# Opaque Intermediation and Credit Cycles*

Joseph Abadi†
Princeton University

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**Abstract**

I propose a theory of credit cycles driven by the private production of opaque, liquid assets (e.g., ABS or CLOs). Opacity enhances assets' liquidity, permitting greater issuance volumes, but prevents investors from determining whether the underlying projects are of low quality. Strong macroeconomic fundamentals give rise to credit booms characterized by opaque asset origination and pervasive credit misallocation. As bad projects build up in the economy, investors begin to question the value of opaque assets and eventually refuse to finance them altogether, precipitating a collapse in liquidity and investment. The bust has a cleansing effect: opaque origination is abandoned, and investors no longer finance projects whose quality they cannot evaluate. I show that a policymaker would limit opaque intermediation during booms in order to moderate the subsequent bust by implementing transparency regulations and macroprudential policies.

**Keywords:** Adverse selection, credit cycles, financial intermediation, information design, liquidity, macroprudential policy

**JEL Codes:** E32, E44, G01, G21, G23

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†Email: jaabadi@princeton.edu

# 1 Introduction

Credit booms are often fueled by the creation of liquid securities backed by assets that investors know little about. However, these booms sometimes run out of steam and end in busts: investors begin to question the quality of the assets underlying the new securities, liquidity dries up, and investment collapses.[1] The run-up to the Great Recession provides a striking example: intermediaries financed a surge in mortgage lending by issuing an array of complex securities, such as ABS and CDOs. As perceptions of the underlying mortgages' quality soured, markets for those securities froze, causing a crash in new lending and a recession. Similarly, recent years have witnessed the reemergence of opaque assets, such as CLOs, as well as a loosening of lending standards, but the onset of the Covid-19 crisis disrupted the functioning of markets for even the highest-rated securities.[2] While the literature has stressed the role of opacity in enhancing assets' liquidity,[3] less attention has been directed towards the macroeconomic side effects of the private production of opaque, liquid assets. Under what circumstances will opaque asset production emerge, and how does it shape the dynamics of credit and financial market liquidity? Should policy seek to increase the transparency of asset origination and curb private liquidity provision, or should a public provider of liquidity instead aim to supplement it?

To address these questions, I develop a macroeconomic model of credit booms and busts driven by the private production of opaque assets. I begin in a static setting to highlight a novel tradeoff between *asset liquidity* and *credit misallocation* governing the transparency of claims produced by the financial system and demonstrate that strong macroeconomic fundamentals incentivize the production of opaque assets. I then embed the key mechanism of the static setting into a dynamic model in order to understand its positive implications for credit cycles as well as to derive normative prescriptions for private and public liquidity provision. I show that the misallocation caused by opaque asset production during transitory credit booms leads to slumps featuring depressed credit and persistent illiquidity, and I characterize conditions under which such cycles are fully endogenous (in the sense that they arise even in the absence of exogenous shocks). I further prove that the production of opaque, liquid assets is always excessive in equilibrium and outline realistic policy tools that can be used to implement the social optimum.

[1] Beyond the examples of the Great Recession and the Covid-19 crisis, such episodes go back to at least the boom in farm-adjacent mortgages of the 1850s in the United States (Riddiough and Thompson, 2012). Other examples include the rise of commercial real estate loan securitzation in the period preceding the Great Depression (White, 2009) and the boom-bust cycles of loan syndication in emerging markets in the 1980s and 1990s (Kaminsky, 2008).

[2] Foley-Fisher, Gorton, and Verani (2020) argue that safe CLO tranches command a liquidity premium due to their opacity and document the increase in spreads even for AAA tranches during the Covid crisis.

[3] Dang, Gorton, and Hölmstrom (2015), among others, highlight this role of "symmetric ignorance."

In the static model, intermediaries lend to firms of heterogeneous quality (good or bad) and sell assets backed by firms' projects to investors with varying ability to evaluate their quality (skilled or unskilled). To capture the idea that asset originators differ in the quantity of information they disclose about the underlying projects, I assume there are two types of intermediaries that may enter to channel funds from investors to firms. *Transparent* intermediaries (e.g., IPO underwriters) disclose key details about firms' projects to investors, whereas *opaque* intermediaries (e.g., shadow banks) keep those details secret.[4] Expertise is scarce in this economy– only skilled investors are sophisticated enough to interpret any information revealed by transparent intermediaries, but they sometimes lack the funds to finance good firms' projects.

The central mechanism that gives rise to a role for opaque intermediation is that information permits two opposing types of selection. On the one hand, information allows for *virtuous selection*: a skilled investor who knows more about a firm's quality is able to direct investment towards good firms' projects and avoid misallocation towards bad ones. On the other hand, information creates *adverse selection*: to the extent that investors are not equally able to interpret signals of an asset's quality, information will put unskilled investors at a disadvantage when making investments.

The tension between virtuous and adverse selection yields a tradeoff between financial assets' liquidity and the efficient allocation of credit. Transparent projects are illiquid because unskilled investors will compete with skilled investors over claims on good projects, but they will be alone in demanding claims on bad ones. Claims against a transparent project must then be sold at a discount to attract investment from unskilled investors. If the illiquidity discount is large enough, it may prevent the intermediary from being able to profitably finance the project altogether. The cost of adverse selection is then *under*-investment in good projects. Opaque intermediation renders investors' information symmetric, which resolves the adverse selection problem and creates liquid assets that can be freely issued to any investor. Opacity comes at a cost, however: it deprives skilled investors of the benefits of virtuous selection. Thus, opaque projects are financed regardless of their quality, causing misallocation, i.e., *over*-investment in bad projects. The key result of the static model is therefore that opaque liquidity creation is attractive when investment in firms' projects is profitable on average, whereas asset origination tends to be transparent when the expected profitability of investment is low.

After establishing this result, I proceed to the dynamic model. The key state variables that govern the model's dynamics are the exogenous productivity of firms' projects and the

[4] Arora et al. (2009) argue that, in fact, asset-backed securities are typically so complex that it is computationally infeasible to compute their fundamental value.

average quality of the pool of firms in the economy, which evolves endogenously. In particular, I assume that credit is essential to firms' survival: the average quality of the pool deteriorates when bad firms are financed and improves when they are discovered and fail to raise additional funds.

I show that the economy can exhibit both amplification of fundamental shocks and fully endogenous credit cycles. The economy transits through two regimes in the dynamic equilibrium: an "opaque boom" regime and a "transparent bust" regime. Opaque booms occur when macroeconomic fundamentals are strong; that is, when either productivity or the average quality of firms in the economy is high. It is costly to miss out on good investment opportunities, so opaque intermediaries enter to issue liquid assets against firms' projects. Financial markets are highly liquid in the boom regime. Good firms' projects are always financed, and output expands. Misallocation is widespread, though, and bad firms are able to attract financing as well. This misallocation causes a gradual build-up of bad firms in the economy. Nevertheless, as long as it remains profitable for unskilled investors to finance opaque projects, the boom continues.

The economy enters the transparent bust regime and experiences a sharp reversal when the fundamental profitability of firms' projects falls below a critical threshold, which can be triggered by an exogenous reversion in productivity or the endogenous deterioration of firms' quality during the boom. In particular, this occurs when the benefits of virtuous selection exceed the costs of adverse selection. Investors become unwilling to finance new investment in opaque projects, and private liquidity creation is abruptly abandoned. Financial markets become fragmented, and credit contracts: assets are originated by transparent intermediaries, which are able to finance projects only when skilled capital is available. The disruption in financial markets pushes the economy into a recession, which has a cleansing effect due to the greater prevalence of transparency. Bad firms are identified and fail to raise funds, forcing them to exit. As misallocation is undone, the economy can eventually re-enter the opaque boom regime, allowing the credit cycle to restart. Thus, financial cycles in this economy feature recurring episodes of high liquidity, loose lending standards, and opaque liquidity creation followed by periods of low liquidity, tight lending standards, and a return to more traditional asset origination.

The intrinsic link between information, liquidity, and misallocation in the model has distinctive policy implications. I study the problem of a social planner who possesses the same information as unskilled investors. The environment features a *dynamic* information externality: investors do not internalize that by purchasing opaque assets, they continue bad firms' projects and allow them to remain in the pool to borrow from others in the future. By contrast, the benefits of liquidity creation are fully internalized by intermediaries. The constrained optimal degree of liquidity provision is therefore lower than what competitive markets deliver. I show that private liquidity provision can be reined in using three equivalent tools: transparency regulation, which alters the information structure available to investors by restricting the quantity of opaque projects in the economy, macroprudential policy (taxes on opaque asset origination), which reduce the incentives to produce opaque assets, or monetary policy, which increases the rate of return investors can earn on safe assets and reduces demand for risky ones. Nevertheless, it is not always optimal to fully eliminate opacity: despite the fact that opacity allows bad projects to be financed, it can be socially beneficial because it also permits greater investment in good projects.

**Related literature**. The central mechanism in my paper highlights that intermediaries may create opacity to mitigate adverse selection and enhance assets' liquidity. Similarly to my paper, Dang, Gorton, Hölmstrom, and Ordoñez (2017) argue that opacity is an essential function of banks. In their model, though, the key tradeoff is between a lower quantity of stable liquidity (provided by banks) and a greater quantity of risky liquidity (provided by capital markets). Hence, in that model, banking eliminates risk rather than adverse selection. Closer to my tradeoff, Pagano and Volpin (2012) show that opaque securitization can alleviate adverse selection in the primary market for debt securities, but they argue that the other side of the tradeoff is decreased liquidity in the secondary market if experts choose to acquire information on their own later on. My paper is the first to incorporate a role for opaque liquidity creation in a macroeconomic model. I obtain a tradeoff that is new to the literature: when liquidity creation requires opacity, it necessarily goes hand-in-hand with the misallocation of credit.

My paper also relates to others that model credit booms and busts as changes in the prevailing informational regime in the economy. Gorton and Ordoñez (2014) show that small fundamental shocks can cause abrupt shifts to a regime in which lenders inspect collateral, triggering adverse selection between borrowers and lenders and leading to a financial crisis. In a related model, Gorton and Ordoñez (2020) demonstrate that their mechanism can generate fully endogenous credit cycles. In those models, however, information has no social value– all investment projects have positive present value, while information concerns the quality of an exogenous stock of collateral that serves only to facilitate borrowing. As a result, there is a sense in which it would be optimal in those models to ban information acquisition (i.e., impose total opacity). By contrast, in my model, information concerns real investment opportunities rather than an exogenous supply of collateral. Thus, opacity generates misallocation, which is a force absent from theirs. This distinction has welfare consequences: transparency has a socially beneficial cleansing effect in my model, thereby allowing me to analyze the tradeoff entailed by private liquidity creation. Farboodi and Kondor (2020) study a model of endogenous credit cycles in which investors choose whether to be bold or cautious when evaluating entrepreneurs (rather than information being concealed by intermediaries for liquidity creation motives). While the externality in their model is similar to mine in the sense that investors collect too little information about borrowers, their environment is quite different: their focus is investors' information acquisition, whereas mine is the production of liquid assets as a driver of cycles. There are other theories of information acquisition over the credit cycle that are relevant to my work. Dell'Ariccia and Marquez (2009) provide an early model in which lax screening is optimal during economic booms but sub-optimal in busts. Asriyan, Laeven, and Valencia (2019) build a model of the amplification of busts in which information deteriorates during booms as financial collateral substitutes for costly screening.

There is a literature on securitization that also relates to my paper. Vanasco (2017) builds a model in which screening by an intermediary reduces the liquidity of claims it sells in secondary markets, providing an alternative channel through which information acquisition and more efficient credit allocation affect an asset's liquidity. Chemla and Hennessy (2014) provide a role for opacity in the creation of securities when investors are risk-averse: opacity prevents uninformed investors from facing adverse selection in asset markets, allowing them to more efficiently insure against shocks

Finally, in macroeconomics, my paper builds off of a literature on information asymmetries and the cyclicality of liquidity. Eisfeldt (2004) shows how liquidity can respond procyclically to productivity shocks and Kurlat (2013) examines the transmission of exogenous shocks to macroeconomic aggregates in a model with asymmetric information, showing that information frictions tend to amplify shocks to the economy. Bigio (2015) calibrates a related model and shows that asymmetric information can provide a reasonable quantitative explanation of the Great Recession. While my model predicts that liquidity will be procyclical, as in these papers, the mechanism is different. In this literature, the information structure is exogenous and information does not play an allocative role. In my paper, the key driver of procyclical liquidity is the endogenously opaque nature of assets created by the financial sector during booms. In a sense, then, my model endogenizes the emergence of information asymmetries. Caramp (2017) also models an economy in which the demand for liquidity during booms leads to misallocation, but his focus is on moral hazard in securitization rather than the intrinsic tradeoff between virtuous and adverse selection that features in my model.

**Outline**: The paper is structured as follows. Section 2 presents the static model. Section 3 characterizes the static equilibrium and outlines the conditions under which opaque intermediation emerges. Section 4 introduces dynamics. Section 5 studies optimal policies in the dynamic model. Section 6 concludes. All proofs can be found in the Appendix.

## 2 Static Model: Environment

I begin with a static model to highlight the role of opacity and understand the circumstances under which intermediaries finance investment through the issuance of opaque, liquid claims. I will derive implications for liquidity and misallocation and precisely characterize the tradeoff between virtuous selection and adverse selection faced by investors when choosing to finance transparent or opaque projects. Then, I will show that opacity will tend to dominate transparency when the average firm's project is profitable, which is the key result that will drive the dynamic model.

There are three periods, $\tau = 0, 1, 2$ (morning, afternoon, and evening). There is a single good. The economy consists of a continuum of "islands" $n \in [0, 1]$, as in Lucas (1973). On each island, there is a continuum of investors and firms. Investors are indexed by $i$, and firms are indexed by $j$. The islands inhabited by an investor or firm are denoted by $n(i)$ and $n(j)$, respectively. An island should be thought of, in this model, as comprising a collection of investors that have the expertise to evaluate a collection of firms. All agents are risk-neutral and do not discount. There is also a unit mass of intermediaries on each island that match randomly with firms. Intermediaries on an island are owned by investors on the same island and therefore maximize their profits with respect to the discount factor used by those investors.

**Firms**: Each firm runs a *project* in which it can invest $x$ units of goods in the afternoon in order to produce $\varphi(x) = \min\{x, 1\}z$ goods if the project succeeds.[5] I will refer to parameter $z$ as the productivity of firms' projects. In the dynamic model, I will allow $z$ to vary exogenously over time.

Each firm may be good ($\Theta_j = G$) or bad ($\Theta_j = B$). On each island, a fraction $1 - \delta$ of firms are good, and the remaining fraction $\delta$ are bad. The probability $\theta_j$ that a firm's project succeeds is type-dependent:

$$\theta_j = \begin{cases} \theta_G & \Theta_j = G \\ \theta_B & \Theta_j = B \end{cases} \tag{1}$$

I assume that bad projects have negative net present value, whereas good projects have positive present value: $\theta_B z < 1 < \theta_G z$. I will refer to $\theta_j$ as the firm's quality or the quality of its project interchangeably. The ex ante probability that a project succeeds will be denoted

$$\overline{\theta} = (1 - \delta)\theta_G + \delta\theta_B. \tag{2}$$

**Intermediaries**: The role of intermediaries will be to issue securities to investors backed

[5] That is, the maximum size of a project is one unit of investment.

by firms' projects and to mediate the information about the underlying projects that is available to investors. On each island $n$, intermediaries are matched with a single firm. Intermediaries have access to a *disclosure technology* they can use to design the information they will reveal about firms to investors. I describe this technology in greater detail below. Firms are incapable of otherwise credibly communicating their types to other agents in the economy.

After matching with a firm, intermediaries make take-it-or-leave-it offers to firms specifying the amount they are to repay in the evening (as a function of their output).[6] Firms then pledge their entire output to the intermediary, so I will sometimes refer to the firm's project as the intermediary's project. In the afternoon, intermediaries will have to raise additional funds to finance interim investment in firms' projects. They do so by selling claims on projects in an asset market described in Section 3.1.

**Investors**: Investors receive an endowment of goods $e$ in the morning and lend it to intermediaries on the same island. In the afternoon, investors will preference shocks that are heterogeneous across islands. Their preferences are

$$U_n = \mathbb{E}[\tilde{\lambda}_n c_1 + c_2],$$

where $\tilde{\lambda}_n \in \{1, \lambda\}$ (with $\lambda > 1$) reflects an *impatience shock* that is iid across islands, with $\Pr(\tilde{\lambda} = \lambda) = \alpha$. That is, on a fraction $\alpha$ of islands, investors are impatient and discount final consumption at a high rate $\frac{1}{\lambda}$, whereas on the remaining islands, investors are patient and do not discount final consumption. Islands that receive the impatience shock will be called *impatient islands*, and those that do not will be *patient islands*. After receiving these shocks, investors will purchase additional claims on firms' projects from intermediaries in the asset market.

**Information**: The information available to investors about a firm $j$ in the afternoon, when it needs to raise funds for investment, will consist of a market price and a signal $s_j \in [0, 1]$ revealed by the intermediary matched with the firm.[7] The structure of the signal will be determined by the *disclosure policy* of the intermediary that lends to firm $j$. In the morning, intermediaries do not know the type of the firms to which they are matched, but in the afternoon, they receive information about the firm in a *file* and learn its type.

Intermediaries are free to choose a disclosure policy in the morning, which consists of a

[6] In principle, there are other ways to specify the split of surplus between firms and intermediaries. In any case, firms and intermediaries would act to maximize their joint surplus, however, so the surplus split will not affect aggregate outcomes.

[7] That is, investors do not see the island $n(j)$ on which an asset was originated. This assumption allows me to embed an adverse selection problem in a model with Walrasian markets rather than a more complicated setting with asymmetric information, as in Kurlat (2016).

CDF $F(\cdot|\Theta)$ for $\Theta \in \{G, B\}$ (defined over the unit interval $[0,1]$). The signal $s$ disclosed by the intermediary will be distributed according to $F$ (conditional on the firm's true type). For simplicity, I assume that the CDF also must have finite support. Otherwise, I allow for fully flexible information design– the intermediary may perfectly reveal the firm's type (transparency), reveal nothing about the firm (opacity), or reveal a noisy signal. I denote the class of feasible CDFs by $\mathcal{F}$.

I make the key assumption that only a subset of investors have the expertise to infer a firm $j$'s quality from its file: when a firm's file is disclosed, information is *asymmetrically revealed* across islands. In particular, only investors on the same island, $n(j)$, have the expertise to interpret the file's contents. Investors on other islands, by contrast, will gain no information by observing the file. Hence, investors on each island $n$ are *skilled* at evaluating firms on the same island, whereas others are *unskilled*.

Formally, I assume that investor $i$ receives a signal $s_{ij}$ of firm $j$'s quality of the form

$$s_{ij} = \begin{cases} s_j & \Theta_j = G,\ n(i) = n(j) \\ N & n(i) \neq n(j) \end{cases} \tag{3}$$

where $s_j$ is the signal disclosed under the intermediary's policy and $N$ denotes an uninformative signal.

In addition to potentially having private information about the quality of firms on the same island, all agents on an island $n$ are also privately informed of their impatience shocks. Other investors on islands $n' \neq n$ will therefore be unable to infer whether a firm on $n$ lacks access to capital from its own island (skilled capital) because investors on $n$ are impatient or because they have identified the firm as bad. This inference problem will give rise to adverse selection in equilibrium.

Everyone can observe the disclosure policy used by an intermediary. That is, even though some agents may not be able to interpret the information disclosed by an intermediary, all agents can observe whether it did in fact disclose information. Opacity (full or partial) will then serve as a public signal that no investor knows the quality of a firm's project.

**Frictions**: Agents face limited commitment: all financial contracts across islands must be collateralized by claims on firms' projects. In turn, this assumption implies that unsecured borrowing across islands will be infeasible. Heterogeneity in islands' preference shocks will therefore generate a need to trade claims on projects across islands: goods will need to flow from patient islands to impatient ones. Information asymmetries across islands will have the potential to hinder trade, however.

Further, I assume that only a fraction $\xi \in (0,1)$ of a project's output can be pledged across islands.[8] Under this assumption, illiquidity will be costly: if claims on a project sell at a low enough price, investment in that project may not proceed even when it has positive present value in expectation. Nevertheless, I assume the average project is of high enough quality that

$$\xi \cdot \overline{\theta} z \geq 1 \tag{4}$$

That is, the pledgeable output of the average project is high enough to sustain the maximum scale of investment.

**Financial assets**: There is only one type of financial asset in the economy: claims on intermediaries that pay $z$ if their projects succeed, which trade in the afternoon and may be sold by intermediaries across islands. These assets are backed by intermediaries' claims on firms, which have the same structure. Given that projects pay either $z$ or 0, the assumption that assets take this form is without loss of generality. In what follows, I will refer to an asset issued by an intermediary that uses disclosure policy $F$ as an asset of type $F$.

**Timing**: In the morning, intermediaries choose their disclosure policies. In the afternoon, intermediaries match with firms, disclose information and attempt to raise additional funds by selling claims to investors under (potentially) asymmetric information. Investment in projects takes place. In the evening, output is realized and investors are repaid. The timeline is illustrated in Figure 1.

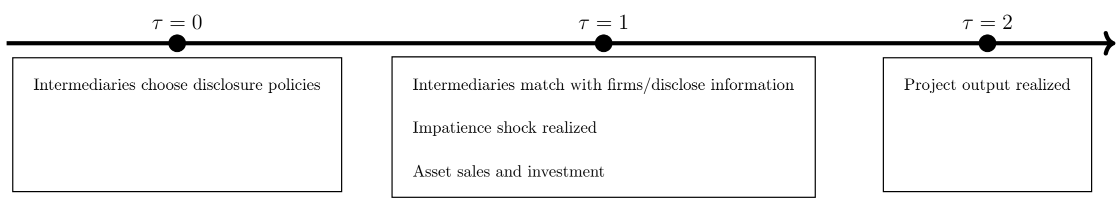


Figure 1: Timeline of the static model.

I solve the static model by backwards induction. I begin with agents' problems in the afternoon and work back to the morning.

## 2.1 Discussion of setting and assumptions

I introduce a model with intermediaries that issue securities to investors and differ in the information they disclose about the physical projects backing those securities. Furthermore, for each project, there are some investors who have the expertise to evaluate its quality (those on the same "island") and others who do not. I interpret intermediaries as entities that issue

[8] This assumption can be micro-founded, for example, by assuming that agents on an island possess specific, inalienable human capital required to extract a fraction $1 - \xi$ of a project's output.

different types of securities in the primary market. For instance, the issuance of a "transparent" asset could correspond to an IPO issuance, in which key details of the issuer's balance sheet are publicly disclosed. In this case, the intermediary would be the IPO underwriter. I interpret "opaque" assets as encompassing complex securitized products such as an ABS or CLO, for which less information is available to investors at the time of issuance.[9] The corresponding opaque intermediary would be the securitizer issuing the security. Investors with the expertise to evaluate the underlying project map to highly sophisticated financial institutions with limited ability to quickly raise funds to finance investment opportunities, such as hedge funds (specializing in stocks or securitized products, respectively).

The key feature of this environment is that islands are heterogeneous in both their preference shocks and in their information. This combination of assumptions captures that while there are investors who have the specific expertise required to evaluate certain assets, they may sometimes have more profitable investment opportunities elsewhere. In the context of securitized products, this could, for example, reflect that hedge funds specialized in evaluating the prospects of real estate management companies in a particular region may not be able to raise sufficient capital to fully meet mortgage demand in that region. Hence, it may be necessary for less expert investors to meet that demand. Importantly, the assumption that preference shocks are private information of investors on an island implies that less expert investors do not know which assets are passed up by skilled investors because they are bad and which are passed up because skilled investors did not have sufficient funds to buy them. This inference problem will be at the heart of the model's main mechanism, since it causes unskilled investors to face adverse selection. Even in markets with highly efficient price discovery, this type of adverse selection can reduce the price at which a security can be issued.[10]

There are other assumptions in the model that are convenient for the exposition but inessential. The most salient of these is that investors cannot trade the initial claims they hold on intermediaries– if these claims could be traded across islands, it would be possible for skilled investors to purchase some assets even when their endowments are zero. However, the main mechanism would still operate under these circumstances provided that the these claims did not provide skilled investors with sufficient liquidity to finance all good projects on an island.

[9] See Arora et al. (2009), who argue that valuing such securities is effectively computationally infeasible.

[10] For example, see the seminal work of Rock, 1986, which explains the anomalous underpricing of IPOs as a symptom of adverse selection.

# 3 Static Model: Decision problems and equilibrium

## 3.1 Afternoon: Asset market

At $\tau = 1$, firms' types are realized and intermediaries use their disclosure technologies. Intermediaries attempt to issue claims to investors in order to finance investment. Intermediaries will repay investors in the evening only if their projects succeed. Investors do not initially know the probability $\theta_j$ that an intermediary's project will succeed, but they draw inferences about this probability from the information disclosed by the intermediary about its project (if any) as well as the prices at which assets trade. They purchase claims issued by intermediaries with their endowments and profits $\pi_n$ rebated to them by intermediaries (which depend on the island $n$ on which they reside).

There are individual markets for claims on each firm $j$'s project with prices $p_j$. Intermediaries sell claims in these markets, and investors buy. In each market, an investor $i$ sees the firm's index $j$, the price $p_j$, the disclosure policy $F_j$ used by the associated intermediary, and her signal $s_{ij}$, but she does not see the island $n(j)$ on which the firm resides. This assumption captures the idea that less expert investors cannot tell whether demand for an asset is low because the asset is of low quality or because skilled investors lack the funds to purchase it.[11] Investors are price-takers, but as in Gârleanu, Panageas, and Yu (2019), intermediaries are monopolists in the market for claims on their projects, so they take into account the impact of their asset sales on the price at which they sell.

### 3.1.1 Investor's problem

Investors solve a portfolio choice problem. They form expectations $\mathbb{E}[\theta_j | s_{ij}, F_j, p_j]$ of the probability that claims on firms' projects pay off $z$ in the evening based on their signals and the market price. Their signals are informative for transparent projects that they have the expertise to evaluate (those on their own island), but uninformative for all other assets. They choose how much to consume, $c$, the quantity of funds to store until $\tau = 2$, $b$, and the quantity of claims to purchase on each project $j$, $a_{Bj}$, subject to a budget constraint. Consistent with the assumption of limited commitment, they may not short assets. The

[11] Importantly, it does not matter that investors *on the same island* cannot identify the island on which the firm resides– they know their own liquidity shock, so they can disentangle why a particular transparent asset they have the skill to evaluate is traded at a low price.

problem of an investor on island $n$ is

$$\max_{c,b,a_{Bj}} \tilde{\lambda}_n c + b + \int_j \mathbb{E}[\theta_j z | s_{ij}, F_j, p_j] a_{Bj} dj \tag{5}$$

$$\text{s.t. } c + b + \int_j p_j a_{Bj} dj \leq e + \pi_n, \ b \geq 0, \ a_{Bj} \geq 0 \ \forall \ j.$$

As usual, investors purchase the assets that deliver the highest returns in expectation, given their signals and publicly available information. The solution to investors' problem will determine the demand schedule faced by intermediaries.

**Lemma 1.** *Investors are indifferent between all assets $j$ that maximize their returns on wealth,*

$$R_i^* = \max_j \frac{\mathbb{E}[\theta_j z | s_{ij}, F_j, p_j]}{p_j}.$$

*If $R_i^* > \tilde{\lambda}$, they invest their entire endowment among such assets. If $R_i^* = 1$, they are indifferent between consuming and investing in those assets. Otherwise, they consume their endowment.*

I make the following assumption about investors' impatience, which ensures they will consume all of their funds when they are impatient.

**Assumption 1.** *The marginal value of consumption for impatient investors satisfies $\lambda > \theta_G z$.*

Under this assumption, the marginal returns to immediate consumption, $\lambda$, exceed the maximum return on investment in any project, $\theta_G z$.

### 3.1.2 Intermediary's problem

Intermediaries choose asset sales $a_S$ and investment $x$. They take into account the impact of their asset sales on the price at which they sell, which is summarized by a price schedule $p_j(a_S)$ that the intermediary takes as given. In general, demand for an intermediary's assets will depend on the information it discloses (determined by its disclosure policy $F_j$), the type of its project $\theta_j$, and the impatience shock faced by skilled investors on its island $\tilde{\lambda}_j$.[12] I will show that in equilibrium, the form of this price schedule will be unimportant, but the fact that intermediaries internalize their price impact will give rise to pooling in equilibrium. In particular, opaque assets will always sell at a single price regardless of their quality, as will transparent assets for which skilled capital is unavailable (either because the investors on the

[12] Note that this implies the intermediary has all the information required to back out the price schedule.

corresponding island are impatient or because they have identified the underlying project as bad). This will be the key feature of the model that causes investors who do not have the expertise to evaluate transparent assets' quality to face adverse selection.

Intermediaries cannot invest more funds than they raise through asset sales, so intermediary $j$'s investment satisfies $x \leq \min\{1, p_j(a_S)a_S\}$ (since the project's investment capacity is equal to one unit of goods per unit of capital). Furthermore, each intermediary faces limited commitment, and may sell no more than a fraction $\xi$ of the firm's output. Hence, intermediaries effectively face a collateral constraint, and attempted asset sales per unit of capital must satisfy $a_S \leq \xi x$.

The problem of an intermediary $j$ is then

$$v_j = \max_{x, a_S} \tilde{\lambda}(p_j a_S - x) + \theta_j z(x - a_S), \text{ s.t. } 0 \leq a_S \leq \xi x \qquad (6)$$
$$x \leq \min\{1, p_j(a_S)a_S\}.$$

Here $v_j$ denotes the value achieved by intermediary $j$. It consists of an intermediary's expected profits from investment. This object will be important in transparent or opaque intermediaries' entry decisions, since only those intermediaries that can attain the highest value (in expectation) will be able to enter and successfully raise funds from investors in the morning.

The solution to the intermediary's problem is simple.

**Lemma 2.** *Intermediaries sell the quantity $a_S$ of assets that maximizes $(p_j(a_S) - 1)a_S$, independently of the type of the underlying project. They invest whenever there exists $a_S > 0$ such that $p_j(a_S) \geq \frac{1}{\xi}$.*

The intermediary is always willing to sell assets if it is able to finance its investment by doing so. In equilibrium, demand for an intermediary's assets will be elastic at a given price $p_j$. The collateral constraint faced by the intermediary implies that it can raise $\xi p_j$ per unit invested, so it will be possible for the intermediary to invest whenever $\xi p_j \geq 1$ (the cost of investment).

The reason that the intermediary's decision depends only on the market price of its assets (rather than the type of the underlying project) is that the intermediary does not have funds of its own in the afternoon– the entire endowment of goods is owned by investors. Intermediaries' role is therefore mechanical. Essentially, investment decisions are made by the marginal investor who prices the asset sold by an intermediary. Note that the collateral constraint implies that in some cases, an investment may not go forward even when investors think it is socially efficient in expectation: the marginal investor believes the project is profitable if $p_j \geq 1$, but the intermediary can invest only if $p_j \geq \frac{1}{\xi}$. As in Hölmstrom and Tirole (1998), this implies that there is a role for *liquidity creation*. Opacity will allow intermediaries to resolve their liquidity needs by mitigating the adverse selection problem that arises in equilibrium when information is disclosed, raising the price at which their liabilities sell and allowing investment to proceed more often.

#### 3.1.3 Market clearing and asset market equilibrium

I now characterize the equilibrium in the asset market, which is effectively a subgame of the full model. An equilibrium in asset markets is standard. It consists of solutions to investors' and intermediaries' problems (Problems 5 and 7), price schedules for each asset $p_j$, and expectations of projects' quality for both investors and intermediaries such that agents optimize, markets clear, and expectations are consistent with Bayes' rule whenever possible.

I look for symmetric asset market equilibria in which asset prices depend only on the underlying project's type $\theta_j$, the intermediary's disclosure policy $F_j$, and the impatience shock $\tilde{\lambda}_{n(j)}$ of investors on the corresponding island. The following proposition characterizes the unique equilibrium satisfying these properties.

**Proposition 1.** *Let $\hat{\theta}_j$ denote skilled investors' posterior belief of a firm j's quality, and let $\hat{F}_j$ denote the prior distribution of $\hat{\theta}_j$ given the corresponding intermediary's disclosure policy. Then there exists a symmetric equilibrium such that for any $\hat{F}$, there is $\hat{\theta}^*(F)$ such that*

- *When the investors with the skill to evaluate a firm are patient, they are willing to buy claims on its project whenever $\hat{\theta} \geq \hat{\theta}^*(F)$ at price*

  $$p^S(\hat{\theta}, F) = \hat{\theta} z$$

  *. The project is financed if $\xi\hat{\theta}z \geq 1$.*

- *When skilled investors are impatient or $\hat{\theta} < \hat{\theta}^*(F)$, skilled investors do not buy claims on the project. Unskilled investors price it at the margin, and claims on the project trade at price*

  $$p^U(F) = \frac{\alpha\overline{\theta} + (1-\alpha)\,\mathbb{E}[\hat{\theta}|\hat{\theta} < \hat{\theta}^*(F)]}{\alpha + (1-\alpha)F(\hat{\theta}^*(F))} z$$

  *. The project is financed if $\xi p^U(F) \geq 1$.*

*The threshold satisfies $\hat{\theta}^*(F)z = p^U(F)$.*

This proposition shows how adverse selection arises in markets for claims on firms' projects due to information disclosure. Skilled investors will finance a project only when they are patient and they perceive its quality to be sufficiently high. Then, when unskilled investors see that skilled investors did not finance a project, they will rationally draw a negative inference: they know skilled investors may have not invested in the project because it was bad rather than because they were simply impatient. Thus, information disclosure allows skilled investors to more efficiently allocate capital towards good projects. However, information disclosure also forces intermediaries to issue claims to unskilled investors at a lower price, making it more difficult to finance the project when skilled capital is unavailable. The consequence of illiquidity can therefore be *under*-investment in good projects.

On the other hand, opacity (concealing information) prevents skilled investors from allocating capital efficiently, but it also mitigates the adverse selection problem faced by unskilled investors. This is why the issuance of opaque assets will generate booms featuring misallocation of credit towards bad projects in this model.

### 3.2 Morning: Intermediary disclosure policy

In the morning, before matching with firms, intermediaries choose their disclosure policies. They do so in order to maximize their expected profits with respect to the discount factor of investors on the same island. The main tradeoff in disclosing information is that by doing so, an intermediary causes unskilled investors to face adverse selection, lowering the price at which it can sell claims to them and perhaps preventing investment from taking place, whereas transparency increases the price at which it can sell claims to skilled investors.

Formally, the intermediary's information design problem is

$$\max_{F \in \mathcal{F}} \ \mathbb{E}[v_j | F_j]. \tag{7}$$

In principle, an intermediary can choose any disclosure policy. While this problem is thus quite abstract, later I show that in equilibrium, intermediaries will make use of only two simple disclosure policies: full transparency and full opacity.

### 3.3 Equilibrium

I now define and characterize a symmetric equilibrium of the static model. In a symmetric equilibrium, asset prices depend only on a project's quality, the disclosure policy of the associated intermediary, and the local impatience shock. Agents on all islands that receive the same impatience shock behave in the same way. Their decisions in the afternoon depend on the local shock as well as their information.

**Definition 1.** *A* ***symmetric static equilibrium*** *consists of a disclosure policy $F$, intermediary returns $v(s, F, \tilde{\lambda})$ investors' decisions $\{c(\tilde{\lambda}), b(\tilde{\lambda}), a_B(\tilde{\lambda}, s, F, p)\}$, intermediaries'* *decisions* $\{x(\theta, F, p), a_S(\theta, F, p)\}$*, a price schedule* $p(a_S|\theta, F, \tilde{\lambda})$*, and expectations* $\mathbb{E}[\cdot|s, F, p]$ *for investors such that*

1. *Investors' choices* $c, b, a_B$ *solve Problem 5 taking prices as given;*
2. *Intermediaries' decisions are optimal given the price schedule p they face at* $\tau = 1$*, and their returns are defined by Equation* **??***;*
3. *Markets clear at* $\tau = 1$*, and the price schedules faced by intermediaries' are consistent with investors' demand;*
4. *Investors' expectations are consistent with Bayes' Rule whenever possible.*

I focus on symmetric equilibria in which asset prices are as in Proposition 1.

#### 3.3.1 The choice of information structure

The key determinant of equilibrium outcomes will be intermediaries' choice of information disclosure. This decision, in turn, will determine the information structure in the economy when it comes time to invest goods in projects in the afternoon. I will show that there are two possible outcomes: an *opaque regime* in which intermediaries disclose no information, and a *transparent regime* in which intermediaries fully disclose the quality of their projects.

The central feature of this economy that gives rise to a role for opacity is its information structure. Within an island, investors always know the quality of all transparent projects. Across islands, however, investors cannot tell whether an asset sells at a low price because (1) those with the expertise to evaluate the underlying project's quality are impatient, or (2) those with the expertise to evaluate it know it is of bad quality. Assets will sometimes sell at a low price even when the underlying project is good, which can cause intermediaries to forgo ex-post efficient investments.

I now describe the intermediary's information design problem. The intermediary's disclosure policy induces a distribution $F$ over skilled investors' posterior belief $\hat{\theta}$ of the firm's quality. When skilled investors are not impatient (with probability $1-\alpha$), they will finance the project if and only if $\hat{\theta} \geq \theta^* = \frac{1+r}{z}$ (that is, if they perceive the project to be positive-NPV). If skilled investors are impatient (with probability $\alpha$), they never finance the project. Then, when skilled investors do not finance the project, unskilled investors think its expected quality is

$$\theta^U(F) = \frac{\alpha\overline{\theta} + (1-\alpha)\,\mathbb{E}[\theta|\hat{\theta} < \theta^*]}{\alpha + (1-\alpha)F(\theta^*)}$$

Intermediaries can sell claims on the project at price $p(\hat{\theta}) = \max\{\hat{\theta}, \theta^U(F)\}z$. Equivalently, the project is financed at an interest rate $R(\hat{\theta}) = \frac{z}{p(\hat{\theta})} = \frac{1}{\max\{\hat{\theta}, \theta^U(F)\}}$. The project is financed as long as $R(\hat{\theta}) \leq \xi z$ (that is, as long as the interest repayment $R$ is less than the project's collateral, $\xi z$). The intermediary's profits are $p(\hat{\theta}) - 1 = \frac{z}{R(\hat{\theta})} - 1$ if the project is financed, so its problem is then

$$\max_{F \in \mathcal{F}} \; \alpha\lambda\left(\frac{z}{R(\theta^U(F))} - 1\right) \cdot \mathbf{1}\{R(\theta^U(F)) \leq \xi z\} + (1-\alpha)\int_0^1 \left(\frac{z}{R(\hat{\theta})} - 1\right) \cdot \mathbf{1}\{R(\hat{\theta}) \leq \xi z\} dF(\hat{\theta}). \tag{8}$$

The first result that I prove is that in equilibrium, intermediaries choose either a policy of full transparency or full opacity.

**Proposition 2.** *In equilibrium, the solution to intermediaries' problem can be implemented by choosing one of two disclosure policies: transparency (in which case skilled investors learn the project's quality in the afternoon) or opacity (in which case they learn nothing).*

I provide a proof sketch, with a more complete proof in the Appendix.

*Proof.* There are two possibilities for the intermediary. It may wish to finance the project by issuing claims to unskilled investors, or it may not. If it issues claims to unskilled investors, then the project is always financed (regardless of its quality). Investors break even, so the average price at which the intermediary sells claims cannot exceed the average project cashflow, $\overline{\theta}z$. Hence, the intermediary cannot do better than a policy of full opacity, which maximizes the price unskilled investors are willing to pay (and thus prevents a situation in which the price those investors pay is insufficient to cover the intermediary's cost of investment).

On the other hand, the intermediary may design an information disclosure policy such that only skilled investors finance the project, forgoing investment when unskilled capital is needed. This occurs when the adverse selection faced by unskilled investors is so severe that they are not willing to finance the project. The price paid by skilled investors is $\hat{\theta}z$, where $\hat{\theta}$ denotes their expectation of the project's quality. The project is financed if $\xi \cdot \hat{\theta}z \geq 1$, the cost of investment. Let $F$ denote the distribution of $\hat{\theta}$, investors' posterior expectation of the project's quality. The intermediary's problem in this case is

$$v = \max_F \; (1-\alpha)\int_{\frac{1}{\xi z}}^1 (\hat{\theta}z - 1)dF(\hat{\theta}) \text{ s.t. } \int_0^1 \hat{\theta}dF(\hat{\theta}) = \overline{\theta}.$$

Note that the right-hand side is a convex function of $\hat{\theta}$, since it is linear for $\hat{\theta} \geq \frac{1}{\xi z}$ and identically zero otherwise. Thus, the right-hand side is increasing under a mean-preserving spread of $F$. The intermediary can therefore do no better than providing all information to skilled investors (i.e., a policy of full transparency). $\square$

Intuitively, when the intermediary wants to sell claims to unskilled investors, it maximizes the price at which it does so through a policy of full opacity, which mitigates adverse selection concerns. On the other hand, if an intermediary issues to skilled investors only, it can do no better than a policy of full transparency, which maximizes the average price at which it sells claims to them. This differs from traditional solutions to information design problems (e.g., Kamenica and Gentzkow, 2011) because the intermediary's payoffs do not depend only on whether the project is financed, which is a binary action. Rather, payoffs depend on the *price* paid by investors, which is a continuous variable.

If an intermediary uses a policy of full transparency, it can sell claims on the project to skilled investors when they are patient *and* the project is good (at price $\theta_G z$). On the other hand, if skilled investors are impatient *or* the project is bad, it will have to attempt to sell to unskilled investors. Those investors will value the project at

$$\theta_U z \equiv \frac{\alpha(1-\delta)\theta_G + \delta\theta_B}{\alpha(1-\delta)+\delta} z. \tag{9}$$

Parameter $\theta_U$ represents the project's expected quality to unskilled investors when skilled investors do not finance the project under transparency. The (expected) value of an intermediary that uses a policy of full transparency is then

$$V^T = \big(\alpha\lambda + (1-\alpha)\delta\big)(\theta_U z - 1)\mathbf{1}\{\theta_U z \geq \xi^{-1}\} + (1-\alpha)(1-\delta)(\theta_G z - 1).$$

If the price $\theta_U z$ at which a transparent intermediary can sell assets is too low when skilled capital is unavailable, it may be prevented from investing entirely. That is, illiquidity can hamper investment even when it is efficient. Nevertheless, illiquidity also prevents inefficient investments from proceeding: if a transparent intermediary is able to sell claims and invest only when skilled capital is available, it never finances a bad project.

An intermediary that uses a policy of full opacity, on the other hand, always sells claims at the same price $p^O = \overline{\theta} z$. Its value is

$$V^O = (1 + \alpha(\lambda - 1))(\overline{\theta} z - 1)\mathbf{1}\big\{\overline{\theta} z \geq \xi^{-1}\big\}.$$

From this equation, it is clear how opacity differs from transparency. Opacity raises the price at which intermediaries can sell assets when skilled capital is unavailable. Hence, opacity may allow the intermediary to invest when it would be unable to do so under transparency. Opacity enhances the liquidity of an intermediary's liabilities, allowing it to finance its project by attracting unskilled capital. On the other hand, it also causes greater misallocation towards bad projects– no agent is able to determine the project's quality, so the intermediary faces the same financing terms when the project is good and when it is bad. Opaque assets are, in a sense, the mirror image of transparent ones. They are more liquid and therefore easier to trade across islands, but they deprive skilled investors of the information required to ensure they do not finance bad projects.

#### 3.3.2 Adverse selection vs. virtuous selection

Having characterized the tradeoff between transparency and opacity, I now describe the equilibrium outcome in the economy.

**Proposition 3.** *The unique symmetric static equilibrium consists of two regimes.*

1. ***Opaque regime**: When*

$$(1+\alpha(\lambda-1))(\overline{\theta}z-1) \geq (1-\alpha)(1-\delta)(\theta_G z-1),$$

*all intermediaries choose a policy of opacity. All projects, both good and bad, are financed in the afternoon, independently of the preference shock on each island. There is trade in financial assets across islands.*

2. ***Transparent regime**: When*

$$(1+\alpha(\lambda-1))(\overline{\theta}z-1) < (1-\alpha)(1-\delta)(\theta_G z-1),$$

*only transparent intermediaries enter. Good projects are financed only when skilled capital is available (i.e., investors on the same island are patient). Bad projects are never financed. Investors purchase only assets whose quality they can evaluate.*

This proposition draws a sharp distinction between two types of regimes that may arise in equilibrium: an opaque regime and a transparent regime. In the opaque regime, assets are highly liquid and can be sold across islands to investors who lack the skills to evaluate the quality of the underlying projects. Unskilled investment, however, goes hand-in-hand with misallocation, and bad projects are always financed. That is, the opaque regime essentially corresponds to a situation in which lending standards are lax.

In the transparent regime, investors are reluctant to finance projects through intermediaries that will conceal information. Rather, each investor finances only projects whose quality they can observe. This improves allocative efficiency– bad projects are never financed in the transparent regime. The resulting information asymmetries hamper liquidity, though. In fact, financial markets are fully illiquid in the sense that assets are never traded across islands. Therefore, many good projects go unfunded (in particular, those for which skilled capital is unavailable).

In the opaque regime, there is *over*-investment relative to the first-best benchmark. In the transparent regime, by contrast, there is *under*-investment. What determines which regime will arise? There are two forces that play a role in determining the equilibrium outcome: the benefit of *virtuous selection* (VS), which I define as the value of forgoing negative-present value investments, and the cost of *adverse selection* (AS), which I define as the cost of the inability to finance a good project when skilled capital is unavailable.

Transparent intermediation grants skilled investors the benefits of virtuous selection but comes at the cost of adverse selection: in the transparent regime, projects are financed only when they are good and skilled investors are patient. By allowing skilled investors to see a signal of the project's quality, the intermediary lowers its cost of funds when those investors finance the project, but by giving information to skilled investors, it increases its cost of raising funds from unskilled investors to the point that doing so is unprofitable. Opaque intermediation, by contrast, gives up the benefits of virtuous selection in order to mitigate adverse selection costs. When the underlying project is good, skilled investors are no longer willing to pay such a high price for assets issued by the intermediary, since they cannot see the project's quality, but unskilled investors no longer require an illiquidity discount in order to finance the intermediary's project.

The cost of adverse selection is forgone investment when a project is good but skilled investors lack funds: with probability $\alpha(1-\delta)$, an investment opportunity worth $\theta_G Z - 1$ is passed up. The benefit of virtuous selection (to investors) is avoiding investment in bad projects and not incurring a loss of $1 - \theta_B Z$ when the project is bad (with probability $\delta$). Investors factor this cost into the price they are willing to pay for claims on an intermediary's project, so it is passed on to intermediaries through an elevated cost of funds. Thus, the cost of adverse selection is greater than the benefit of virtuous selection whenever

$$\underbrace{\alpha\lambda(1-\delta)(\theta_G Z - 1)}_{\text{AS cost}} \geq \underbrace{(1+\alpha(\lambda-1))\delta(1-\theta_B Z)}_{\text{VS benefit}}. \tag{10}$$

From Proposition 3, this is precisely the condition required for the economy to be in the opaque regime.

Before moving to the dynamic model, it will be useful to derive comparative statics results.

**Proposition 4.** *There exists $\delta^*$ such that the economy is in the opaque regime whenever*

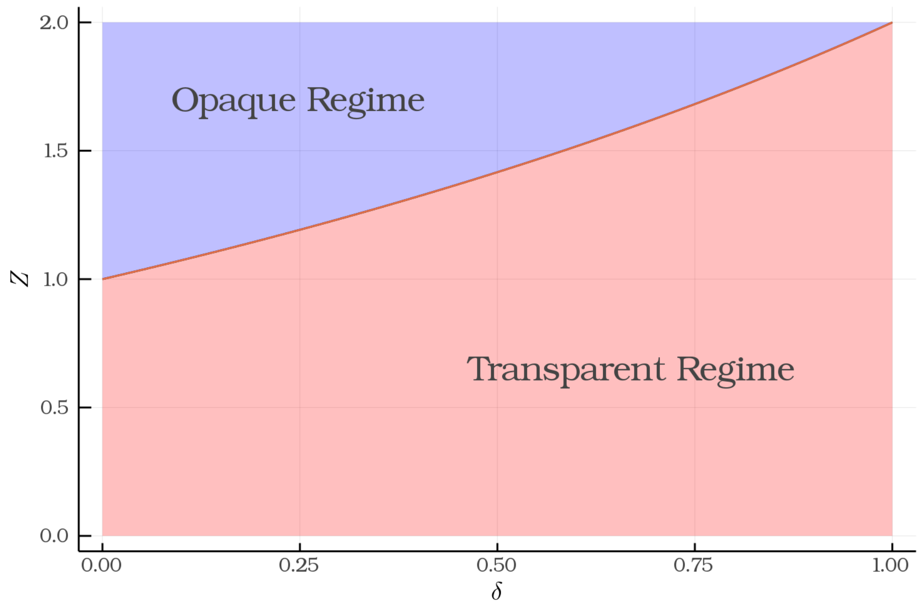


Figure 2: Opaque and transparent regimes described in Proposition 3. This example uses parameters $\alpha = 0.3$, $\theta_G = 1.0$, $\theta_B = 0.5$.

*$\delta \leq \delta^*$ and in the transparent regime otherwise, where*

$$\delta^* = \frac{\alpha\lambda(\theta_G z - 1)}{\alpha\lambda(\theta_G z - 1) + (1 + \alpha(\lambda - 1))(1 - \theta_B z)}. \tag{11}$$

*Likewise, holding other parameters fixed, there exists $z^*$ such that the economy is in the opaque regime for $z \geq z^*$ and in the transparent regime otherwise.*

The logic underlying this result is that the cost of adverse selection is high, and the benefit of virtuous selection is low, when the average project in the economy is profitable. This is because the cost of adverse selection relates to passing up good investment opportunities, whereas the benefit of virtuous selection relates to avoiding up bad ones. The critical threshold $\delta^*$ that demarcates the boundary between the opaque and transparent regimes will be crucial in governing endogenous cycles in the dynamic model. Figure 2 depicts the opaque and transparent regimes in $(z, \delta)$ space. In the dynamic model, exogenous productivity $z$ and the endogenous fraction of bad firms $\delta$ will be the key state variables.

# 4 Dynamics

In this section, I extend the static model to a dynamic setting to study the macroeconomic conditions under which opacity can arise as well as its role in generating and amplifying credit cycles. I embed opaque intermediaries in a dynamic production economy and introduce persistence in the quality of projects. The dynamic model, which features long-lived investors, will effectively reduce to a repeated version of the static one, with periods linked only by the evolution of productivity and the fraction of bad projects, as well as the accumulation of physical capital. Opacity will keep inferior projects in the pool, whereas transparency weeds out bad projects. Under these assumptions, the economy will feature both amplification of busts following long booms and fully endogenous credit cycles.

## 4.1 Model setup

Time is discrete and infinite, $t = 0, 1, 2, \ldots$, and each period consists of three subperiods, $\tau = 0, 1$ (morning and afternoon). As in the static model, there is a single good that can be consumed or invested as capital, and the economy consists of islands $n \in [0, 1]$. The economy is populated by investors, firms, and intermediaries that match randomly with firms in each period. Agents are randomly sent to new islands at the beginning of each period. The consumption good can be stored across periods (from $\tau = 1$ of $t$ to $\tau = 0$ of $t + 1$) to earn returns $1 + r$. This implies an aggregate resource constraint in each period,

$$y_t = c_t + \overline{k}_t. \tag{12}$$

**Investors**: The economy is populated by investors who face impatience shocks. They have preferences that are an infinite-horizon analogue of those in the static model,

$$U = \mathbb{E}\left[\sum_{t=0}^{\infty} \beta^t \tilde{\lambda}_{nt} c_t\right], \tag{13}$$

where $\beta \in (0, 1)$ denotes the subjective discount factor used by investors. Impatience shocks $\tilde{\lambda}_{nt} \in \{1, \lambda\}$ are I.I.D. across islands and time but perfectly correlated within an island, with $\Pr(\tilde{\lambda} = \lambda) = \alpha$. Investors are endowed with the economy's entire capital stock at $t = 0$. In the afternoon of each period, investors finance projects, consume, and choose how many goods to store until the next period.

**Firms and intermediaries**: Each firm has a type $\Theta_{jt}$ that may evolve over time according to a process specified later. Firms are sent to random islands at the beginning of the morning of each period. Then, intermediaries enter and match anonymously with firms, as in the static model. The production technology available to firms is as in the static model, with one minor modification: the investment capacity of a project is $\omega\overline{k}_t$ rather than one unit.[13] I allow the productivity $z_t$ of projects to vary exogenously over time.

Intermediaries choose a disclosure policy $F \in \mathcal{F}$ in the morning and anonymously meet with a firm in the afternoon of each period. In the afternoon, they sell claims on the firm's project to investors in order to finance it. Firms and intermediaries rebate all profits to investors on the same island in proportion to their wealth.[14]

The only differences from the static model are that (1) firms' types $\Theta_{jt}$ may change over time, (2) firms randomly match with an intermediary in each period, and (3) the productivity of firms' technology, $z_t$, follows a stochastic process.

**Shocks and state variables**: There are three aggregate state variables: the productivity of firms' technology $z_t$, the fraction of bad firms at $t$, which I denote $\delta_t$, and the aggregate capital stock $\overline{k}_t$. Shocks to $z_t$ are the only source of aggregate uncertainty in this economy. For now, I simply assume that $z_t$ follows an arbitrary stochastic process.

I now specify the process followed by firms' types $\Theta_{jt}$ (which gives rise to the process followed by $\delta_t$). Aggregate firm quality evolves through exit and entry. When a firm exits (or "dies"), it is replaced by a newborn firm that is good with exogenous probability $1 - \overline{\delta}$. The key assumption is that firms exit when either (1) their projects fail, or (2) they fail to raise additional funds at $\tau = 1$. An exiting firm is replaced by a newborn good firm.[15] In order to survive into the next period, a firm must raise funds and successfully complete its investment project. These assumptions correspond to a setting in which a firm's failure to raise funds is, to a certain extent, observable. In addition, in every period, a firm may die with exogenous probability $\kappa \in (0, 1)$. This specification captures mean reversion in firm quality and ensures that the fraction of bad projects (when only good firms are financed) has a nondegenerate stationary distribution.

**Timing**: At the beginning of the morning, agents are sent off to random islands. Then, intermediaries publicly commit to their disclosure policies. The afternoon is the exact analogue of $\tau = 1$ in the static model. Intermediaries first match randomly and anonymously with firms.[16] Each island receives an endowment of goods through firms' dividends, and then firms get investment opportunities. Intermediaries attempt to raise funds to finance

[13] I assume $\omega\theta_G z \leq 1$, so that investors financing projects always break even.

[14] That is, the fraction of profits received by an investor on an island is proportional to the wealth of that investor.

[15] It is not important that newborn firms are good rather than drawn from some distribution containing both good and bad firms. I make this assumption only for simplicity of exposition.

[16] Intermediaries therefore have no knowledge of the firm's type within a period. This assumption circumvents a situation in which investors and intermediaries need to keep track of a distribution of beliefs about firm quality.

investment in their firms' projects. They follow their disclosure policies and then trade with investors in the same markets as in the static model. Investors consume and make their investment decisions. All output that is not consumed or invested in firms' projects is stored until the next period. Finally, at the beginning of the morning in the next period, firms return output to intermediaries, who in turn pay back investors.

## 4.2 Dynamic equilibrium

The dynamic model is essentially identical to a repeated version of the static one. Just as in the static model, intermediaries choose their disclosure policies and then attempt to raise additional funds in financial markets subject to asymmetric information. The output of a project that receives investment is $z_t$ at the beginning of the next period (per unit invested). The information structure within a period is also unchanged: intermediaries and investors enter a period with a common prior $\delta_t$ that any given firm is bad, and further information is revealed in the afternoon according to intermediaries' disclosure technologies.

The only difference between the static and dynamic models occurs when investors make their consumption-savings decisions, since they now solve a dynamic optimization problem rather than a static one. I outline that decision here.

**Investors' optimization problem**: Investors on each island $n$ enter a period with their net worth $w_t$ and receive an impatience shock $\tilde{\lambda}_{nt}$ in the afternoon. Then, they choose their consumption $c_t \geq 0$, how many claims $a_{Bj,t}$ to purchase on each project $j$, and the amount $b_t$ they want to store until the next period, subject to the budget constraint

$$c_t + b_t + \int_j p_{jt} a_{Bj,t} \leq (1 + \pi_{nt}) w_t, \tag{14}$$

where $\pi_{n,t}$ denotes intermediary profits rebated to investors on island $n$ per unit of net worth. Investors accumulate net worth according to

$$w_{t+1} = (1 + r) b_t + \int_j \tilde{z}_{jt} a_{Bj,t} dj, \tag{15}$$

where $\tilde{z}_{j,t+1} = z_t$ if firm $j$'s project succeeds and 0 if it fails. An investor's problem can then be written as

$$\max_{c_t, b_t, a_{Bj,t}} \mathbb{E}\left[\sum_{t=0}^{\infty} \beta^t \tilde{\lambda}_{nt} c_t\right] \text{ s.t. (14), (15), } c_t \geq 0, \; w_t \geq 0. \tag{16}$$

I make the following assumption to guarantee that investors consume if and only if they are impatient, thereby simplifying the characterization of their optimization problem greatly.

**Assumption 2.** *The marginal utility of consumption* $\lambda$ *conditional on an impatience shock satisfies*

$$\lambda > (1 + \alpha(\lambda - 1)) \max\{\theta_G \overline{z}, 1 + r\}$$

*where* $\overline{z}$ *denotes the supremum of the support of* $z_t$*. Furthermore,* $\beta(1-\alpha)\max\{\theta_G\overline{z}, 1+r\} < 1 < \beta(1+r)$*.*

With risk-neutral preferences, Problem 16 is particularly simple to solve.

**Proposition 5.** *Investor* $i$ *consumes if and only if she is impatient. When she does so, she consumes all of her net worth. Otherwise, she invests. She is indifferent between all assets that maximize her expected returns on investment,*

$$\max\left\{1 + r,\ \max_j \frac{\mathbb{E}_{it}[\theta_{jt} z_t]}{p_{jt}}\right\}.$$

Investors choose how to allocate their funds between consumption, storage, and investment in projects. They consume only when they are hit by impatience shocks. Otherwise, they invest in projects and storage, which are perfect substitutes.

**Equilibrium concept**: I now define a dynamic equilibrium of this economy. I will show that in the dynamic equilibrium, the only link between periods will be the evolution of the state variables $(Z_t, \delta_t, \overline{k}_t)$.

**Definition 2.** *A* ***symmetric dynamic equilibrium*** *consists of a disclosure policy* $F_t$*, intermediary returns* $v_t(s, F, \tilde{\lambda})$ *investors' decisions* $\{c_t(w, \tilde{\lambda}), b_t(w, \tilde{\lambda}), a_{Bt}(w, \tilde{\lambda}, s, F, p)\}$*, intermediaries' decisions* $\{x_t(\theta, F, p), a_{St}(\theta, F, p)\}$*, a price schedule* $p_t(a_S|\theta, F, \tilde{\lambda})$*, expectations* $\mathbb{E}_t[\cdot|s, F, p]$ *for investors, and an aggregate state process* $\{z_t, \overline{k}_t, \delta_t\}$ *such that*

1. *Investors' individual decisions are optimal, taking prices, returns earned by intermediaries, and the law of motion of the aggregate state as given;*

2. *Intermediaries' decisions maximize their single-period returns, taking price schedules* $p_t$ *as given, and their returns are given by the analogue of Equation* **??***;*

3. *Investors' and intermediaries' expectations are consistent with Bayes' Rule whenever possible;*

4. *The sequence* $\delta_t$ *is consistent with investment decisions at* $\tau = 1$*, and the sequence* $\overline{k}_t$ *is consistent with the family's consumption-savings decision;*

5. *All markets clear, and the price schedules faced by intermediaries are consistent with investors' demand.*

The following proposition allows me to treat the dynamic equilibrium as a repeated sequence of static equilibria. The morning and the afternoon of each period will be exactly as in the static model, but the state variables $(Z_t, \delta_t, \overline{k}_t)$ that determine outcomes in that model will vary over time.

**Proposition 6.** *In the symmetric dynamic equilibrium, within a period, the equilibrium features two regimes, given the state* $(z_t, \delta_t, \overline{k}_t)$. *Let*

$$\delta_t^* = \frac{\alpha\lambda(\theta_G z_t - (1+r))}{\alpha\lambda(\theta_G - \theta_B)z_t + (1 + r - \theta_B z_t)} \tag{17}$$

*The economy is in an opaque regime (in which all intermediaries choose opacity) if and only if* $\alpha\lambda(1-\delta_t)(\theta_G z_t - (1+r)) \geq (1 + \alpha(\lambda - 1))\delta_t(1 + r - \theta_B z_t)$*; otherwise, the economy is in the transparent regime. Investors consume if and only if they are hit by an impatience shock. The state* $\delta_t$ *follows the process*

$$\delta_{t+1} = \begin{cases} \kappa\overline{\delta} + (1-\kappa)\overline{\delta}((1-\delta_t)(1-\theta_G) + \delta_t(1-\theta_B)) + (1-\kappa)\theta_B\delta_t & \textit{Opaque regime} \\ \kappa\overline{\delta} + (1-\kappa)\overline{\delta}\big((\alpha + (1-\alpha)(1-\theta_G))(1-\delta_t) + \delta_t\big) & \textit{Transparent regime} \end{cases} \tag{18}$$

Crucially, this proposition implies that the opaque and transparent regimes correspond to those in the static model: whenever $(z_t, \delta_t)$ are such that

$$\alpha\lambda(1-\delta_t)(\theta_G z_t - (1+r)) \geq (1 + \alpha(\lambda-1))\delta_t(1 + r - \theta_B z_t),$$

the dynamic equilibrium will feature an opaque regime. The only difference from the static model is that now the exogenous return on storage $1 + r$, which can be thought of as an interest rate, enters into the expression determining whether the economy is in the opaque or transparent regime. Intuitively, when the interest rate is higher, the substitute safe asset is more attractive, reducing the incentives for intermediaries to produce opaque assets in order to invest in large volumes.

### 4.3 Steady states and endogenous cycles

In this section, I study the behavior of the economy in the absence of shocks to productivity. I prove that the economy may either converge to a steady state or experience endogenous cycles of transparency and opacity generated by the dynamics of firm quality. I characterize the conditions under which steady states or cycles emerge and analyze their implications for macroeconomic outcomes. For the remainder of this section, I assume that productivity is fixed at some constant level $z_t = z$.

Recall that firms exit when either their projects fail or they fail to raise funds at $\tau = 1$. Denote the probability that a firm of type $\Theta \in \{G, B\}$ dies at time $t$ by

$$\mu_{\Theta t} \equiv \Pr_t(j \text{ dies} \mid \Theta_{jt} = \Theta).$$

Under these assumptions, the fraction of bad firms in the economy, $\delta_t$, follows the process

$$\delta_{t+1} = \big(\mu_{Gt}(1-\delta_t) + \mu_{Bt}\delta_t\big)\overline{\delta} + (1-\mu_{Bt})\delta_t. \tag{19}$$

The second term corresponds to the fraction of bad firms that survive after getting financed. This endogenous survival mechanism is the key channel that will generate cycles. Note that this channel operates only when some bad firms are financed, which, in turn, is possible only in the opaque regime. The first term simply represents firms that die and are reborn as bad firms with probability $\overline{\delta}$. This equation highlights that the survival of bad firms endogenously worsens the overall pool.

The economy is in the opaque regime whenever

$$\delta_t \leq \delta^* = \frac{\alpha\lambda(\theta_G z - (1+r))}{\alpha\lambda(\theta_G - \theta_B)z + (1 + r - \theta_B z)}.$$

As in the static model, when average firm quality is sufficiently high, intermediaries finance investment by originating opaque assets. In particular, this occurs whenever the fraction of bad projects $\delta_t$ is below its critical value $\delta^*$. When this is the case, all bad projects receive additional financing in the afternoon. On the other hand, when $\delta_t > \delta^*$, investors no longer want to finance projects they know nothing about, and asset origination becomes transparent. Due to the adverse selection problem, investors require a large premium in order to purchase new claims on transparent projects whose quality they do not have the skills to evaluate (i.e., those originated on other islands). This premium is so large that intermediaries cannot raise sufficient funds to complete their investment by selling claims to unskilled investors. Only skilled investors participate in markets for transparent assets, meaning investors purchase only assets originated on their own islands. There is no trade across islands, so good projects go unfunded when those with the skill to evaluate them lack funds. Investors never misallocate financing towards bad projects in the transparent regime.

The probability that a bad firm dies in either regime is

$$\mu_{Bt} = \begin{cases} \kappa + (1-\kappa)(1-\theta_B) & \delta_t \leq \delta^* \\ 1 & \delta_t > \delta^* \end{cases} \tag{20}$$

Similarly, the death rate of good firms is discontinuous at the threshold $\delta^*$. The discontinuity in the survival rate of firms can generate cycles. The long-run dynamics depend on the basins of attraction of the law of motion, which differ depending on whether $\delta_t$ is greater or less than $\delta^*$. The basins of attraction are $\delta_h$ for $\delta_t \leq \delta^*$ and $\delta_l$ for $\delta_t > \delta^*$, which are defined as

$$\delta_h = \frac{\mu_G^O \overline{\delta}}{\mu_G^O \overline{\delta} + \mu_B^O (1 - \overline{\delta})}, \ \delta_l = \frac{\mu_G^T \overline{\delta}}{\mu_G^T \overline{\delta} + \mu_B^T (1 - \overline{\delta})}. \tag{21}$$

where $\mu_G^O = \kappa + (1-\kappa)(1-\theta_G)$ and $\mu_G^T = \kappa + (1-\kappa)(\alpha + (1-\alpha)(1-\theta_G))$ are the death rates of good firms in the opaque and transparent regimes, respectively, and $\mu_B^O$ and $\mu_B^T$ are the death rates of bad firms given in Equation 20.

Cycles will arise when $\delta_l < \delta^* < \delta_h$. Even when the fraction of bad firms $\delta_t$ is slightly less than the critical value $\delta^*$ that triggers a switch to the transparent regime, the fraction of bad firms can continue to climb towards $\delta_h$. The intuition is that whenever the fraction of bad firms is not critically high, a project's value is maximized if it is financed by an opaque intermediary, since claims on the project will be liquid and will always sell at a high price. Even as the critical threshold $\delta^*$ is approached, then, intermediation remains opaque. The economy suddenly exits the opaque regime when there are many bad firms and the benefit of avoiding misallocation towards bad projects (virtuous selection) begins to exceed the cost of passing up good ones (adverse selection). After the critical threshold $\delta^*$ is crossed, a project's value is instead maximized by transparency, which, despite precluding financing when skilled capital is unavailable, allows the intermediary to signal the project's quality to skilled investors and sell claims at a higher price when they can identify the project as good. In the transparent regime, only skilled investors participate in financial markets at $\tau = 1$ when projects require investment, and they identify all bad projects. This forces a large quantity of bad firms to exit, thereby cleansing the pool and causing the fraction of bad projects to converge down towards $\delta_l$. Subsequently, the economy can re-enter the opaque regime.

Let $\delta^+(\cdot)$ represent the transition law in Equation **??**, so that $\delta^+(\delta_t) = \delta_{t+1}$. I now formally define the notions of a steady state and an equilibrium cycle.

**Definition 3.** *A* ***steady state*** *is a value of $\delta$ such that $\delta^+(\delta) = \delta$ in the recursive dynamic equilibrium. An* ***equilibrium cycle*** *consists of a sequence $\{\delta_n\}_{n=1}^m$ (for some $m \geq 2$) such that in the dynamic equilibrium, $\delta^+(\delta_n) = \delta_{n+1}$ for $n \leq m-1$ and $\delta^+(\delta_m) = \delta_1$.*

The following result characterizes the conditions determining whether the economy converges to a steady state or experiences recurring cycles of transparency and (at least partial) opacity.

**Proposition 7.** *The recursive dynamic equilibrium features a steady state in the transparent regime at $\delta_l$ if $\delta_l > \delta^*$. There is a steady state in the opaque regime at $\delta_h$ if $\delta_h < \delta^*$. If $\delta_l < \delta^* < \delta_h$, the equilibrium features a cycle.*

When there is a steady state, the model's dynamics are standard. For instance, consider the case in which there is a steady state in the opaque regime, $\delta_h < \delta^*$. When $\delta_t < \delta_h$, the economy is in an opaque regime (since $\delta_t < \delta^*$ as well) and the fraction of bad firms steadily increases. However, for $\delta_t > \delta_h$, the rate at which bad firms exit (due to failure of their projects) is high enough to offset the entry of new bad firms. Intuitively, such a steady state can arise when the success rate of bad firms, $\theta_B$, is low, because then bad firms will tend to exit even when they obtain financing. In this case, the fraction of bad firms never grows so large that the economy enters the transparent regime, and there is a steady state in the opaque or mixed regime. On the other hand, a steady state in the transparent regime can arise when the rate $\kappa$ at which good firms go bad is large relative to the critical threshold $\delta^*$. In this case, the steady-state fraction of bad firms is high even when no bad firm is financed. Hence, the economy remains in the transparent regime: the fraction of bad firms tends to remain high enough that investors never want to finance projects through opaque intermediaries (because the value of virtuous selection is high at the steady state relative to the cost of adverse selection).

Throughout the rest of this section, I will focus on the case in which cycles emerge. I interpret an equilibrium cycle as a medium-run phenomenon capturing recurrent shifts in the structure of the financial system and the types of claims it produces. Booms will correspond to times in which large volumes of credit are intermediated through entities that issue opaque financial claims, and busts will be times in which those opaque claims have fallen out of favor among investors, leading to lower credit volumes and financial market liquidity.

Under the conditions outlined in the proposition, the fraction of bad firms $\delta_h$ to which the economy converges in the opaque regime is greater than the critical threshold $\delta^*$ that triggers the transition from the opaque to the transparent regime. Once in the transparent regime, the point $\delta_l$ towards which the fraction of bad firms starts to converge is less than $\delta^*$. Figure 3 depicts the dynamics in this situation. The economy stays in the opaque regime for seven periods, during which bad firms build up, and then there is a shift to the transparent regime in which unskilled investors are no longer wiling to participate in financial markets.

Economic outcomes differ markedly across the two regimes. The opaque regime features much greater investment in firms' risky projects due to participation by unskilled investors.

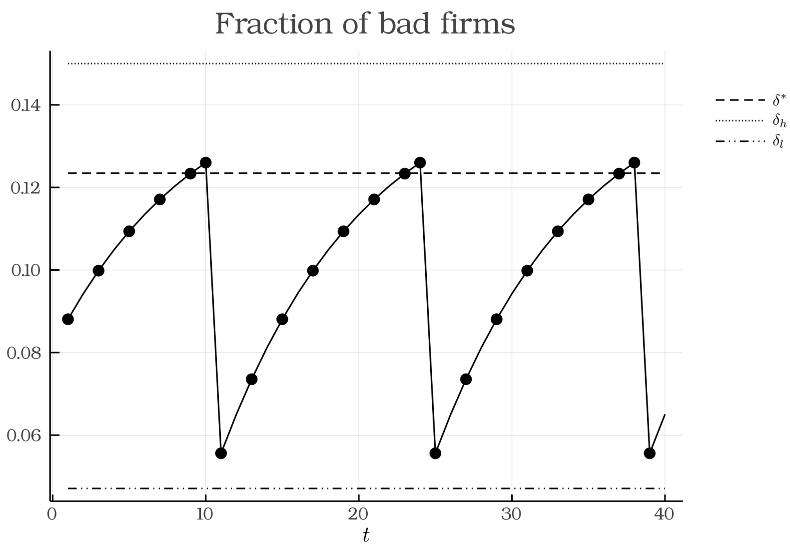


Figure 3: This figure illustrates a typical path of the fraction of bad firms $\delta_t$. In this case, there is an eight-period cycle: seven boom periods in which investors are willing to finance opaque intermediaries (while $\delta_t \leq \delta^*$) and one period in which the fraction of bad firms is high enough that opaque intermediation is abandoned.

In turn, this generates higher output $y_t^R \overline{k}_t$ produced by risky projects, where

$$y_t^R = \begin{cases} \omega \overline{\theta}_t z & \text{Opaque regime} \\ \omega(1-\alpha)(1-\delta_t)\theta_G z & \text{Transparent regime} \end{cases} \tag{22}$$

Higher output increases the growth rate of the economy, since investors save some output for the future. Therefore, the opaque regime corresponds to a credit boom and, more broadly, an economic boom. In the transparent regime, these patterns reverse. Importantly, the transition from the opaque to the transparent regime causes a crash, which manifests as a sharp dip in output and investment.

Financial markets also exhibit starkly different behavior in booms and busts. In the opaque boom phase, liquidity is high, and the returns achievable for both skilled and unskilled investors are low. However, misallocation towards bad projects progressively worsens over the course of the boom, and the default premium on assets sold by opaque intermediaries (which is just $\frac{\theta_G}{\overline{\theta}_t} - 1$) increases. The transition to the transparent regime triggers a reversal in credit markets. The collapse in opaque intermediation creates an informational environment in which adverse selection is pervasive, and investors are no longer willing to finance projects they cannot evaluate. The adverse selection problem manifests as an *illiquidity* premium for claims on good transparent projects. The wedge between the value of a good transparent

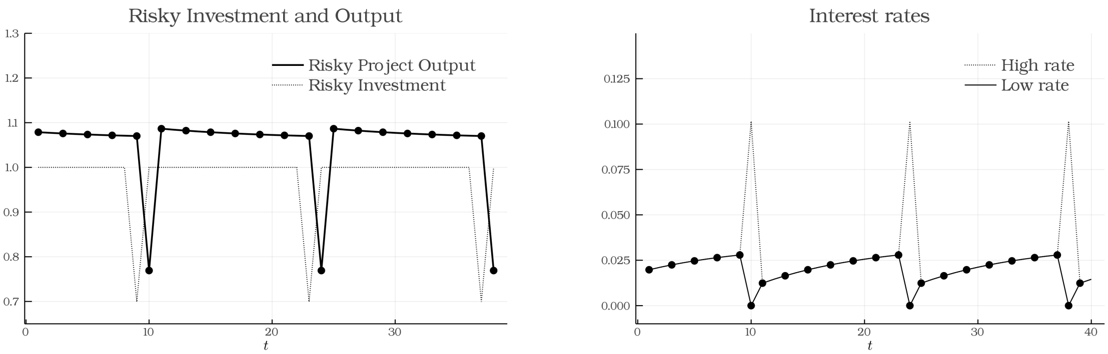


Figure 4: The left panel depicts investment into and output from risky projects (per unit of capital) over the course of a cycle with seven opaque boom periods and a transparent bust period. The right panel shows the low interest rate at which projects are financed in equilibrium (solid line) and the high interest rate faced by some firms in the transparent regime when there is adverse selection (dashed line).

project and the price at which claims on such projects can be sold to unskilled investors is

$$\frac{\delta_t(\theta_G - \theta_B)}{(1-\alpha)(1-\delta_t)\theta_G + \delta_t\theta_B}.$$

The transparent regime has a cleansing effect: after opaque intermediation is abandoned, skilled investors finance only those projects they recognize as good, forcing bad firms out of the pool. Although the quantity of credit provided to firms shrinks in the transparent regime, the *quality* of credit is higher: all firms that obtain credit end up repaying investors. These dynamics are consistent with a common view of financial cycles: booms are periods of ignorance featuring rampant misallocation towards inefficient projects, which ultimately causes them to end in busts during which investors seem to exercise an overabundance of caution. The key channel that generates these dynamics in this model is the endogenous structure of financial claims issued over the cycle: claims are optimally more opaque during booms in order to overcome adverse selection problems, consistent with the boom-bust nature of securitization and the production of other types of liquid liabilities backed by risky assets of unknown quality. The dynamics of real and financial outcomes are illustrated in Figure 4.

# 5 Optimal Opacity

The possibility of endogenous cycles generated by opaque intermediation in this model raises the question of whether these cycles can be efficient. Would a policymaker want to increase the degree of transparency in the economy or would it be better to hide more information and increase financial market liquidity? What tools should be used to implement the optimal quantity of opaque projects? Would a policymaker ever allow for cycles?

In order to answer these questions, I begin by considering an abstract problem faced by a social planner who faces the same inference problem as the model's agents. There are two differences between the planner and private agents: first, the planner internalizes the effects of keeping bad firms in the pool, and second, the planner can circumvent the collateral constraints facing intermediaries.[17] I will analyze the properties of the planner's problem in the absence of shocks and then relate the planner's solution to realistic policies such as transparency regulations, public liquidity provision, and macroprudential policy. Analyzing the economy without shocks will permit me to analytically characterize the externality in this model and the policy that corrects it.

## 5.1 The planner's problem

The planner in this economy plays an *information design* role: he chooses how much information intermediaries will disclose about their projects. That is, for each intermediary $j$, the planner chooses a disclosure policy $F_j$ (which in principle allows the planner to mix between information structures rather than choosing just one). The information available to the planner is the same that would be available to an unskilled investor in the transparent regime. The planner can distinguish two types of projects: those for which skilled capital is available and those for which it is not. In turn, skilled capital is available to a project when skilled investors believe its net present value is positive, $\hat{\theta} z \geq 1 + r$, and those investors are patient. Otherwise, the planner does not observe the project's type. Hence, the planner chooses

1. A finite subset $\mathcal{F}_t^* \subset \mathcal{F}$ of disclosure policies, and a measure $m_{Ft}$ of intermediaries using disclosure policy $F$ for each $F \in \mathcal{F}_t^*$;

2. An investment policy $x_t(\tilde{\theta}|F) \in [0, 1]$, where

$$\tilde{\theta} = \begin{cases} \hat{\theta} & \text{Skilled investors are patient and } \hat{\theta} z \geq 1 + r \\ \alpha \overline{\theta} + (1 - \alpha) \mathbb{E}\left[\theta \middle| \hat{\theta} z \leq 1 + r\right] & \text{Otherwise} \end{cases}$$

[17] Implicit in this assumption is that the planner has a better ability to commit than private agents do. Any sort of tax or subsidy scheme requires some ability on behalf of the planner to promise repayments to agents.

Claims on projects sell at price $\tilde{\theta}z$. Hence, consumption on islands hit by the impatience shock is

$$c_{nt} = \begin{cases} \overline{k}_t(1 + \omega\,\mathbb{E}[x(\tilde{\theta}|F)(\tilde{\theta}z - 1)]) & \tilde{\lambda}_{nt} = \lambda \\ 0 & \tilde{\lambda}_{nt} = 1 \end{cases} \tag{23}$$

The capital stock grows according to the investment policy chosen by the planner. Thus

$$\overline{k}_{t+1} = (1+r)(\overline{k}_t - c_t) + \underbrace{\mathbb{E}[\omega(x_t(\tilde{\theta}|F)\tilde{\theta}z - (1+r))]\overline{k}_t}_{\text{Risky investment}}. \tag{24}$$

The economy grows due to investment in the risk-free technology and risky investment, which is determined by the planner's optimal policy.

The planner uses a utilitarian social welfare function to rank outcomes. Formally, the problem faced by the planner is

$$W = \max_{\mathcal{F}_t^*, m_{Ft}, x(\tilde{\theta}|F)} \mathbb{E}\left[\sum_{t=0}^{\infty} \beta^t \int_0^1 \tilde{\lambda}_{nt} c_{nt} dn\right] \text{ s.t.(23), (24)}. \tag{25}$$

That is, $W$ is just the weighted sum of the utilities achieved by all agents. I first show that at an optimum, the planner chooses a disclosure policy either transparency or opacity for each project.

**Proposition 8.** *At an optimum, the only disclosure policies that may be chosen for any project are a policy of full transparency or one of full opacity. Hence, the planner's problem reduces to choosing a fraction of opaque projects* $m_t^O \in [0,1]$.

## 5.2 The externality and optimal policy

I write the planner's problem in recursive form in order to characterize the externality in this environment. The main state variables in this problem are the aggregate capital stock $\overline{k}$ and the fraction of bad firms $\delta$. Due to the linearity of the technology, the planner's value function can be written as $V(\overline{k}, \delta) = v(\delta)\overline{k}$. The value function $v$ satisfies

$$\begin{aligned} V(\overline{k}, \delta) = \max_{\mu^O}\ & \lambda\big(1 + \omega m^O(\overline{\theta}z - 1)\big)\overline{k} + \beta\,\mathbb{E}[V(k', \delta')] \\ \text{s.t. } & k' = (1+r)(1 - \alpha(1 + \omega m^O(\overline{\theta}z - 1)))k + \omega\big(m^O\overline{\theta}z + (1 - m^O)(1-\alpha)\theta_G z\big)k \\ & \delta' = \kappa + (1-\kappa)\big(m^O(1-\theta_B) + (1-m^O)(\alpha + (1-\alpha)(1-\theta_G))\big)\overline{\theta} + (1-\kappa)m^O\theta_B\delta. \end{aligned}$$

This problem captures two tradeoffs. First, the planner understands that by choosing a greater fraction of opaque projects, investment is increased but at the cost of greater misallocation. This is essentially the same tradeoff faced by intermediaries: opacity increases their investment volume but prevents them from selling to skilled investors at a high price. This tradeoff is captured in the growth of the capital stock and in investors' consumption. However, the planner also understands that greater opacity has an effect on the fraction of bad firms in the economy. In particular, it allows more bad firms to survive, which can increase the fraction of bad firms going forward. There will be a role for policy because this tradeoff is not internalized by agents in the economy, who simply take the fraction of bad firms as given.

Intuitively, investors do not internalize that when they finance an opaque project whose quality they cannot evaluate, they may be keeping a bad firm alive to be financed by other investors later on, thereby lowering those investors' return on capital. This implies that investors are willing to pay a price for opaque assets that is too high, giving intermediaries too great of an incentive to produce such assets. Therefore, the equilibrium will feature too much creation of opaque, liquid assets, as formalized by the following proposition.

**Proposition 9.** *The optimum may feature a cycle with opaque and transparent regimes. When both the constrained optimum and the equilibrium feature a cycle, the cutoff $\delta^{*,sp}$ at which the planner stops the production of opaque assets is less than the equilibrium cutoff $\delta^{*,eqm}$.*

I provide a numerical example of the optimal policy compared to the equilibrium outcome in Figure 5. Just as in the equilibrium, the economy undergoes boom-bust cycles driven by private liquidity creation in the planner's social optimum. The reason such a "bang-bang" policy may be optimal is that a sharp bust can greatly cleanse the economy of bad firms for the following boom, allowing the economy to recover more. However, the optimal length of the boom is shorter than in equilibrium. This prevents crashes from being overly severe, since fewer bad firms accumulate in the economy.

The result that the constrained optimum may feature a cycle depends on agents' risk-neutrality, but the prescription that private liquidity creation should be reduced rather than increased is robust. This result can be interpreted as saying that the planner should lean against booms driven by private liquidity creation rather than financing firms that cannot borrow in busts, which resembles policies such as quantitative easing, when a central bank purchases risky assets on the open market to provide *public* liquidity to firms or financial intermediaries. Such a policy could keep bad firms alive for *longer* than they would survive in equilibrium, which would actually exacerbate the externality rather than counteracting it.

The externality in this model comes from short-term contracting: investors finance one of a firm's projects, but if the firm survives, it will raise funds in the future from other investors.

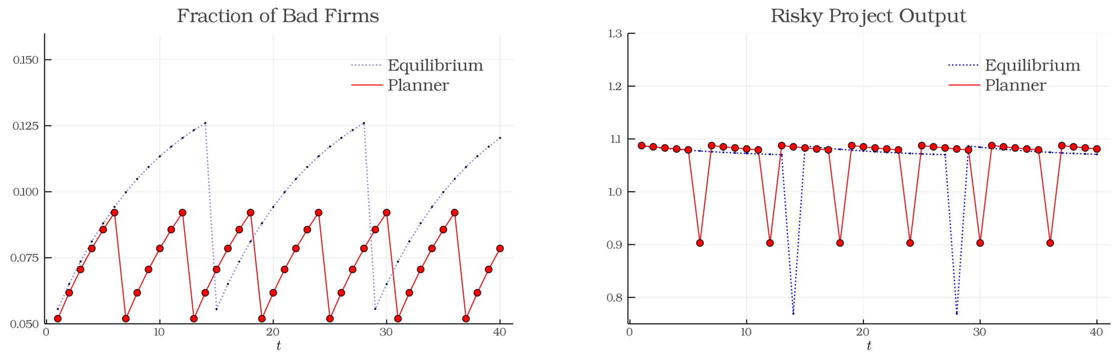


Figure 5: Fraction of bad firms (left panel) and output produced by risky projects per unit of capital in the economy (right panel). The equilibrium outcome is shown in blue, whereas the planner's constrained optimum is in red.

Thus, this is an information externality– one intermediary's decision to reveal information about a particular firm impacts the investment opportunities of investors who will finance the firm in the future under a different contract.

### 5.3 Implementation

I now discuss how the constrained optimum in the planner's optimization problem can be implemented using common tools. In fact, I show that there are several equivalent tools that the planner could use in order to achieve it. These tools are

1. *Transparency regulation*: A restriction $\overline{m}^O(\delta)$ on the fraction of projects that are financed through the issuance of opaque assets. That is, a fraction $1 - m^O(\delta)$ of intermediaries are required to disclose information in aggregate state $\delta$.

2. *Macroprudential policy*: A Pigouvian tax $\tau(\delta)$ on the origination of opaque assets (whose revenue is rebated back to investors in proportion to wealth).

3. *Monetary policy*: A subsidy to the interest rate $1 + r$ such that the return on storage faced by agents is $1 + \tilde{r}(\delta) \geq 1 + r$ (financed by a proportional wealth tax on agents).

A transparency regulation in the model is similar to what is seen in reality: the planner simply forces intermediaries to disclose information to investors about the projects they are financing. This generates adverse selection and reduces issuance volumes, but it prevents investors from financing projects whose quality they cannot identify and thus counteracts the externality in this environment.

I show that all of these tools are equivalent in terms of their ability to achieve the constrained optimum.

**Proposition 10.** *The constrained optimum can be achieved through a transparency regulation, macroprudential policy, or monetary policy. Transparency regulation may need to fluctuate over time, but it is always sufficient to use a macroprudential policy or monetary policy that is constant over time.*

Hence, each tool can be used to achieve the planner's policy objective. The common thread among all three tools is that they should be used to discourage the production of opaque, liquid assets. The one difference between the tools is that while a constant macroprudential policy or monetary policy suffices to moderate booms driven by private liquidity creation, transparency regulation must vary over time. In particular, the optimal transparency regulation may need to allow a boom to develop for some time before requiring information disclosure about projects. That is, opacity has social value that the planner would like to exploit. One interpretation of such a cyclical transparency policy is that an asset class must be allowed to develop for some time before bad projects build up to the point that transparency is required. After the implementation of transparency, issuance volumes and liquidity will decrease, but the boom is cut off before it could cause an even larger bust. The economy then proceeds towards a new boom, which can be interpreted as being driven by a different asset class (set of firms) that will later require regulation as well.

# 6 Conclusion

In this paper, I study the macroeconomic effects of the private production of opaque, liquid assets. I characterize the tradeoff governing the conditions under which this type of opaque intermediation can arise: on the one hand, opacity mitigates asymmetric information among investors, allowing unskilled investors to finance projects without fear of facing adverse selection. On the other, opacity prevents investors from uncovering bad projects, causing them to misallocate credit towards bad projects. During good times, when firms' projects tend to be profitable, opacity maximizes the expected value of a project because it ensures the project will always be financed when it is good. During bad times, by contrast, project value is maximized by transparency because it ensures the project will never be financed when it is bad.

I embed this mechanism in a dynamic macroeconomic model in order to study its implications for credit booms and busts. When economic fundamentals are strong, opaque intermediation is prevalent, permitting an expansion in the supply of credit and an increase in financial market liquidity but also leading to a deterioration of the quality of firms in the economy. As such, booms featuring an expansion in the supply of liquid assets, high credit volumes, and lax lending standards are followed by persistent slumps with fragmented financial markets, depressed credit, and tight lending standards. These dynamics amplify busts following transitory booms and can even produce fully endogenous cycles.

The optimal policy in the face of opaque intermediation involves restricting the quantity of opaque, private liquidity creation. This can involve transparency regulations, macroprudential tools, or even monetary policy. Increased transparency and taxes on the issuance of opaque assets lean against unskilled investment during booms, combating the build-up of bad projects brought about by opacity. The benefits of private liquidity creation are fully internalized by intermediaries in this model, so there is no particular reason for a policymaker to provide public liquidity. I interpret this result as a statement about the medium run, which is the frequency of financial cycle fluctuations that the model intends to capture.

A fruitful avenue to extend this paper's results would be a quantitative examination of the main mechanisms. In particular, the model implies that the issuance of opaque securities (i.e., the rise of certain types of intermediation) should predict subsequent credit busts during which issuance of those securities collapses. This prediction could confronted with data on privately produced liquid assets and the default rates of the underlying projects. Furthermore, the model implies a strong comovement between liquidity premia and the excess returns to skilled capital that could be tested by measuring the correlation between common measures of the liquidity premium and the return on sophisticated financial institutions' equity.

# Appendix

## Proofs for Section 3

**Proof of Lemma 1**:

*Proof.* Let $\lambda$ be the multiplier on investors' budget constraint, and let $\mu_j$ be the multiplier on the short-sale constraint for asset $j$ (with $\mu_0$ being the multiplier on the no-borrowing constraint $b \geq 0$). The first-order condition for investors' demand for asset $j$ is

$$\mathbb{E}[\theta_j Z | s_{ij}, \sigma_j, p_j] + \mu_j = \lambda p_j,$$

and the first-order condition on storage $b$ is

$$1 + \mu_0 = \lambda.$$

Each multiplier $\mu_j$ is either positive or zero (where positivity indicates that the corresponding constraint binds, $a_{Bj} = 0$), so the investor holds only assets such that

$$\frac{\mathbb{E}[\theta_j Z | s_{ij}, \sigma_j p_j]}{p_j} = \lambda,$$

where $\lambda \geq 1$ by the first-order condition for storage. If $R_i^* < 1$, then, the investor is never willing to purchase a positive quantity of any asset. □

**Proof of Lemma 2**

*Proof.* Note that the intermediary will always choose $x = \min\{1, p_j(a_S)a_S\}$ whenever it is profitable to invest. If the intermediary sells assets $a_S$ at price $p_j(a_S)$, its profits are

$$\theta_j(p_j(a_S) - 1)a_S.$$

Hence, the intermediary's problem reduces to

$$\max_{a_S} \; (p_j(a_S) - 1)a_S,$$

which does not depend on the intermediary's type. The intermediary must raise at least 1 per unit of assets that it sells, but it cannot pledge more than a fraction $\xi$ of each unit of assets created. Thus, it can invest only if there exists $a_S$ such that $\xi p_j(a_S) \geq 1$. Note that it is always optimal for the intermediary to invest a positive amount in this case, since the above simplification of the intermediary's problem shows that it is profitable for the intermediary to invest whenever it can sell at $p_j \geq 1$. □

**Proof of Proposition 1**:

*Proof.* In this section, I construct the model's equilibrium. I assume a symmetric equilibrium such that investors' demand schedules depend only on their signals $s$, their liquidity shocks $\tilde{\lambda}$, and the intermediary's disclosure policy $F$. Observe that under these conditions, aggregate demand for any particular asset will depend only on the signals of investors who are not hit by a liquidity shock. Therefore, the demand for an asset $j$ will depend on the signal $\hat{\theta}_j$ disclosed to skilled investors, the intermediary's disclosure policy $F_j$, and the liquidity shock $\tilde{\lambda}_{n(j)}$ of investors on its island.

Observe that skilled investors will purchase an asset $j$ only if (1) they are not hit by the liquidity shock, $\tilde{\lambda}_{n(j)} = 1$, and (2) their posterior of its quality is sufficiently high, $\hat{\theta}_j \geq \hat{\theta}^*(F_j)$ for some cutoff value $\hat{\theta}^*(F_j)$ that depends on the intermediary's disclosure policy $F_j$. In this case, these investors are willing to buy the entire stock of the asset as long as $p_j \leq \hat{\theta} z$ (their expected value of the asset). Thus, their demand curve is given by

$$a_B^S(p|\hat{\theta}, F, \tilde{\lambda} = 1) = \begin{cases} 0 & p > \hat{\theta} z \\ a_B^S(F) & p = \overline{\theta} z \\ \frac{e}{p} & p < \overline{\theta} z \end{cases}$$

for some constant $a_B^S(F)$ (which will be set such that asset markets clear).

Skilled investors do not finance the project when either their posterior of the project's quality is low enough, $\hat{\theta}_j < \hat{\theta}^*(F_j)$, or when they are impatient, $\tilde{\lambda}_{n(j)} = \lambda$. Then unskilled investors' expected value of the project's quality is

$$\hat{\theta}^U(F_j) = \frac{\alpha\overline{\theta} + (1-\alpha)\,\mathbb{E}[\hat{\theta}|\hat{\theta} < \theta^*(F_j)]}{\alpha + (1-\alpha)F_j(\hat{\theta}^*(F_j))}.$$

Unskilled investors' demand curve is given by

$$a_B^U(p|F) = \begin{cases} 0 & p > \hat{\theta}^U(F) \\ a_B^U(F) & p = \hat{\theta}^U(F) \\ 0 & p > \hat{\theta}^U(F) \end{cases}$$

for a constant $a_B^U(F)$. There is an indeterminacy in who actually purchases these assets, since everyone will observe the price in equilibrium and observe that the asset is good. However, this indeterminacy is irrelevant in determining aggregate outcomes.

Now I show that there is pooling in equilibrium: assets such that $\hat{\theta}_j < \theta^U(F_j)$ are pooled with all assets such that the corresponding skilled investors are impatient, $\tilde{\lambda}_{n(j)} = \lambda$). Investors hit by a liquidity shock must submit a demand of zero. Furthermore, skilled investors must submit a demand of zero at any price $p \geq \hat{\theta} z$. Hence, the demand for these assets must come from unskilled investors on surplus islands. This immediately implies that the demand schedules faced by intermediaries selling such assets must be identical. By Lemma 2, all these intermediaries must then supply the same quantity of assets. The entire supply is absorbed by investors on patient islands. Out of the assets available, a fraction $\frac{(1-\alpha)(1-\delta)}{(1-\alpha)(1-\delta)+\delta}$ are actually good. Therefore, these investors will break even if

$$p^U(F) = \frac{\alpha\overline{\theta} + (1-\alpha)\,\mathbb{E}[\hat{\theta}|\hat{\theta} < \hat{\theta}^*(F)]}{\alpha + (1-\alpha)F(\hat{\theta}^*(F))}.$$

It is simple to check that these demand schedules are optimal for investors. Further, they imply that each intermediary effectively faces a perfectly elastic demand schedule, making their problems relatively simple. When skilled investors are willing to finance the project, intermediaries can sell claims at price $p = \hat{\theta}z$, so the project is financed if $\xi\hat{\theta}z \geq 1$, and intermediaries sell $a_S(\hat{\theta}, F, \tilde{\lambda} = 1) = \frac{1}{\hat{\theta}z}$ assets and invest $x = 1$. When skilled investors are not willing to finance a project, intermediaries are able to sell claims to unskilled investors at price $p^U(F)$, so the project is financed whenever $\xi p^U(F) \geq 1$. Then intermediaries invest $x = 1$ and supply a quantity $a_S(\hat{\theta}, F, \tilde{\lambda}) = \frac{1}{p^U(F)}$ of assets.

Finally, I derive the quantities of assets demanded at each market-clearing price. First, I assume that agents on patient islands absorb the entire supply of assets from their islands, so if $\omega(F)$ is the fraction of projects with disclosure policy $F$, they must purchase a quantity $a_B^S(F) = \omega(F) \cdot F(\hat{\theta}^*(F))$ of assets. They also purchase all available assets from other islands, so $a_B^U(F) = \omega(F) \cdot \frac{\alpha+(1-\alpha)F(\hat{\theta}(F))}{1-\alpha}$.

□

**Proof of Proposition 2**

*Proof.* Note that there are two possibilities in equilibrium. Either the information structure chosen by the intermediary is such that the project can be financed by unskilled investors (so the intermediary can sell to those investors at price $p^U(F) \geq \xi^{-1}$), or it is such that the project is not financed by unskilled investors (so $p^U(F) < \xi^{-1}$). In the former case, the project is always financed. The intermediary sells claims on the project at price $p^U(F)$ when skilled investors are impatient and at price $\max\{p^U(F), p^S(\hat{\theta}, F)\}$. The value function of an intermediary can be written as

$$\begin{aligned}
v(F) &= \alpha\lambda\,\mathbb{E}[(p^U(F) - 1) \mid \tilde{\lambda} = \lambda] + (1-\alpha)\,\mathbb{E}[(\max\{p^U(F), p^S(\hat{\theta}, F)\} - 1) \mid \tilde{\lambda} = 1] \\
&\leq (1 + \alpha(\lambda - 1))\,\mathbb{E}[\max\{p^U(F), p^S(\hat{\theta}, F)\} - 1] \\
&= (1 + \alpha(\lambda - 1))(\overline{\theta}z - 1).
\end{aligned}$$

The last line uses the fact that $\mathbb{E}[\max\{p^U(F), p^S(\hat{\theta}, F)\}] = \overline{\theta}z$, since investors break even and the project is financed in every state (regardless of its quality). Hence, if the intermediary wishes to issue claims to unskilled investors, it can do no better than a policy of full opacity.

On the other hand, if the intermediary wishes to issue claims only to skilled investors, the project will be financed only when those investors expect it to have positive net present value and are patient. Then the intermediary always sells claims at $p^S(\hat{\theta}, F) = \hat{\theta}z$, and its value in this case is

$$v(F) = (1-\alpha)\,\mathbb{E}[(\hat{\theta}z - 1)^+].$$

The function inside the expectation on the right-hand side is a convex function of $\hat{\theta}z$. Thus, a distribution $F$ that provides a mean-preserving spread of $\hat{\theta}$ increases the intermediary's value. Therefore, in this case, a policy of full transparency is optimal.

□

**Proof of Proposition 3**:

*Proof.* First, observe that any symmetric static equilibrium must define a symmetric equilibrium of the asset market in the afternoon. This equilibrium is characterized in Proposition 1, and the relevant objects in the asset market equilibrium ($b(\tilde{\lambda})$, $a_B(p|\hat{\theta}, F, \tilde{\lambda})$, $x(p|\hat{\theta}, F, \tilde{\lambda})$, $a_S(p|\hat{\theta}, F, \tilde{\lambda})$, $p(a_S|\hat{\theta}, F, \tilde{\lambda})$, $\mathbb{E}[\cdot|\hat{\theta}, F, p]$) are derived in the proof of that proposition.

Let $O$ denote a disclosure policy of full opacity ($\hat{\theta} = \overline{\theta}$ with probability 1), and let $T$ denote one of full transparency ($\hat{\theta} = \theta$). In this equilibrium, the value of an opaque intermediary, $v_j = v(\theta_j, F_j = O, \tilde{\lambda}_{n(j)})$ is

$$v(\theta_j, F_j = O, \tilde{\lambda}_{n(j)}) = \tilde{\lambda}(p^O\xi - 1) + \theta_j z(1 - \xi),$$

where $p^O = \overline{\theta}$. This implies that

$$V^O = \mathbb{E}[v_j|F_j = O] = \big(1 + \xi\alpha(\lambda - 1)\big)(\overline{\theta}z - 1).$$

Let

$$\overline{p}^T = \theta_G z,\ \underline{p}^T = \frac{\alpha\overline{\theta} + (1-\alpha)\delta\theta_B}{\alpha + (1-\alpha)\delta}.$$

The value of a transparent intermediary is

$$v(\theta_j, F_j = T, \tilde{\lambda}_{n(j)}) = \begin{cases} \theta_G z - 1 & \theta_j = \theta_G \text{ and } \tilde{\lambda}_{n(j)} = 1 \\ \big(\lambda(\underline{p}^T\xi - 1) + \theta_G z(1-\xi)\mathbf{1}\{\underline{p}^T \geq \xi^{-1}\}\big) & \theta_j = \theta_G \text{ and } \tilde{\lambda}_{n(j)} = \lambda \\ \big(\tilde{\lambda}(\underline{p}^T\xi - 1) + \theta_B z(1-\xi)\big)\mathbf{1}\{\underline{p}^T \geq \xi^{-1}\} & \theta_j = \theta_B \end{cases}$$

After some algebra, this implies

$$V^T = \mathbb{E}[v_j|F_j = T] = (1-\alpha)(1-\delta)(\theta_G z-1)+\big(\alpha+(1-\alpha)\delta\big)\big(1+\xi\alpha(\lambda-1)\big)(\theta_U z-1)\mathbf{1}\{\theta_U z \geq \xi^{-1}\}.$$

Equations 3.3.1 and 3.3.1 imply that, whenever

$$\big(1 + \xi\alpha(\lambda - 1)\big)(\overline{\theta} - 1) \geq (1-\alpha)(1-\delta)(\theta_G z - 1),$$

opacity dominates transparency: as shown in Proposition 2, it is never optimal to choose transparency if the intermediary raises funds from unskilled investors.

In the opaque regime, there is trade in financial assets across islands, since opaque projects are always financed even when investors on the same island have no funds. Projects are financed regardless of quality because no investor can tell if opaque projects are good or bad.

If

$$\big(1+\xi\alpha(\lambda-1)\big)(\overline{\theta}-1) < (1-\alpha)(1-\delta)(\theta_G z-1),$$

on the other hand, the value of a transparent intermediary is strictly higher than that of an opaque intermediary, so in that region, investors will lend capital only to transparent intermediaries. Furthermore, since $\theta_U z < 1 < \xi^{-1}$, transparent intermediaries will never be able to profitably finance their investments by selling assets to unskilled investors, since that would require instead that $\theta_U z \geq \xi^{-1}$ (Proposition 1). In the transparent regime, then, there is no trade in financial assets across islands. All intermediaries are transparent, so they are able to finance investment by selling assets to investors on their own islands only when their projects are good.

□

**Proof of Proposition 4**:

*Proof.* The opaque regime consists precisely of the pairs $(Z, \delta)$ such that

$$(1+\xi\alpha(\lambda-1))((1-\delta)\theta_G z+\delta\theta_B z-1) \geq (1-\alpha)(1-\delta)(\theta_G z-1).$$

Letting $\hat{\lambda} = 1+\xi(\lambda-1)$ and rearranging, we obtain

$$\alpha\hat{\lambda}(1-\delta)(\theta_G z-1) \geq (1-\alpha)\delta(1-\theta_B z) \Rightarrow \delta \leq \frac{\alpha\hat{\lambda}(\theta_G z-1)}{\alpha\hat{\lambda}(\theta_G z-1)+(1+\alpha(\hat{\lambda}-1))(1-\theta_B z)},$$

as claimed. Note that, equivalently, the transparent regime obtains whenever

$$z \leq z^* = \frac{\alpha\hat{\lambda}+(1-\alpha)\delta}{\alpha\hat{\lambda}(1-\delta)\theta_G+(1+\alpha(\hat{\lambda}-1))\delta\theta_B}.$$

□

## Proofs for Section 4

**Proof of Proposition 5**:

*Proof.* We first outline properties that the solution to the investor's problem must satisfy if it exists. In fact, we will show that the solution to the investor's problem is essentially unique. When an investor is patient, she will never consume because the rate of return on the risk-free technology satisfies $\beta(1+r) > 1$. On the other hand, when the investor is impatient at $t$, in order to justify postponing consumption until a later date $\tau > t$ it must be that

$$\max_{\tau} \mathbb{E}_t[\beta^{\tau-t} w_\tau] \geq \lambda w_t.$$

Note first that $\tilde{\lambda}_\tau$ must be equal to $\lambda$, since the investor cannot consume at any time such that $\lambda = 1$. Next, define $\zeta = \max\{\theta_G \overline{z}, 1+r\}$. An investor's expected wealth at time $\tau$ must satisfy $\mathbb{E}_t[w_\tau] \leq \zeta^{\tau-t}$ (since the price of a claim on a project cannot be less than one if an intermediary is able to finance its investment, and the maximum possible payoff of such a claim is $\theta_G \overline{z}$). It is enough to check that the investor is not better off simply by waiting until the next time a liquidity shock arrives. We have

$$\begin{aligned}
\mathbb{E}_t[\beta^{\tau-t} w_\tau] &= \sum_{\tau=t+1}^{\infty} (1-\alpha)^{\tau-t-1} \beta^{\tau-t} \alpha \, \mathbb{E}_t[w_\tau] \\
&\leq \sum_{\tau=t+1}^{\infty} (1-\alpha)^{\tau-t-1} \beta^{\tau-t} \zeta^{\tau-t} \alpha w_t \\
&= \frac{\alpha}{1-(1-\alpha)\beta\zeta} w_t
\end{aligned}$$

Then, if

$$\frac{\alpha}{1-(1-\alpha)\beta\zeta} < \lambda,$$

it is optimal for the investor to consume immediately.

Next, we show that the investor's problem is well defined. Our previous result showed that the investor consumes at the first time $t$ such that $\tilde{\lambda}_{nt} = \lambda$. Denote this time by $\tau \geq 0$. Then, the value achieved by an investor with initial wealth $w_0$ is

$$\lambda \, \mathbb{E}[\beta^\tau w_\tau] = \lambda \sum_{t=0}^{\infty} (1-\alpha)^t \beta^t \alpha \, \mathbb{E}[w_t | \tau = t].$$

Next, observe that no matter what sequence of states arises, the investor's return on wealth within a period cannot exceed $\zeta \equiv \max\{\theta_G \overline{z}, 1+r\}$ (since the price of a claim on a project cannot be less than one if an intermediary is able to finance its investment, and the maximum possible payoff of such a claim is $\theta_G \overline{z}$). Hence, $\mathbb{E}[w_t | \tau = t] \leq \zeta^t w_0$. We then have

$$\lambda \, \mathbb{E}[\beta^\tau w_\tau] \leq \left( \sum_{t=0}^{\infty} (1-\alpha)^t \beta^t \zeta^t \right) \alpha \lambda w_0 = \frac{1}{1-(1-\alpha)\beta\zeta} \alpha \lambda w_0,$$

since we have assumed $(1-\alpha)\beta\zeta < 1$ in the statement of the proposition. Thus, the investor's value is finite and her problem is well-defined.

□

**Proof of Proposition 6**:

*Proof.* As shown in the proof of the previous proposition, within a period, investors simply try to maximize their returns on wealth. Investors' problems in a period are therefore identical to those in the static model, with the exception of the fact that the returns on storage are equal to $1 + r$ rather than 1. The solutions to their decision problems in the dynamic model are then identical to the solutions to those problems in the static model. Likewise, intermediaries make their decisions so as to maximize returns in the same way as in the static model.

Thus, all decision-makers act in the same way within a period. Plugging in the decisions, prices, and expectations from the static equilibrium, then, we again obtain optimization and market clearing in the dynamic model, so the equilibrium within a period coincides with the symmetric static equilibrium.

□

**Proof of Proposition 7**:

*Proof.* Observe that if $\delta_h < \delta^*$, then when $\delta_t = \delta_h$, the economy is in the opaque regime, and the fraction of bad firms in the next period satisfies

$$\begin{aligned}\delta_{t+1} &= (\mu_G(1-\delta_h) + \mu_B^O\delta_h)\overline{\delta} + (1-\mu_B^O)\delta_h \\ &= \delta_h - (\mu_B^O(1-\overline{\delta}) + \mu_G\overline{\delta})\delta_h + \mu_G\overline{\delta} \\ &= \delta_h - \mu_G\overline{\delta} + \mu_G\overline{\delta} = \delta_h\end{aligned}$$

so $\delta_h$ is a steady state.

Similarly, if $\delta_l > \delta^*$, whenever $\delta_t = \delta_l$, the economy is in the transparent regime, and we have

$$\begin{aligned}\delta_{t+1} &= (\mu_G(1-\delta_l) + \mu_B^T\delta_l)\overline{\delta} + (1-\mu_B^T)\delta_l \\ &= \delta_l - (\mu_B^T(1-\overline{\delta}) + \mu_G\overline{\delta})\delta_l + \mu_G\overline{\delta} \\ &= \delta_l - \mu_G\overline{\delta} + \mu_G\overline{\delta} = \delta_l\end{aligned}$$

so $\delta_l$ is a steady state.

Finally, if $\delta_l < \delta^* < \delta_h$, neither $\delta_l$ nor $\delta_h$ is a steady state. For $\delta_t \in [\delta_l, \delta^*)$, the law of motion is

$$\delta_{t+1} = \left(1 - (\mu_G(1-\overline{\delta}) + \mu_B^O\overline{\delta})\right)\delta_t + \mu_G\overline{\delta} \equiv \zeta^O\delta_t + \Delta$$

whereas for $\delta_t \in (\delta^*, \overline{\delta}]$, the law of motion is

$$\delta_{t+1} = \left(1 - (\mu_G(1-\overline{\delta}) + \mu_B^T\overline{\delta})\right)\delta_t + \mu_G\overline{\delta} \equiv \zeta^T\delta_t + \Delta.$$

Hence, we get a linear law of motion for $\delta$ with $0 < \zeta^T < \zeta^O < 1$. Whenever $\delta_t$ is in the opaque regime, $\delta_{t+1} > \delta_t$, and whenever it is in the transparent regime, $\delta_{t+1} < \delta_t$.

In order to proceed, it will be useful to define the following:

$$\hat{\delta}_{T,1} = \frac{\delta^* - \Delta}{\zeta^T},\ \hat{\delta}_{T,n+1} = \frac{\hat{\delta}_{T,n} - \Delta}{\zeta^T},$$

$$\hat{\delta}_{O,1} = \frac{\delta^* - \Delta}{\zeta^O}, \hat{\delta}_{O,n+1} = \frac{\hat{\delta}_{O,n} - \Delta}{\zeta^O}.$$

Note that since $\zeta^T\delta^* + \Delta < \delta^* < \zeta^O\delta^* + \Delta$ by assumption, it must be the case that $\hat{\delta}_{O,1} < \delta^* < \hat{\delta}_{T,1}$, and by the continuity of the law of motion on either side of $\delta^*$, $\hat{\delta}_{O,n}$ is decreasing in $n$ and $\hat{\delta}_{T,n}$ is increasing in $n$. We will define the intervals $I_{O,n} = [\hat{\delta}_{O,n}, \hat{\delta}_{O,n-1}]$ and $I_{T,n} = [\hat{\delta}_{T,n-1}, \hat{\delta}_{T,n}]$ for $n \geq 1$, where it is understood that $\hat{\delta}_{O,0} = \hat{\delta}_{T,0} = \delta^*$.

By definition, whenever $\delta_t \in I_{O,n}$ for $n > 1$, then $\delta_{t+1} \in I_{O,n-1}$. Furthermore, $\delta_{t+1} > \delta^*$ when $\delta_t \in I_{O,1}$. Similarly, whenever $\delta_t \in I_{T,n}$ for $n > 1$, then $\delta_{t+1} \in I_{T,n-1}$, and when $\delta_t \in I_{T,1}$, we have $\delta_{t+1} < \delta^*$.

We first look for a cycle that transits the opaque regime for only one period. In order for this to occur, it must be that for all $\delta > \delta^*$, $\zeta^T\delta + \Delta \in I_{O,1}$. We will show that there exists a cycle with an initial point $\delta_0 \in I_{O,1}$. As noted previously, $\delta^+(\delta_0) > \delta^*$. There must be some finite number $n(\delta_0) + 1$ such that $\delta^{+(n(\delta_0)+1)}(\delta_0) \in I_{O,1}$, then, since if $\delta^+(\delta_0) \in I_{T,n}$ for some $n$, then, $\delta^{+k}(\delta_0) \in I_{T,n(\delta_0)-k+1}$ for $k \leq n(\delta_0) + 1$. Denote $G(\delta) = \delta^{+(n(\delta)+1)}$ for $\delta \in I_{O,1}$. We have that $G(\delta)$ is continuous in $\delta$ because $\delta^+(\delta_0)$ is continuous and the law of motion $\delta^+(\cdot)$ is continuous in the region $\delta > \delta^*$. Then observe that $G(\delta^*)$ must be less than $\delta^*$, since it lies in the interval $I_{O,1}$, and by the same token $G(\hat{\delta}_{O,1}) > \hat{\delta}_{O,1}$. There must then exist some $\delta_0^{**}$ such that $G(\delta_0^{**}) = \delta_0^{**}$. The sequence $\{\delta_0^{**}, \delta^+(\delta_0^{**}), \ldots, \delta^{+k}(\delta_0^{**}), \ldots, \delta^{+n(\delta_0)}(\delta_0^{**}), \delta_0^{**}\}$ is then an equilibrium cycle of length $n(\delta_0^{**})$.

I omit the proof, but by exactly analogous reasoning it follows that whenever $\delta^+(\delta^*) \in I_{T,1}$, then there is a cycle that transits the transparent regime for one period and remains in the opaque regime in all other periods.

Observe that as $z$ increases, $\delta^*$ increases as well, but $\delta_h$ and $\delta_l$ remain fixed. In particular, $\delta^*$ is an increasing function of $z$, so there is $\underline{z}$ such that $\delta_l = \delta^*$ and $\overline{z}$ such that $\delta_h = \delta^*$. These threshold values of $z$ satisfy the conditions required by the proposition.

□

## Proofs for Section 5

### Proof of Proposition 8

*Proof.* When the planner chooses an investment policy $x(\tilde{\theta}|F)$, the relevant tradeoff is investment in the project versus investment in the risk-free technology. This is because impatient investors consume all of their funds, and patient investors must save all of their funds, so there is no tradeoff between investment in a particular project and consumption. Then it is optimal to finance a project only if its expected return (from the planner's perspective) is at least $1 + r$.

The expected returns on a project given the planner's information $\tilde{\theta}$ are just $\tilde{\theta}z$. It is therefore optimal to fully finance a project whenever $\tilde{\theta}z \geq 1 + r$, so

$$x(\tilde{\theta}|F) = \begin{cases} 1 & \tilde{\theta}z > 1 + r \\ \in [0, 1] & \tilde{\theta}z = 1 + r \\ 0 & \tilde{\theta}z < 1 + r \end{cases}$$

Furthermore, observe that the lowest possible value that $\tilde{\theta}$ can take is $\tilde{\theta}_{\min} \equiv \alpha\overline{\theta} + (1 - \alpha)\,\mathbb{E}_F[\theta|\hat{\theta}z < 1 + r]$.

There are two possibilities. First, assume that $F$ is such that $\tilde{\theta}_{\min}z < 1 + r$. Then the project is not financed whenever $\hat{\theta}z < 1 + r$ or whenever skilled investors are impatient. The expected returns on the project are

$$\mathbb{E}[\theta z \cdot x(\tilde{\theta}|F)] = (1 - \alpha) \int_{\frac{1+r}{z}}^{\theta_G} \hat{\theta} z dF(\hat{\theta}) \leq (1 - \alpha)(1 - \delta)\theta_G z.$$

The probability that a bad firm survives is

$$\mathbb{E}[\Pr(\theta = \theta_B)\mathbf{1}\{\hat{\theta} \geq \frac{1 + r}{z})\}] = \int_{\frac{1+r}{z}}^{\theta_G} \frac{\theta_G - \hat{\theta}}{\theta_G - \theta_B} dF(\hat{\theta}) \geq 0.$$

Notice that it is possible to earn returns $(1 - \alpha)(1 - \delta)\theta_G z$ under full transparency while ensuring that no bad firm survives. Therefore, an information structure of full transparency dominates any information structure $F$ such that it is optimal to finance the project when skilled investors do not choose to do so.

Second, it may be that $F$ is such that $\tilde{\theta}_{\min}z \geq 1 + r$. In this case, the project is financed regardless of its quality. Thus, a policy of opacity must at least weakly dominate such an information structure $F$. Along with the previous result, this observation implies that we may restrict attention to policies in which the planner chooses only fully opaque or fully transparent projects.

□

**Proof of Proposition 9**:

*Proof.* Figure 5 shows by example that cycles can emerge as an outcome under the planner's solution. If the constrained optimum features a cycle, there exists $\delta^{*,\mathrm{sp}}$ such that the planner chooses opaque projects only for $\delta < \delta^{*,\mathrm{sp}}$ and transparent projects only for $\delta \geq \delta^{*,\mathrm{sp}}$.

First, we define a fictitious planner's problem in which the planner does not take into account the evolution of $\delta$, and we prove that the outcome under the solution to this problem coincides with the equilibrium outcome. Then, we show that since the planner takes into account the evolution of $\delta$, it must be optimal to switch to the transparent regime for a lower value of $\delta^*$ than under the fictitious planner's problem.

In recursive form, the fictitious planner's problem for an exogenous threshold $\delta^*$ is

$$
\begin{aligned}
V(k,\delta) = \max_{m^O} \;& \lambda\alpha k(1+\omega m^O(\overline{\theta}z-(1+r))) + \beta V(k',\delta') \text{ s.t. } \delta' = \zeta(\delta|\delta^*)\delta + \Delta, \\
& k' = (1+r)(1-\alpha(1+\omega m^O(\overline{\theta}z-(1+r))))k \\
& + \omega(m^O(\overline{\theta}z-(1+r)) + (1-m^O)(1-\alpha)(\theta_G z-(1+r)))k
\end{aligned}
$$

where $\zeta(\delta|\delta^*) = \zeta_T$ if $\delta \geq \delta^*$ and $\zeta(\delta|\delta^*) = \zeta_O$ otherwise.

□

**Proof of Proposition 10**:

*Proof.* I outline how each of the three types of policy tools is formally represented in the model and then prove that each can achieve the constrained optimum when the planner's optimum and the equilibrium both feature a cycle.

**Transparency regulation**: Under a transparency regulation, the planner can directly ban the creation of opaque, liquid assets. That is, the planner can specify regions of the state space $\delta \in [0,1]$ such that creating opaque assets is not allowed. If the planner bans the production of opaque assets for all $\delta \geq \delta^{*,\mathrm{sp}}$, then the constrained optimum is implemented. The optimal policy must fluctuate over time, since there are states in which no transparency regulation is needed and others in which it is.

**Macroprudential policy**: Macroprudential policy corresponds to the imposition of a tax $\tau(\delta)$ on the origination of opaque assets (that is, a tax on the profits of intermediaries that produce such assets). I will show that a flat tax $\tau$ is sufficient to implement the constrained optimum.

With a tax $\tau$, an intermediary's value under opacity is

$$v^O(\delta, \tau) = (1-\tau)(1+\alpha(\lambda-1))(\overline{\theta}z - (1+r)),$$

whereas its value under transparency is

$$v^T(\delta) = (1-\alpha)(\theta_G z - (1+r)).$$

The threshold $\delta^*(\tau)$ at which the economy transitions from the opaque regime to the transparent one satisfies $v^O(\delta, \tau) = v^T(\delta)$. For $\tau = 1$, an opaque intermediary's profits are equal to zero, so $\delta^*(1) = 0$. For $\tau = 0$, the equilibrium outcome arises. Since $\delta^*(\tau)$ is continuous, there must exists some $\tau^* \in (0, 1)$ such that $\delta^*(\tau^*) = \delta^{*,\text{sp}} < \delta^{*,\text{eqm}}$.

**Monetary policy**: Monetary policy is a subsidy to investment in the risk-free technology, so that investors perceive a return $\tilde{r}(\delta) > r$. Again, I show that it is possible to implement the constrained optimum under a fixed interest rate $\tilde{r}(\delta) = \tilde{r}$. In this case, the intermediary's value under opacity is

$$v^O(\delta, \tilde{r}) = (1+\alpha(\lambda-1))(\overline{\theta}z - (1+\tilde{r}))$$

and its value under transparency is

$$v^T(\delta, \tilde{r}) = (1-\alpha)(\theta_G z - (1+\tilde{r})).$$

As shown previously, the threshold value $\delta^*(\tilde{r})$ at which the economy transitions from the opaque regime to the transparent regime satisfies

$$\delta^*(\tilde{r}) = \frac{\alpha\lambda(\theta_G z - (1+\tilde{r}))}{\alpha\lambda(\theta_G z - (1+\tilde{r})) + (1+\alpha(\lambda-1))(1+\tilde{r}-\theta_B z)}.$$

Observe that the right-hand side is continuous, decreasing in $\tilde{r}$, and can become arbitrarily negative. Thus, there must exist some $\tilde{r}^*$ such that $\delta^*(\tilde{r}) = \delta^{*,\text{sp}} < \delta^{*,\text{eqm}}$.

□