\ \bar{f}(u,1) \\ \bar{f}(b,0) \\ \bar{f}(b,\hat{\alpha}) \\ \bar{f}(b,1) \end{pmatrix}.$$

C.2 Distribution Dynamics with Aggregate Quality Shock

Denote by $f_t, \tilde{f}_t$ and $\bar{f}_t$ the distributions of firms in the morning, beginning-of-evening and end-of-evening at time t, respectively. Let $\eta_t(s,\alpha)$ and $\nu_t(s,\alpha)$ be the probability that a firm with state (s,α) utilizes a project-sensitive and collateral-sensitive contract at time t, respectively. Note that the land quality can be of 5 types, $\alpha \in \{0, \zeta\hat{\alpha}, \hat{\alpha}, \zeta, 1\}$. The

beginning-of-evening distribution satisfies

$$\begin{aligned}
\tilde{f}_t(g,0) &= f_t(g,0) + f_t(u,0)\eta_t(u,0)\omega + f_t(g,\hat{\alpha})\nu_t(g,\hat{\alpha})(1-\hat{\alpha}) \\
&\quad + f_t(g,\zeta\hat{\alpha})\nu_t(g,\zeta\hat{\alpha})(1-\zeta\hat{\alpha}) + f_t(g,\zeta)\nu_t(g,\zeta)(1-\zeta), \\
\tilde{f}_t(g,\zeta\hat{\alpha}) &= f_t(g,\zeta\hat{\alpha})(1-\nu_t(g,\zeta\hat{\alpha})) + f_t(u,\zeta\hat{\alpha})\eta_t(u,\zeta\hat{\alpha})\omega, \\
\tilde{f}_t(g,\hat{\alpha}) &= f_t(g,\hat{\alpha})(1-\nu_t(g,\hat{\alpha})) + f_t(u,\hat{\alpha})\eta_t(u,\hat{\alpha})\omega, \\
\tilde{f}_t(g,\zeta) &= f_t(g,\zeta)(1-\nu_t(g,\zeta)) + f_t(u,\zeta)\eta_t(u,\zeta)\omega, \\
\tilde{f}_t(g,1) &= f_t(g,1) + f_t(u,1)\eta_t(u,1)\omega + f_t(g,\zeta\hat{\alpha})\nu_t(g,\zeta\hat{\alpha})\zeta\hat{\alpha} \\
&\quad + f_t(g,\hat{\alpha})\nu_t(g,\hat{\alpha})\hat{\alpha} + f_t(g,\zeta)\nu_t(g,\zeta)\zeta, \\
\tilde{f}_t(u,0) &= f_t(u,0)(1-\eta_t(u,0)) + f_t(u,\zeta\hat{\alpha})\nu(u,\zeta\hat{\alpha})(1-\zeta\hat{\alpha}) \\
&\quad + f_t(u,\hat{\alpha})\nu(u,\hat{\alpha})(1-\hat{\alpha}) + f_t(u,\zeta)\nu(u,\zeta)(1-\zeta), \\
\tilde{f}_t(u,\zeta\hat{\alpha}) &= f_t(u,\zeta\hat{\alpha})(1-\eta_t(u,\zeta\hat{\alpha}) - \nu_t(u,\zeta\hat{\alpha})), \\
\tilde{f}_t(u,\hat{\alpha}) &= f_t(u,\hat{\alpha})(1-\eta_t(u,\hat{\alpha}) - \nu_t(u,\hat{\alpha}), \\
\tilde{f}_t(u,\zeta) &= f_t(u,\zeta)(1-\eta_t(u,\zeta) - \nu_t(u,\zeta)), \\
\tilde{f}_t(u,1) &= f_t(u,1)(1-\eta_t(u,1)) + f_t(u,\zeta\hat{\alpha})\nu_t(u,\zeta\hat{\alpha})\zeta\hat{\alpha} \\
&\quad + f_t(u,\hat{\alpha})\nu_t(u,\hat{\alpha})\hat{\alpha} + f_t(u,\zeta)\nu_t(u,\zeta)\zeta, \\
\tilde{f}_t(b,0) &= f_t(b,0) + f_t(u,0)\eta_t(u,0)(1-\omega) + f_t(b,\zeta\hat{\alpha})\nu_t(b,\zeta\hat{\alpha})(1-\zeta\hat{\alpha}) \\
&\quad f_t(b,\hat{\alpha})\nu_t(b,\hat{\alpha})(1-\hat{\alpha}) + f_t(b,\zeta)\nu_t(b,\zeta)(1-\zeta), \\
\tilde{f}_t(b,\zeta\hat{\alpha}) &= f_t(b,\zeta\hat{\alpha})(1-\nu_t(b,\zeta\hat{\alpha})) + f_t(u,\zeta\hat{\alpha})\eta_t(u,\zeta\hat{\alpha})(1-\omega), \\
\tilde{f}_t(b,\hat{\alpha}) &= f_t(b,\hat{\alpha})(1-\nu_t(b,\hat{\alpha}) + f_t(u,\hat{\alpha})\eta_t(u,\hat{\alpha})(1-\omega), \\
\tilde{f}_t(b,\zeta) &= f_t(b,\zeta)(1-\nu_t(b,\zeta) + f_t(u,\zeta)\eta_t(u,\zeta)(1-\omega), \\
\tilde{f}_t(b,1) &= f_t(b,1) + f_t(u,1)\eta(u,1)(1-\omega) + f_t(b,\zeta\hat{\alpha})\nu_t(b,\zeta\hat{\alpha})\zeta\hat{\alpha} \\
&\quad f_t(b,\hat{\alpha})\nu_t(b,\hat{\alpha})\hat{\alpha} + f_t(b,\zeta)\nu_t(b,\zeta)\zeta.
\end{aligned}$$

Let $(\tilde{s},\tilde{\alpha}) \mapsto e(\tilde{s},\tilde{\alpha})$ be the fraction of surviving $(\tilde{s},\tilde{\alpha})$-firms that exit. The end-of-evening stationary distribution satisfies

$$\begin{aligned}
\bar{f}(g,\alpha) &= \theta\tilde{f}(g,\alpha), \\
\bar{f}(b,\alpha) &= \theta\tilde{f}(b,\alpha), \\
\bar{f}(u,\alpha) &= \tilde{f}(u,\alpha) + [1-\theta]\tilde{f}(g,\alpha) + [1-\theta]\tilde{f}(b,\alpha).
\end{aligned}$$

Finally, the morning stationary distribution satisfies

$$f_{t+1} = (B^{\rho})' \otimes (B^{\varrho})' \bar{f}_t,$$

where

$$f_t = \begin{pmatrix} f_t(g,0) \\ f_t(g,\zeta\hat{\alpha}) \\ f_t(g,\hat{\alpha}) \\ f_t(g,\zeta) \\ f_t(g,1) \\ f_t(u,0) \\ f_t(u,\zeta\hat{\alpha}) \\ f_t(u,\hat{\alpha}) \\ f_t(u,\zeta) \\ f_t(u,1) \\ f_t(b,0) \\ f_t(b,\zeta\hat{\alpha}) \\ f_t(b,\hat{\alpha}) \\ f_t(b,\zeta) \\ f_t(b,1) \end{pmatrix}, \quad \bar{f}_t = \begin{pmatrix} \bar{f}_t(g,0) \\ \bar{f}_t(g,\zeta\hat{\alpha}) \\ \bar{f}_t(g,\hat{\alpha}) \\ \bar{f}_t(g,\zeta) \\ \bar{f}_t(g,1) \\ \bar{f}_t(u,0) \\ \bar{f}_t(u,\zeta\hat{\alpha}) \\ \bar{f}_t(u,\hat{\alpha}) \\ \bar{f}_t(u,\zeta) \\ \bar{f}_t(u,1) \\ \bar{f}_t(b,0) \\ \bar{f}_t(b,\zeta\hat{\alpha}) \\ \bar{f}_t(b,\hat{\alpha}) \\ \bar{f}_t(b,\zeta) \\ \bar{f}_t(b,1) \end{pmatrix}.$$

D Algorithms

D.1 Algorithm for Steady State

1. Guess $f^{(0)}$. Set $m = 0$.
2. Guess $U^{(0)}, \nu^{(0)}$ and $\eta^{(0)}$. Set $n = 0$
3. Given $U^{(n)}$, solve for $J^{(n)}$.
4. Given $f^{(m)}, \nu^{(n)}$ and $\eta^{(n)}$, solve for $\tilde{f}^{(n)}$.
5. Given $J^{(n)}, f^{(m)}, \nu^{(n)}$ and $\eta^{(n)}$, solve for $U^{c,(n)}, q^{(n)}$ and $e^{(n)}$.
6. Solve for $W^{q(n)}$ and $W^{s(n)}$.
7. Solve for $V^{I(n)}, V^{C(n)}, V^{P(n)}, \eta^{(n+1)}$ and $\nu^{(n+1)}$.

(a) We first note that types $(g,0),(g,1),(b,0)$ and $(b,1)$ cannot affect the marginal cost of expert skill.

(b) The remaining types are $(g,\hat{\alpha}),(b,\hat{\alpha}),(u,\hat{\alpha}),(u,0)$ and $(u,1)$.

(c) Let $\varphi^{XX'}(s,\alpha)$ be the marginal cost that solves $V^X(s,\alpha)=V^{X'}(s,\alpha)$, where $X,X'\in\{I,C,P\}$ and $X\neq X'$. We only care about this 7 values

$$\varphi^{CP}(g,\hat{\alpha}),\varphi^{IC}(b,\hat{\alpha}),\varphi^{IP}(u,1),\varphi^{IC}(u,\hat{\alpha}),\varphi^{IP}(u,\hat{\alpha}),\varphi^{CP}(u,\hat{\alpha}),\varphi^{IP}(u,0).$$

Generally, if $\varphi>\varphi^{XX'}$, a firm of that type prefers less informationally costly contract. We now give an explicit expression for the above 7 values

$$\begin{aligned}
\varphi^{CP}(g,\hat{\alpha}) &= \left\{(\theta A-1)(\hat{\alpha}q(1)-\bar{k})+W^C(g,\hat{\alpha})-W^P(g,\hat{\alpha})\right\}/(\theta A\gamma^c),\\
\varphi^{IC}(b,\hat{\alpha}) &= \left\{(\theta A-1)\hat{\alpha}q(1)+W^C(b,\hat{\alpha})-W^I(b,\hat{\alpha})\right\}\\
&\quad /\left\{\left(\frac{\theta A-1}{\hat{\alpha}(1-\theta)(q(1)/q(\hat{\alpha})-1)}+\theta A\right)\gamma^c\right\},\\
\varphi^{IP}(u,1) &= \left\{(\theta A-1)(\omega\bar{k}-q(1))+W^P(u,1)-W^I(u,1)\right\}/\gamma^p.
\end{aligned}$$

Define

$$\hat{\varphi}\equiv\frac{\hat{\alpha}(1-\theta)(q(1)/q(\hat{\alpha})-1)q(\hat{\alpha})}{\gamma^c}.$$

Let

$$\begin{aligned}
\varphi^{IC,b}(u,\hat{\alpha}) &= \left\{(\theta A-1)\hat{\alpha}q(1)+W^C(u,\hat{\alpha})-W^I(u,\hat{\alpha})\right\}\\
&\quad /\left\{\left(\frac{\theta A-1}{\hat{\alpha}(1-\theta)(q(1)/q(\hat{\alpha})-1)}+\theta A\right)\gamma^c\right\},\\
\varphi^{IC,nb}(u,\hat{\alpha}) &= \frac{(\theta A-1)(\hat{\alpha}q(1)-q(\hat{\alpha}))+W^C(u,\hat{\alpha})-W^I(u,\hat{\alpha})}{\theta A\gamma^c}.
\end{aligned}$$

$$\begin{aligned}
\varphi^{IP,nb}(u,\hat{\alpha}) &= \left\{(\theta A-1)(\omega\bar{k}-q(\hat{\alpha}))+W^P(u,\hat{\alpha})-W^I(u,\hat{\alpha})\right\}/\gamma^p,\\
\varphi^{IP,b}(u,\hat{\alpha}) &= \left\{(\theta A-1)\omega\bar{k}+W^P(u,\hat{\alpha})-W^I(u,\hat{\alpha})\right\}\\
&\quad /\left\{\left[\frac{(\theta A-1)\gamma^c}{\hat{\alpha}(1-\theta)(q(1)/q(\hat{\alpha})-1)}+\gamma^p\right]\right\}.
\end{aligned}$$

Then

$$\varphi^{IP}(u,\hat{\alpha})=\begin{cases}\varphi^{IP,b}(u,\hat{\alpha}), & \varphi^{IP,b}<\hat{\varphi},\\ \varphi^{IP,nb}(u,\hat{\alpha}), & \varphi^{IP,b}\geq\hat{\varphi}.\end{cases}$$

$$\varphi^{IC}(u,\hat{\alpha})=\begin{cases}\varphi^{IC,b}(u,\hat{\alpha}), & \varphi^{IC,b}<\hat{\varphi},\\ \varphi^{IC,nb}(u,\hat{\alpha}), & \varphi^{IC,b}\geq\hat{\varphi}.\end{cases}$$

Finally,

$$\begin{aligned}
\varphi^{CP}(u,\hat{\alpha}) &= \left\{(\theta A-1)(\omega\bar{k}-\hat{\alpha}q(1))+W^P(u,\hat{\alpha})-W^C(u,\hat{\alpha})\right\}/(\gamma^p-\theta A\gamma^c),\\
\varphi^{IP}(u,0) &= \frac{(\theta A-1)\omega\bar{k}+W^P(u,0)-W^I(u,0)}{\gamma^p}.
\end{aligned}$$

(d) We first understand the relationship of $\varphi^{IC}(u,\hat{\alpha})$, $\varphi^{IP}(u,\hat{\alpha})$ and $\varphi^{CP}(u,\hat{\alpha})$. There are only 2 possible arrangements

$$\varphi^{CP}(u,\hat{\alpha})\geq\varphi^{IP}(u,\hat{\alpha})\geq\varphi^{IC}(u,\hat{\alpha}),$$

or

$$\varphi^{IC}(u,\hat{\alpha})\geq\varphi^{IP}(u,\hat{\alpha})\geq\varphi^{CP}(u,\hat{\alpha}).$$

In the first arrangement, only the value $\varphi^{IP}(u,\hat{\alpha})$ matters. If the equilibrium marginal cost φ is above $\varphi^{IP}(u,\hat{\alpha})$, then $(u,\hat{\alpha})$-firm chooses information-insensitive contract. Otherwise, they choose project-sensitive contract.

In the second arrangement, there are 2 cut-offs that matter, $\varphi^{IC}(u,\hat{\alpha})$ and $\varphi^{CP}(u,\hat{\alpha})$. If $\varphi>\varphi^{IC}(u,\hat{\alpha})$, the optimal contract is information-insensitive. If $\varphi^{IC}(u,\hat{\alpha})>\varphi>\varphi^{CP}(u,\hat{\alpha})$, the optimal contract is contract-sensitive. Otherwise, the optimal contract is project-sensitive.

(e) We can rank these values from the highest to the lowest. Denote by $\varphi^{(\ell)}$ the ranking of $\varphi^{XX'}$ such that $\varphi^{(1)} > \varphi^{(2)} > \dots$. We separate into two cases.

Arrangement 1 We sort these 5 values

$$\varphi^{CP}(g,\hat{\alpha}), \varphi^{IC}(b,\hat{\alpha}), \varphi^{IP}(u,1), \varphi^{IP}(u,\hat{\alpha}), \varphi^{IP}(u,0).$$

Starting with $\varphi^{(1)}$. Suppose all the firms of this type chooses information costly contract. We check if the marginal cost under this assumption is greater than $\varphi^{(1)}$. If it is, then the equilibrium marginal cost φ is equal to $\varphi^{(1)}$ and we solve the corresponding η and ν. If it is not, then we let the corresponding η or ν to be 1 and proceed to $\varphi^{(2)}$.

Again, we suppose all the firms of this type chooses information costly contract. We check if the marginal cost under this assumption, including the demand from the type with $\varphi^{(1)}$, is greater than $\varphi^{(2)}$. If it is, the equilibrium φ is equal to $\varphi^{(2)}$ and we can solve the corresponding η and ν. Otherwise, let the corresponding η or ν to be 1 and proceed to $\varphi^{(3)}$.

Arrangement 2 We first make the assumption that $(u,\hat{\alpha})$-firm chooses either information-insensitive contract or collateral-sensitive contract in the equilibrium. We first sort these 5 values

$$\varphi^{CP}(g,\hat{\alpha}), \varphi^{IC}(b,\hat{\alpha}), \varphi^{IP}(u,1), \varphi^{IC}(u,\hat{\alpha}), \varphi^{IP}(u,0).$$

We then run the previous algorithm. Let φ be the value given by the above algorithm. We now check if our assumption is correct. If $\varphi > \varphi^{CP}(u,\hat{\alpha})$, then we are done. Otherwise, we sort these 5 values

$$\varphi^{CP}(g,\hat{\alpha}), \varphi^{IC}(b,\hat{\alpha}), \varphi^{IP}(u,1), \varphi^{CP}(u,\hat{\alpha}), \varphi^{IP}(u,0)$$

and run the algorithm above.

8. Compute $U^{(n+1)}$.
9. Check convergence. If not converge, set $n = n+1$ and repeat from step 3.
10. Compute $f^{(m+1)}$. Check convergence. If not converge, set $m = m+1$ and repeat from step 2.

D.2 Algorithm for Transition Dynamics

The computation of distribution transition and value function is standard. We first guess a distribution sequence and solve value function backward given the steady state value. We then use the optimal decision of firms to solve the distribution forward. We iterate until both the value functions and distribution sequence converge.

We now focus on the computation of equilibrium expert's skill marginal cost. We need to compute 17 thresholds. They are

$$\begin{gathered}\varphi^{CP}(g,\alpha),\ \forall\alpha\in\{\zeta\hat{\alpha},\hat{\alpha},\zeta\},\\ \varphi^{IC}(b,\alpha),\ \forall\alpha\in\{\zeta\hat{\alpha},\hat{\alpha},\zeta\},\\ \varphi^{IP}(u,0),\varphi^{IP}(u,1),\\ \varphi^{IC}(u,\alpha),\varphi^{IP}(u,\alpha),\varphi^{CP}(u,\alpha),\ \forall\alpha\in\{\zeta\hat{\alpha},\hat{\alpha},\zeta\}.\end{gathered}$$

We compute using the same equations above. Then we identify all types that are of arrangement 2. We first proceed with the assumption that they choose between I and C. After solving for φ under this assumption using the algorithm outlined above, we check if the assumption is satisfied. If it is violated, we first guess that the type of firm with the higher φ^{CP} chooses between P and C. If the resulting $\varphi \geq \varphi^{CP}$ for all relevant types, we are done. Else, we include the next highest φ^{CP}. We proceed until either all types in the group are included or $\varphi \geq \varphi^{CP}$.