Opaque Intermediation and Credit Cycles*

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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 prevent the subsequent bust by implementing transparency regulations and macroprudential policies.

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

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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 two tools: transparency regulation, which alters the information structure available to investors by restricting the quantity of opaque projects in the economy, and taxes on asset origination, which ensure that transparent intermediaries do not seek funds from unskilled investors when skilled capital is unavailable. In turn, I discuss how these taxes resemble commonly used macroprudential policies. 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, they show that in their environment, cycles are constrained optimal, whereas in mine, the planner always stabilizes the economy.

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 are two types of goods: a storable consumption good (c) and capital (k). 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. There are also two types of intermediaries that may enter freely on each island in the morning: *transparent* intermediaries and *opaque* intermediaries. All agents are risk-neutral and do not discount.

Firms: Firms run *projects* that use an investment technology similar to that in Hölmstrom and Tirole (1998). In the morning, firms will borrow some capital $k_j \leq 1$ from intermediaries.[5] In the afternoon, each firm has an opportunity to invest $xk_j \geq 0$ goods in its project to produce

$$\varphi(x)k_j = \min\{x, 1\}Zk_j$$

goods in the evening if the investment is *successful*, and 0 if it fails. The project's capital depreciates in use. 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 δ are bad. The probability θ_j that a firm's investment 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 θ_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 by firms' projects and to mediate the information about the underlying projects that is available to investors. On each island n, intermediaries enter freely in the morning and may be matched with a single firm. Transparent and opaque intermediaries differ in their *disclosure technologies*. I denote the disclosure technology of the intermediary matched to firm j by $\sigma_j \in \{T, O\}$. The information revealed to investors about a firm's quality in the afternoon will be determined by the type of intermediary matched with the firm. Firms are

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

incapable of otherwise credibly communicating their types to other agents in the economy.

After matching with a firm, an intermediary borrows capital from investors in order to lend it to that firm. At this point, 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 capital $\overline{k}_0 = 1$ in the morning and lend it to intermediaries on the same island. In the afternoon, investors will receive endowments of goods that are heterogeneous across islands: a fraction α of islands receive a large endowment $\tilde{e}_n = e$,[7] while a complementary fraction $1-\alpha$ of islands receive an endowment $\tilde{e}_n = 0$. Islands that receive the high endowment will be called *surplus islands*, and those that receive the low endowment will be *deficit islands*. After receiving their endowments, 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 revealed by intermediaries.[8] The structure of the signal will be determined by the type of intermediary (transparent or opaque) 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.

Transparent intermediaries use a disclosure technology that makes the firm's file publicly available in the afternoon. 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*.

Opaque intermediaries use a disclosure technology that renders the file unreadable to any agent in the economy. Investors will gain no information at $\tau = 1$ about firms that

[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] I assume that $e \geq \theta_G Z$, which implies that the aggregate endowment is large enough to finance all projects. Furthermore, in equilibrium investors with funds will always break even in the afternoon.

[8] 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).

borrow from opaque intermediaries. Opacity therefore precludes information asymmetries across islands.

Formally, I assume that when firm j's project is transparent, skilled investor i receives a signal $s_{ij} \in \{G, B, N\}$ (good, bad, or neutral) of the form

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

Investors on island n learn the firm's type, and all others receive an uninformative signal. When firm j's project is opaque, all investors i receive the uninformative signal, $s_{ij} = N$.

In addition to potentially having private information about the quality of firms financed by transparent intermediaries, all agents on an island n are also privately informed of their endowments. 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 have no funds or because they have identified the firm as bad. This inference problem will give rise to adverse selection in equilibrium.

Everyone can observe whether a firm borrows from a transparent or opaque 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 and make the firm's file publicly available. Opacity will then serve as a public signal that no investor knows the quality of a firm's project. I will directly refer to the project of a firm that borrows from an opaque (transparent) intermediary as an opaque (transparent) 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' endowments will therefore generate a need to trade claims on projects across islands: goods will need to flow from those that receive the high endowment to those that do not. 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.[9] 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

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

[9] 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.

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

Financial assets: There are two types of financial assets available to investors. First, there are 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 opaque (transparent) intermediary as an opaque (transparent) asset.

Intermediaries will also issue equity claims in the morning to investors on their own island so that they may purchase capital and install it in the firm's project. Equity claims pay the intermediary's residual value in the evening and do not trade in the afternoon.[10] In particular, investors will only be able to use their own endowments to purchase assets in the afternoon, and intermediaries will be the sole suppliers of assets.

Timing: In the morning, intermediaries enter and match with firms, then issue claims to investors to finance purchases of capital. In the afternoon intermediaries 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.

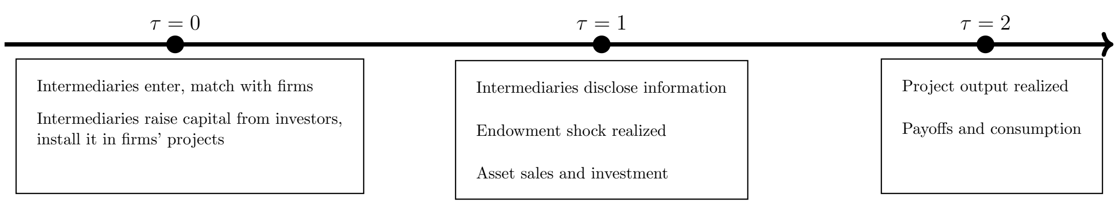

Figure 1: Timeline of the static model.

I will 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

[10] What matters is that these claims do not trade across islands, which is consistent with the fact that only a fraction ξ of a project's output may be pledged across islands. This assumption is convenient but not essential for the main results.

on the same "island") and others who do not. I interpret intermediaries as entities that issue 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.[11] The corresponding opaque intermediary would be the shadow bank 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).

There are two key features of this environment. First, islands are heterogeneous in both their endowments 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 lack the funds required to take advantage of all profitable investment opportunities. 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 endowments 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.[12]

The second important feature of the environment is that the output of intermediaries' projects is not fully pledgeable across islands. This feature is central to the model's main mechanism: it creates a wedge between the returns to investment by the intermediary and the returns that can be promised to outside investors. As I show later, in the presence of a pledgeability constraint, there is a motive for the intermediary to hide information so as to overcome the adverse selection problem described above and ensure its liabilities sell at a high enough price to allow for investment. This assumption will effectively generate a collateral constraint for intermediaries in the afternoon, forcing them to keep a positive stake in their project in order to borrow from investors on other islands. Exogenous collateral constraints

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

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

are typical in the macro-finance literature and can reflect, for instance, the margin constraints commonly observed for securities traded in capital markets.[13]

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.

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 θ_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 $\tilde{e}_n$.

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 technology σ_j used by the associated intermediary (transparent or opaque), 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.[14] 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.

[13] See, for instance, Kiyotaki and Moore (1997), who micro-found the collateral constraint as resulting from the borrower's inability to commit his human capital to the project.

[14] 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.

3.1.1 Investor's problem

Investors solve a portfolio choice problem. They form expectations $\mathbb{E}[\theta_j|s_{ij}, \sigma_j, p_j]$ 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 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.[15] Consistent with the assumption of limited commitment, they may not short assets. The problem of an investor on island n is

$$\max_{b, a_{Bj}} b + \int_j \mathbb{E}[\theta_j Z|s_{ij}, \sigma_j, p_j] a_{Bj} dj \tag{5}$$
$$\text{s.t. } b + \int_j p_j a_{Bj} dj \leq \tilde{e}_n, \ b \geq 0, \ a_{Bj} \geq 0 \ \forall \ j.$$

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,*

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

If $R_i^* > 1$, they invest their entire endowment among such assets. If $R_i^* = 1$, they are indifferent between consuming and investing in those assets. Otherwise, they store their entire endowment.

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 technology σ_j), the type of its project θ_j (if it is transparent), and the endowment of skilled investors on its island $\tilde{e}_{n(j)}$.[16] I will show that in equilibrium, the form of this price schedule will be unimportant,

[15] In principle, the investor could consume some of her endowment at $\tau = 1$ as well. Investors are always indifferent between consumption and storage, so to streamline the exposition I assume any funds not invested in assets sold by intermediaries are sold.

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

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 corresponding island have no funds 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 $xk_j \leq \min\{1, p_j(a_S)a_S\}k_j$ (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 ξ 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

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

Here v_j denotes the value per unit of capital of 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 ξp_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 for transparent projects, 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 6), 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 θ_j, the intermediary's disclosure technology σ_j, and the endowment $\tilde{e}_{n(j)}$ of investors on the corresponding island. The following proposition characterizes the unique equilibrium satisfying these properties.

Proposition 1. *There exists a symmetric equilibrium such that*

- *Opaque assets trade at price $p^O = \overline{\theta} Z$. All opaque intermediaries invest.*
- *Good transparent assets on islands that receive the high endowment sell at price $\overline{p}^T = \theta_G Z$ to skilled investors on the same island. Projects backing such assets are always financed.*
- *Good transparent assets on islands receiving the low endowment, as well as all bad transparent assets, have price $\underline{p}^T = \frac{(1-\alpha)(1-\delta)\theta_G + \delta\theta_B}{(1-\alpha)(1-\delta)+\delta} Z$. If $\underline{p}^T < \frac{1}{\xi}$, the underlying projects are not financed. If $\underline{p}^T \geq \frac{1}{\xi}$, all such projects are financed by unskilled investors on other islands.*

The equilibrium in the asset market will highlight the central tradeoff between assets' market liquidity and the misallocation of real investment in this model. There will be gains from trading across islands, but, at least in markets for transparent assets, adverse selection can preclude these gains from being realized. Opacity will eliminate adverse selection concerns, but, on the other hand, will prevent skilled investors from avoiding misallocation of

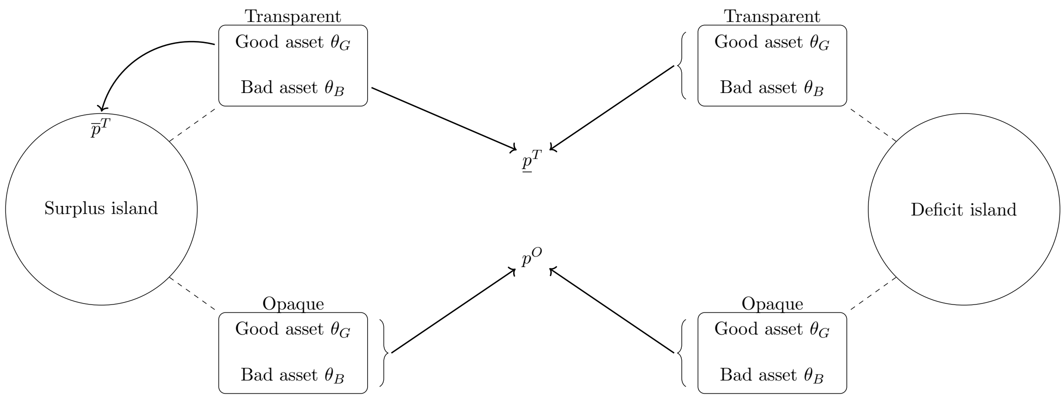

Figure 2: An illustration of the equilibrium described in Proposition 1. Good transparent projects on surplus islands are purchased by agents with the skill to evaluate them (on the same island) at price $\overline{p}^T$, whereas other assets trade across islands (at prices p^O for opaque assets and $\overline{p}^T$ for transparent ones).

funds towards bad projects. Figure 2 illustrates the structure of this equilibrium, which I describe below.

The structure of the equilibrium reflects that investors on surplus islands hold the entire endowment of goods, so they must finance all projects: both those that they have the expertise to evaluate (on their own islands) and those that they do not (on deficit islands). In aggregate, the endowment is sufficient to pursue all investment opportunities. Therefore, investors with funds must break even. No agent has any information about opaque assets, so these trade at price

$$p^O = \overline{\theta} Z. \tag{7}$$

Claims on opaque projects are *fully liquid* in the sense that they trade at their expected value (given any investor's information set). Opaque intermediaries are able to finance their projects, $\xi p^O \geq 1$ (Equation 4), so they will invest regardless of the quality of their projects. This implies there will be *misallocation* of funds towards all bad opaque projects.

In what follows, it will be useful to define two sets of transparent intermediaries. Set S will be the set of intermediaries that can finance their projects by selling claims to skilled investors (i.e., those on the same island). For a transparent intermediary, this is possible only if its project is good *and* the corresponding skilled investors receive the high endowment ($\theta_j = \theta_G$ and $\tilde{e}_{n(j)} = \frac{e}{\alpha}$). Skilled investors break even, so the intermediary is able to sell assets at their expected value from the point of view of those investors,

$$\overline{p}^T = \theta_G Z. \tag{8}$$

Henceforth, I refer to intermediaries in S as having *access to skilled capital.*

The other set of intermediaries, U, will consist of those that must rely on unskilled capital, which are those with bad projects *or* those on deficit islands ($\theta_j = \theta_B$ or $\tilde{e}_{n(j)} = 0$). Note that unskilled investors cannot discern why an intermediary lacks access to skilled capital– they do not know whether it is selling claims on a bad project or whether the investors with the skill to evaluate its project have no funds. The equilibrium will therefore feature a sort of *pooling*: all intermediaries that lack access to skilled capital will have to sell assets at the same price, regardless of why they are unable to sell to skilled investors. This inference problem will be key in generating adverse selection and illiquidity.

A measure $(1-\alpha)(1-\delta)$ of transparent intermediaries with good projects will lack access to skilled capital because investors with the skill to evaluate the project's quality have no funds, whereas a measure δ must sell to unskilled investors because skilled investors identify the underlying project as bad. From the perspective of an unskilled investor, the expected quality θ of a project, given that the corresponding intermediary does not have access to skilled capital, is then

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

Claims on such projects will sell at price $\theta_U Z$, which is equal to the low price $\underline{p}^T$ defined in Proposition 1.

The inference problem faced by unskilled investors leads to *illiquidity* for transparent assets: some good assets trade at a price lower than what their expected value from the perspective of the most informed investor. If the price $\underline{p}^T$ faced by intermediaries without access to skilled capital is high enough that they may invest (i.e., $\xi\underline{p}^T \geq 1$ by Lemma 2), illiquidity is *partial.* In this case less informed investors (who do not have the skills required to evaluate those particular assets) actually purchase claims at $\underline{p}^T$ and finance intermediaries' projects. Note that if there is partial illiquidity, then all transparent intermediaries selling claims on bad projects are able to invest, so there will be misallocation towards bad projects regardless of the adverse selection problem. On the other hand, if $\xi\underline{p}^T < 1$, transparent projects are *fully illiquid*: they are never purchased by any agent without the skill to identify their quality. In the case of full illiquidity, then, claims on transparent projects are never traded across islands, but there is never misallocation towards a bad transparent project. This is the case that will arise in equilibrium.

Finally, note that in a symmetric asset market equilibrium, the value of an intermediary v_j, defined in the intermediary's problem (Problem 6), depends only on the intermediary's disclosure technology σ_j, the type of its project θ_j, and the endowment on its island $\tilde{e}_{n(j)}$. Together, these determine at what price the intermediary may sell assets and whether it is able to invest.

3.2 Morning: Intermediary entry

In the morning, intermediaries enter and are matched with firms. If the measure of intermediaries that enters on an island is greater than the measure of firms, some intermediaries will be left unmatched and exit.[17] Matched intermediaries then issue claims on their equity to investors and use the proceeds to purchase capital to install in the firm's project.

Investors effectively choose whether to invest their capital with transparent or opaque intermediaries. They simply choose the type of intermediary that promises the highest returns (in expectation) at $\tau = 2$. Returns on capital for opaque and transparent intermediaries, in turn, are determined by the financing conditions they face in the asset market.

Formally, investors choose the fraction of their capital holdings they want to invest with opaque intermediaries, ω, and the fraction they want to invest with transparent intermediaries, $1 - \omega$, to solve

$$\max_{\omega} \; V^T(1-\omega)\overline{k} + V^O \omega \overline{k} \;\; \text{s.t.} \;\; 0 \le \omega \le 1, \tag{10}$$

where the returns on capital invested with intermediaries are defined as

$$V^\sigma = \mathbb{E}_0[v_j | \sigma_j = \sigma], \tag{11}$$

and v_j is given by Problem 6, for each type of intermediary $\sigma \in \{T, O\}$. The solution to investors' problem is then

$$\omega = \begin{cases} 1 & V^O > V^T \\ \in [0,1] & V^O = V^T \\ 0 & V^O < V^T \end{cases} \tag{12}$$

The free entry condition implies that in equilibrium, intermediaries must break even. For this to be the case, the measure of entering intermediaries of each type must be equal to the the quantity of capital that investors choose to invest with each type of intermediary (since each firm's project has a size equal to one).[18]

[17] Formally, if I intermediaries enter, I assume a matching probability $\min\{1, \frac{1}{I}\}$ for intermediaries (both transparent and opaque) and $\min\{I, 1\}$ for firms.

[18] Strictly speaking, an equilibrium would also obtain if the measures of entering opaque and transparent intermediaries of each type were proportional to (but greater than) ω and $1 - \omega$.

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 technology of the associated intermediary, and the local endowment. Agents on all islands that receive the same endowment behave in the same way. Their decisions in the afternoon depend on the local endowment as well as their information.

Definition 1. *A* ***symmetric static equilibrium*** *consists of measures of entering intermediaries* $\{M^T, M^O\}$*, intermediary returns* $\{V^T, V^O\}$ *investors' decisions* $\{\omega, b(\tilde{e}), a_B(\tilde{e}, s, \sigma, p)\}$*, intermediaries' decisions* $\{x(\theta, \sigma, p), a_S(\theta, \sigma, p)\}$*, a price schedule* $p(a_S|\theta, \sigma, \tilde{e})$*, and expectations* $\mathbb{E}[\cdot|s, \sigma, p]$ *for investors such that*

1. *Investors' choice* ω *solves Problem 10 taking* V^T, V^O *as given, and* 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 11;*

3. *The measures of entering intermediaries satisfy* $M^O = \omega$*,* $M^T = 1 - \omega$*, 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 whether investors choose to lend their capital to transparent or opaque intermediaries in the morning. 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 all capital is intermediated by opaque intermediaries, and a *transparent regime* in which transparent intermediaries hold the entire capital stock instead.

The fraction of aggregate capital intermediated through opaque intermediaries, ω, is given by Equation 12, the solution to investors' problem in the morning. It then suffices to determine whether opaque or transparent intermediaries deliver higher returns to investors.

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 have no funds, 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.

In equilibrium, investors always break even in the afternoon. Intermediaries then extract the full social surplus from their investments at that time. Furthermore, by Lemma 2, intermediaries invest whenever they can sell their assets at a price $p \geq \xi^{-1}$ (where ξ is the fraction of the firm's output that can be sold across islands by the intermediary). The (expected) value of a transparent intermediary is then

$$\begin{aligned} V^T &= \Pr(\overline{p}^T)(\mathbb{E}[\theta \mid \overline{p}^T]Z - 1)\mathbf{1}\{\overline{p}^T \geq \xi^{-1}\} + \Pr(\underline{p}^T)(\mathbb{E}[\theta \mid \underline{p}^T]Z - 1)\mathbf{1}\{\underline{p}^T \geq \xi^{-1}\} \\ &= \Pr(S)(\theta_G Z - 1) + \Pr(U)(\theta_U Z - 1)\mathbf{1}\{\theta_U Z \geq \xi^{-1}\}. \end{aligned} \tag{13}$$

where $\Pr(S) = \alpha(1-\delta)$ denotes the probability that an intermediary has access to skilled capital, and $\Pr(U) = 1 - \Pr(S)$ is the probability that it does not. If the price $\underline{p}^T$ 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 opaque intermediary, on the other hand, always sells claims at the same price $p^O = \overline{\theta}Z$. Its value is

$$\begin{aligned} V^O &= (\overline{\theta}Z - 1)\mathbf{1}\{\overline{\theta}Z \geq \xi^{-1}\} \\ &= \Pr(S)(\theta_G Z - 1) + \Pr(U)(\theta_U Z - 1), \end{aligned} \tag{14}$$

by Equation 4. 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. This is beneficial for the intermediary, however, only if it is optimal for unskilled investors to finance the project when skilled investors are unwilling or unable to do so (that is, when $\theta_U Z > 1$). 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 2. *All symmetric static equilibria feature the same investment profile as the following equilibrium, which consists of two regimes.*

1. ***Opaque regime**: When $\theta_U Z \geq 1$, only opaque intermediaries enter. All projects, both good and bad, are financed in the afternoon, independently of the idiosyncratic endowment shock on each island. There is trade in financial assets across islands.*

2. ***Transparent regime**: When $\theta_U Z < 1$, only transparent intermediaries enter. Good projects are financed only when skilled capital is available (i.e., the island receives the high endowment shock). Bad projects are never financed. Investors purchase only assets whose quality they can evaluate.*

There may be multiple equilibria because, occasionally, investors may be indifferent between investing their capital with opaque and transparent intermediaries. However, in such cases, opaque and transparent intermediaries are able to finance their projects in the same set of states, so those equilibria are effectively outcome-equivalent to the one described in the proposition.

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 have access to funds. 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 $(1-\alpha)(1-\delta)$, 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 δ). 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

$$\underbrace{(1-\alpha)(1-\delta)(\theta_G Z-1)}_{\text{AS cost}} \geq \underbrace{\delta(1-\theta_B Z)}_{\text{VS benefit}} \;\Leftrightarrow\; \theta_U Z \geq 1, \tag{15}$$

where θ_U is defined in Equation 9. From Proposition 2, 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 3. *There exists δ^* such that the economy is in the opaque regime whenever $\delta \leq \delta^*$ and in the transparent regime otherwise, where*

$$\delta^* = \frac{(1-\alpha)(\theta_G Z-1)}{(1-\alpha)(\theta_G Z-1)-(\theta_B Z-1)} \tag{16}$$

Likewise, holding other parameters fixed, there exists Z^* such that the economy is in the

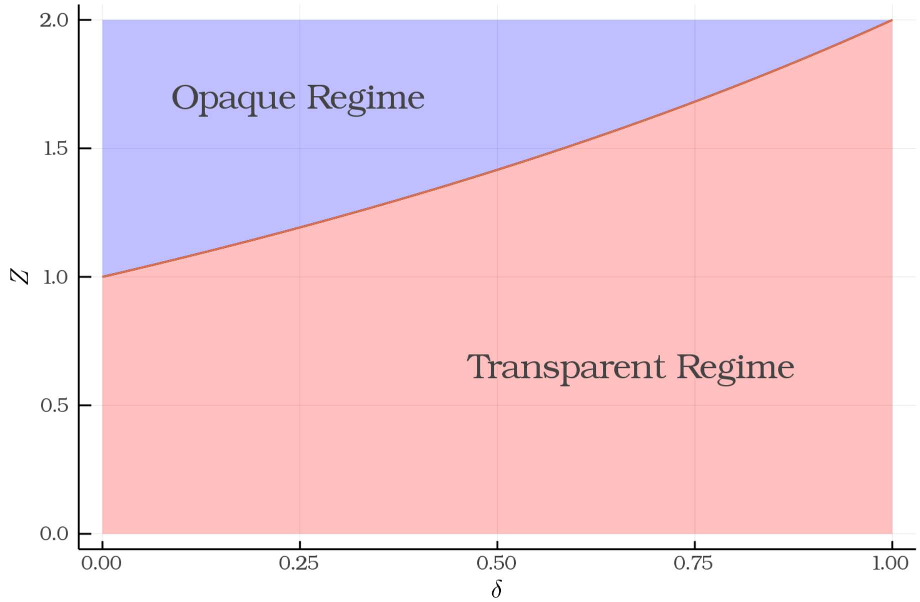

Figure 3: Opaque and transparent regimes described in Proposition 2. This example uses parameters $\alpha = 0.3$, $\theta_G = 1.0$, $\theta_B = 0.5$.

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 δ^* that demarcates the boundary between the opaque and transparent regimes will be crucial in governing endogenous cycles in the dynamic model. Figure 3 depicts the opaque and transparent regimes in (Z, δ) space. In the dynamic model, exogenous productivity Z and the endogenous fraction of bad firms δ 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, $\tau = 0, 1, 2$ (morning, afternoon, and evening). As in the static model, there is a perishable consumption good (c) and durable capital (k), and the economy consists of islands $n \in [0, 1]$.

Investors: The economy is populated by investors with log preferences. As in Gertler and Kiyotaki (2010), there is a continuum of families, each of which is comprised of a continuum of investors $i \in [0, 1]$. These assumptions permit me to construct a representative family with preferences

$$U = \mathbb{E}\left[\sum_{t=0}^{\infty} \beta^t \log c_t\right].$$

The family is endowed with the economy's entire capital stock at $t = 0$. In the morning, investors are individually sent off to random islands, each with an equal share of the family's capital. Individual investors' objective is to maximize their expected payoffs (i.e., end-of-period-wealth) with respect to the family's stochastic discount factor, which is derived from its consumption process. In the evening of each period, investors return home with their wealth, and the family jointly chooses how much to consume and how much to save in capital for the next period. The family has access to a savings technology that transforms consumption goods into capital one-for-one (that is, a standard investment technology without adjustment costs). This implies an aggregate resource constraint in each period,

$$y_t = c_t + \overline{k}_t. \tag{17}$$

Firms and intermediaries: As in the static model, there is a continuum of firms indexed by j and intermediaries that enter freely. Each firm has a type Θ_{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. After matching, each firm will borrow capital $k_{jt} \leq \overline{k}_t$ from the corresponding intermediary.[19] Intermediaries, in turn, borrow capital from investors on the same island.

In the afternoon, each firm j on island n yields dividends $\tilde{e}_{nt} k_{jt}$, where $\tilde{e}_n$ is I.I.D. across

[19] The restriction on k_{jt} simply guarantees a unique distribution of capital across firms. It is analogous to the assumption in the static model that projects have a maximum size of one unit of capital.

islands, taking values $\tilde{e}_n = \frac{e}{\alpha}$ (for some $e \geq 1$) on a fraction α of islands and $\tilde{e}_n = 0$ for the rest. This dividend shock is the analogue of the endowment shock in the static model: investors on some islands will receive goods they can use to purchase claims in asset markets, whereas on other islands, investors will have no goods. As in the static model, only claims on a project's final output can be pledged across islands, so claims on these dividends cannot be traded across islands ex ante. This is a simple way to introduce non-diversifiable endowment risk into the dynamic framework.[20]

After producing dividends, firms attempt to invest additional funds in the afternoon. Intermediaries finance firms' investment by selling claims in an asset market, as in the static model. If firm j invests xk_{jt} goods, it produces

$$\varphi(x)k_{jt} = \min\{x, 1\}Z_t k_{jt}$$

goods in the evening if successful (where the success probabilities are identical to those in Equation 1). Firms are owned by the family and maximize profits with respect to its stochastic discount factor.[21]

The only differences from the static model are that (1) firms' types Θ_{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 δ_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 Θ_{jt} (which gives rise to the process followed by δ_t). 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.[22] 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, each good firm exogenously turns bad with probability $\kappa \in (0, 1)$.[23] This specification captures mean reversion in firm quality and ensures that the steady-state fraction of bad projects

[20]Under the assumption that dividend claims are not tradable across islands, it is without generality to assume that these dividends are paid out to investors rather than retained by intermediaries.

[21] As in the static model, however, they will pledge all output from their projects to intermediaries. This implies that in equilibrium, they will not make profits or have any meaningful decisions.

[22] 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.

[23] I assume that κ satisfies $\frac{\kappa}{1+\kappa}\theta_B + \frac{1}{t+\kappa}\theta_G \geq \xi^{-1}$ to ensure that Equation 4 is satisfied.

(when only good firms are financed) is nonzero.

Timing: At the beginning of the morning, individual investors are each sent off with an equal share of the family's capital. Firms are sent off to islands as well. Intermediaries decide whether to enter at $\tau = 0$, and after entering, they are anonymously matched with firms on the same island, as in the static model.[24] Intermediaries borrow capital from investors in order to lend to the corresponding firm.

The afternoon is the exact analogue of $\tau = 1$ in the static model. Each island receives an endowment of goods through firms' dividends, and then firms get investment opportunities. Each intermediary attempts to raise additional funds to finance investment in its firm's project. Intermediaries follow their disclosure policies and then trade with investors in the same markets as in the static model.

Finally, in the evening, firms return output to intermediaries, who in turn pay back investors. Investors return home with their funds at the end of the period and consume together as a family. All output that is not consumed is saved as capital for the next period.

4.2 Dynamic equilibrium

The dynamic model is essentially identical to a repeated version of the static one. Investors' objective is to maximize their end-of-period wealth with respect to the family's discount factor, but all aggregate uncertainty affecting the family's consumption will be resolved at the beginning of the period before investors are sent off, so they will effectively be risk-neutral within a period. Just as in the static model, intermediaries of each type choose whether to enter, borrow from investors and lend to firms, and then attempt to raise additional funds in financial markets subject to asymmetric information. The output of a project that receives further investment is Z_t at the end of the period. The information structure within a period is also unchanged: intermediaries and investors enter a period with a common prior δ_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 at the end of the evening, when the family makes its consumption-savings decision. I outline that decision here.

Consumption-savings decision at $\tau = 2$: At the end of period t, the family chooses consumption, c_t, and capital holdings for the next period, k_{t+1}, subject to the budget con-

[24] 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.

straint

$$n_t = c_t + k_{t+1}. \tag{18}$$

It takes as given that in the next period, each individual investor will be sent off with an equal share of its capital k_{t+1} and return home with an idiosyncratically random amount of funds $\tilde{w}_{n,t+1}$, which depends only on he island to which the investor is sent. Thus, the family accumulates net worth according to

$$n_{t+1} = \int_0^1 \tilde{w}_{n,t+1} dn = k_{t+1} \int_0^1 \tilde{R}_{n,t+1} dn, \tag{19}$$

where $\tilde{R}_{n,t+1} = \frac{\tilde{w}_{n,t+1}}{k_{t+1}}$ is the return on capital earned by the investor sent to island n. The family's problem is then

$$\max_{c_t, k_{t+1}} \mathbb{E}\left[\sum_{t=0}^{\infty} \beta^t \log c_t\right] \text{ s.t. (18), (19), } n_t \geq 0. \tag{20}$$

With log preferences, Problem 20 is particularly simple to solve.

Proposition 4. *The family consumes a constant fraction out of its net worth every period,*

$$c_t = (1-\beta) n_t = (1-\beta) k_t. \tag{21}$$

Irrespective of the processes followed by aggregate variables, the family simply consumes a constant fraction of its wealth. This is because there are two competing forces that feed through from the family's investment opportunities to its consumption rate: an income effect and a substitution effect. On the one hand, when the family has positive expectations of future returns on investment, it feels richer and wants to consume more (the income effect). On the other, it wants to postpone consumption in order to accumulate wealth and take advantage of those investment opportunities (the substitution effect). Log preferences imply that income and substitution effects on the rate of consumption cancel out. In turn, this will imply that equilibrium outcomes within a period will not depend on agents' expectations of the future. This is why my results hold generally regardless of the stochastic process followed by productivity Z_t. More broadly, this observation will imply that the model can be interpreted as a sequence of static models linked by the evolution of the aggregate state despite the presence of long-lived agents.

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 measures of entering intemediaries* $\{M_t^T, M_t^O\}_{t=0}^{\infty}$*, intermediary returns* $\{V_t^T, V_t^O\}_{t=0}^{\infty}$*, investors' individual decisions* $\{\omega_t, b_t(\tilde{e}),\, a_{Bt}(\tilde{e}, s, \sigma, p)\}_{t=0}^{\infty}$*, intermediaries' decisions* $\{x_t(\theta, \sigma, p),\, a_{St}(\theta, \sigma, p)\}_{t=0}^{\infty}$*, price schedules* $\{p_t(a_S|\theta, \sigma, \tilde{e})\}_{t=0}^{\infty}$*, investors' expectations* $\{\mathbb{E}_t[\cdot|s, \sigma, p]\}_{t=0}^{\infty}$*, returns* $\{\tilde{R}_t(\tilde{e})\}_{t=0}^{\infty}$*, and consumption and savings decisions for the family,* $\{c_t, k_t\}_{t=0}^{\infty}$*, such that*

1. *Investors' individual decisions are optimal, taking prices and returns earned by intermediaries 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 11;*

3. *The family's consumption-savings decision solves Problem 20, taking as given the law of motion of the aggregate state and returns* $\tilde{R}_t$ *earned by investors individually;*

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

5. *Returns* $\tilde{R}_t(\tilde{e})$ *are consistent with investors' end-of-period wealth on an island receiving endowment* $\tilde{e}$*;*

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

7. *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 5. *In the symmetric dynamic equilibrium, within a period, the equilibrium coincides with the symmetric static equilibrium of Proposition 2 given the state* $(Z_t, \delta_t, \overline{k}_t)$*. The family's consumption-savings decision satisfies Equation 21.*

Crucially, this proposition implies that the opaque and transparent regimes correspond to those in the static model: whenever (Z_t, δ_t) are such that $\theta_{Ut} Z_t \geq 1$ (where θ_{Ut} is the analogue of Equation 9), the dynamic equilibrium will feature an opaque regime.

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 additional funds at $\tau = 1$. Denote the probability that a bad firm is financed at time t by

$$\lambda_t \equiv \ \Pr_t(j \text{ is financed} \mid \Theta_{jt} = B).$$

Under these assumptions, the fraction of bad firms in the economy, δ_t, follows the process

$$\delta_{t+1} = \underbrace{\theta_B \lambda_t \delta_t}_{\text{Endogenous}} + \underbrace{\kappa(1-\delta_t)}_{\text{Exogenous}}. \tag{22}$$

The first term corresponds to the fraction θ_B of bad firms that succeed and 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 second term simply represents exogenous switching between types.

The economy is in the opaque regime whenever

$$\theta_{Ut} Z \geq 1 \Leftrightarrow \delta_t \leq \delta^*,$$

where θ_{Ut} is defined as in Equation 9 and δ^* is defined as in Equation 16. As in the static model, when average firm quality is sufficiently high, firms are financed by opaque intermediaries. In particular, this occurs whenever the fraction of bad projects δ_t is below its critical value δ^*. 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 lend their capital to opaque intermediaries, 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 project is financed in either regime is then just

$$\lambda_t = \begin{cases} 1 & \delta_t \leq \delta^* \\ 0 & \delta_t > \delta^* \end{cases} \tag{23}$$

The transition law can then be written in piecewise form:

$$\delta_{t+1} = \begin{cases} \theta_B \delta_t + \kappa(1-\delta_t) & \text{Opaque regime, } \delta_t \leq \delta^* \\ \kappa(1-\delta_t) & \text{Transparent regime, } \delta_t > \delta^* \end{cases} \tag{24}$$

The discontinuity in the law of motion can generate cycles. The long-run dynamics depend on the basins of attraction of the law of motion, which differ depending on whether δ_t is greater or less than δ^*. The basins of attraction are $\overline{\delta}$ for $\delta_t \leq \delta^*$ and $\underline{\delta}$ for $\delta_t > \delta^*$, which are defined as

$$\overline{\delta} = \frac{\kappa}{1+\kappa-\theta_B}, \; \underline{\delta} = \frac{\kappa}{1+\kappa}. \tag{25}$$

Cycles will arise when $\underline{\delta} < \delta^* < \overline{\delta}$. Even when the fraction of bad firms δ_t is slightly less than the critical value δ^* that triggers a switch to the transparent regime, the fraction of bad firms can continue to climb towards $\overline{\delta}$. 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 δ^* 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 δ^* 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 firms require additional 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 $\underline{\delta}$. Subsequently, the economy can re-enter the opaque regime.

Let $\delta^+(\cdot)$ represent the transition law in Equation 24, 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 δ 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 6. *The recursive dynamic equilibrium features a steady state in the transparent regime at $\underline{\delta}$ if $\underline{\delta} > \delta^*$. Otherwise, there is a steady state in the opaque regime at $\overline{\delta}$ if $\overline{\delta} < \delta^*$. If neither of these conditions are satisfied, the equilibrium features a cycle.*

Holding other parameters fixed, there exist productivity levels $\underline{Z} < \overline{Z}$ such that for $Z \leq \underline{Z}$, there is a steady state in the transparent regime, for $Z \in (\underline{Z}, \overline{Z})$ there is an equilibrium cycle, and for $Z \geq \overline{Z}$ there is a steady state in the opaque regime.

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, $\overline{\delta} < \delta^*$. When $\delta_t < \overline{\delta}$, the economy is in an opaque regime (since $\delta_t < \delta^*$ as well) and the fraction of bad firms steadily increases. However, for $\delta_t > \overline{\delta}$, 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, θ_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 κ at which good firms go bad is large relative to the critical threshold δ^*. 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).

The nature of the economy's long-run behavior depends on Z because productivity determines the relative magnitudes of the cost of adverse selection and the benefits of virtuous selection. These two forces, in turn, determine the critical fraction of bad firms δ^* at which opaque intermediation is no longer privately optimal. When productivity is low, the benefits of virtuous selection are high even for small δ, so the transparent regime prevails. When productivity is high, unskilled investors extend credit to opaque projects even for large δ, since good projects are profitable enough to compensate for the losses they incur by investing in bad ones. For intermediate values of productivity, there is a cycle.

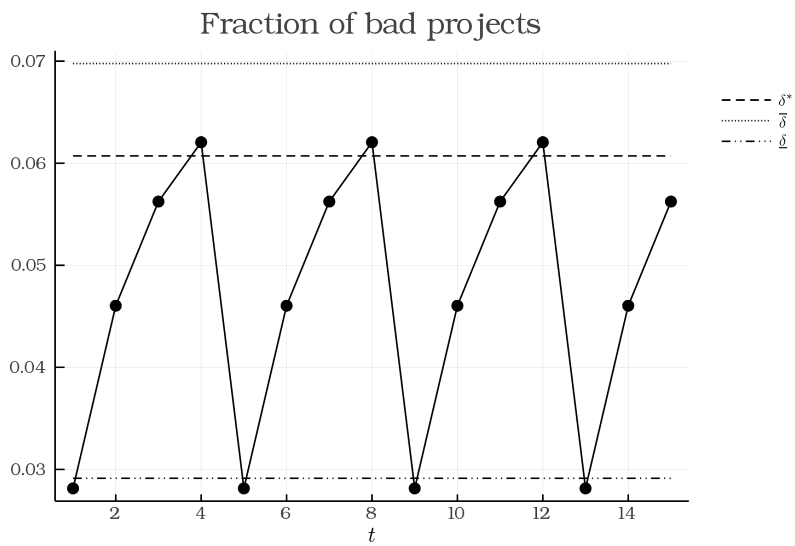

Figure 4: This figure illustrates a typical path of the fraction of bad firms δ_t. In this case, there is a four-period cycle: three boom periods in which unskilled investors are willing to finance opaque intermediaries (while $\delta_t \leq \delta^*$) and one period in which the fraction of bad firms is high enough that opaque intermediation is abandoned.

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 $\overline{\delta}$ to which the economy converges in the opaque regime is greater than the critical threshold δ^* that triggers the transition from the opaque to the transparent regime. Once in the transparent regime, the point $\underline{\delta}$ towards which the fraction of bad firms starts to converge is less than δ^*. Figure 4 depicts the dynamics in this situation. The economy stays in the opaque regime for three 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. In turn, this generates higher output, which consists of the endowment $e\overline{k}_t$ plus the output produced by projects,

$$y_t = \begin{cases} \big(e + (\overline{\theta}_t Z - 1)\big)\overline{k}_t & \text{Opaque regime} \\ \big(e + \alpha(1-\delta_t)(\theta_G Z - 1)\big)\overline{k}_t & \text{Transparent regime} \end{cases} \tag{26}$$

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 know nothing about. The adverse selection problem manifests as an *illiquidity* premium for claims on good transparent projects. The wedge between the value of a good transparent project and the price at which claims on such projects can be sold to unskilled investors is

$$\frac{\theta_G Z}{\underline{p}_t^T} - 1 = \frac{\delta_t(\theta_G - \theta_B)}{(1-\alpha)(1-\delta_t)\theta_G + \delta_t \theta_B}.$$

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 5.

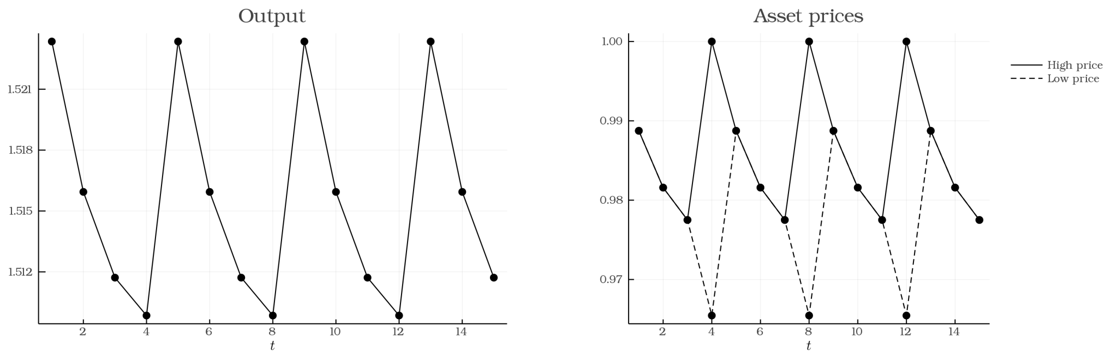

Figure 5: The left panel depicts output over the course of a cycle with three opaque boom periods and a transparent bust period. The right panel shows the high price at which assets trade in equilibrium (solid line corresponding to p_t^O or $\overline{p}^T$, depending on the regime) and the low price of illiquid transparent assets (dashed line, $\underline{p}^T$).

4.4 Transitions and amplification of busts

In this section, I study the economy's dynamics under perfect foresight of future changes in productivity. Due to log preferences, agents' decisions are effectively myopic and depend only on current state variables (Proposition 4), so the economy's response to a sequence of realizations of productivity, $\{Z_s\}_{s\geq t}$, does not depend on whether those shocks are anticipated, unanticipated, or drawn from a known stochastic process. That is, the economy's perfect-foresight dynamics can be interpreted equivalently as impulse response functions to a sequence of productivity shocks.

I study two specific scenarios– a permanent increase in productivity and a transitory boom. In the case of a permanent increase in productivity, I assume that the economy starts at a steady state $(Z^{SS}, \underline{\delta})$ in the transparent regime (with $Z^{SS} \leq \underline{Z}$ defined in Proposition 6) and then, at some time t, increases to $Z^{SS'} > Z^{SS}$ for all $s \geq t$. Following the initial increase in productivity, the investment opportunities in the economy improve, as does the cost of adverse selection. Opaque intermediaries enter and begin to issue large volumes of liabilities backed by their projects, enhancing the liquidity of financial markets. Subsequently, the quality of projects in the economy declines.

There are two possibilities for the long-run behavior of the economy, then. If the initial productivity shock was sufficiently large ($Z^{SS'} > \overline{Z}$), the economy will remain in the opaque regime permanently. Despite the increase in the fraction of bad projects (which converges to $\overline{\delta}$), the productivity of the average projects is high enough that the cost of adverse selection remans elevated. However, if the initial productivity shock was not large enough ($\underline{Z} < Z^{SS'} < \overline{Z}$), the economy instead transitions to a series of cycles: it experiences recurrent booms in

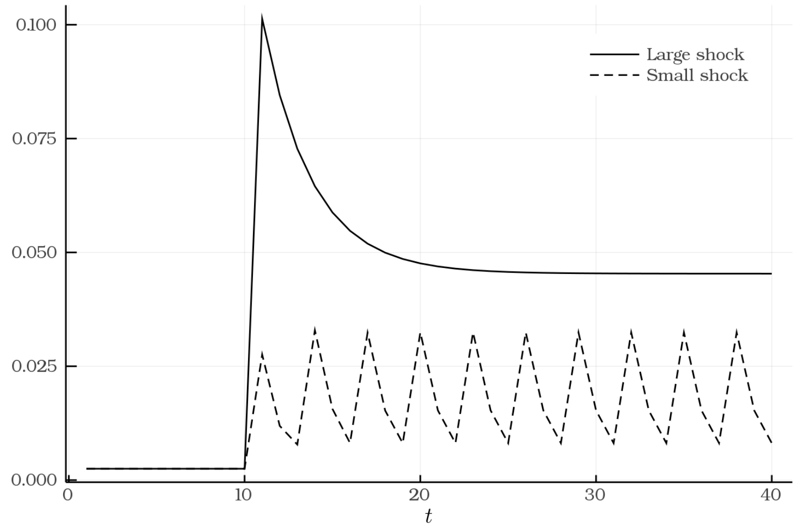

Figure 6: Transition path for a large permanent shock to productivity (solid line), $Z = 1.01$ to $Z = 1.12$, versus a small shock to productivity (dashed line), $Z = 1.01$ to $Z = 1.045$, resulting in a cycle.

opaque intermediation that coincide with declines in firm quality followed by busts in which investors turn away from opaque assets and firm quality recovers. That is, a boom can lead to a permanent increase in the private production of liquid assets and macroeconomic volatility. Figure 6 depicts the path followed by output under these two scenarios.

The endogenous dynamics of asset origination can also amplify busts following transitory booms in this economy. I define a transitory boom as a situation in which the economy starts at a steady state $(Z^{SS}, \underline{\delta})$ in the transparent regime and then experiences an increase in productivity to $Z' > Z^{SS}$ from time t until some time $t + T$. A transitory boom-bust cycle consists of an initial period in which a shock to productivity triggers a transition to the opaque regime. Intermediaries begin to originate assets without disclosing information about the projects backing those assets, thereby enhancing the liquidity of their liabilities and allowing them to invest more in those projects. During the boom, investors finance projects without knowing their quality, so lending standards are effectively lax, and the quality of firms in the economy starts to decline over time.

The economy experiences a bust with certainty. One way for this to happen is for the initial boom to "run out of steam": eventually, the quality of firms declines enough that the economy endogenously transitions back to the transparent regime even before productivity reverts (as in the case of a permanent shock). On the other hand, the bust may not occur until after productivity reverts back to its initial level. When productivity falls to its initial

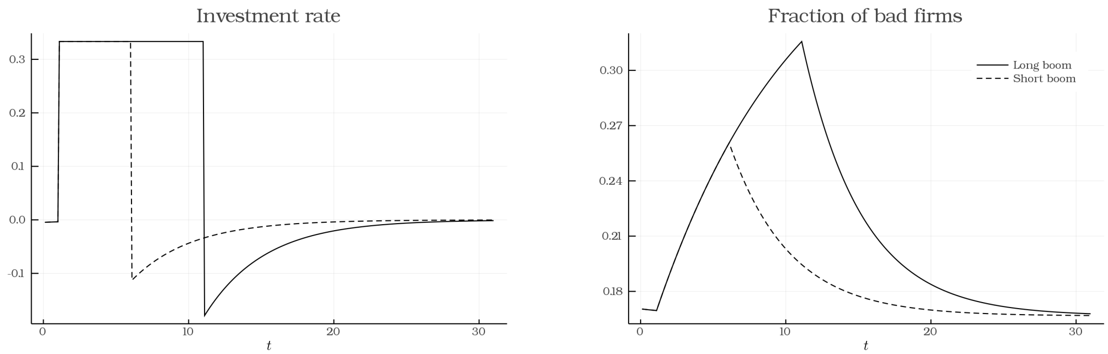

Figure 7: The left panel depicts the investment rate during two transitory booms: a short boom lasting five periods (dashed line) and a long one lasting ten (solid line). The right panel depicts the fraction of bad firms in each scenario.

level, the cost of adverse selection (forgoing good invesments) falls with it, but the value of virtuous selection (avoiding bad ones) is elevated due to the misallocation during the boom. Investors are reluctant to finance projects they know nothing about, so the creation of opaque financial assets halts. Investors turn towards more transparently originated (but less liquid) financial assets, causing credit volumes to contract. The decline in financial market liquidity and investment persists until the quality of firms in the economy recovers. In this case, the quality of firms deteriorates more when the boom is longer, so longer booms lead to deeper busts featuring longer recoveries. Furthermore, this result speaks to episodes in which there are persistent dry-ups in markets for certain types of opaque assets (e.g., the collapse in CDO issuance for several years after the 2008-2009 crisis). Figure 7 illustrates these dynamics.

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 benevolent 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.[25] 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 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. The former are good projects on islands that receive the high endowment. The latter group consists of projects that skilled investors would not finance: good projects on islands that receive the low endowment as well as all bad projects. I denote the set of projects for which skilled capital is available by S, and I denote by U those for which skilled capital is unavailable. The planner chooses the fraction of projects in each group in which to invest, x_{St} and x_{Ut}, as well as aggregate consumption c_t and capital holdings k_{t+1} in each period.[26] After stating the planner's problem formally, I discuss how it can be interpreted as implementing an equilibrium with a given mix of transparent and opaque projects.

Investment in a project for which skilled capital is available always yields output $\theta_G Z_t - 1$ per unit invested (since it has been identified as good by skilled investors). On the other hand, investment in a project for which skilled capital is unavailable results in the financing of some good projects but misallocation of funds towards some bad ones as well: in the pool of projects for which skilled capital is unavailable, there is a measure $(1-\alpha)(1-\delta_t)$ of good projects (corresponding to islands that received low endowments) and a measure δ_t of bad ones (i.e., all the investment opportunities that skilled investors would pass up). When the

[25] 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.

[26] It would never be optimal for the planner to pursue partial investment in a project. Bad projects remain in the pool as long as they attract any investment, so partial investment in any set of projects for which skilled capital is unavailable is dominated by full investment in a subset of those projects– expected output remains the same, but the fraction of surviving bad firms decreases.

planner chooses investment (x_{St}, x_{Ut}), then, aggregate output per unit of capital will be

$$y_t(x_{St}, x_{Ut}|Z_t, \delta_t) = \underbrace{e}_{\text{Endowment}} + \underbrace{\alpha(1-\delta_t)(\theta_G Z_t - 1)x_{St}}_{\text{Skilled investment}} \\ + \underbrace{\Big(\big((1-\alpha)(1-\delta_t)\theta_G + \delta_t\theta_B\big)Z_t - \big((1-\alpha)(1-\delta_t)+\delta_t\big)\Big)x_{Ut}}_{\text{Unskilled investment}}. \tag{27}$$

I analyze the planner's problem in the absence of shocks. The problem faced by the planner is

$$\max_{c_t, x_{St}, x_{Ut}, k_{t+1}, \delta_{t+1}} \sum_{t=0}^{\infty} \beta^t \log c_t \text{ s.t. } c_t + k_{t+1} = y_t(x_{St}, x_{Ut}|Z, \delta_t)k_t, \tag{28}$$

$$\delta_{t+1} = \theta_B x_{Ut}\delta_t + \kappa(1-\delta_t),\ k_0 = \overline{k}_0,\ \delta_0 = \overline{\delta}_0,$$

$$0 \le x_{St} \le 1,\ 0 \le x_{Ut} \le 1.$$

The planner faces the resource constraint and also the constraint on the evolution of the fraction of bad firms δ_t. The fact that the planner takes into account the evolution of firm quality, while private agents do not, reflects a *dynamic information externality.* However, on the other hand, the planner does not face the limited pledgeability problem (represented by $\xi \le 1$) that private intermediaries do: it can make whatever transfers to intermediaries it likes and balance its budget by taxing agents lump-sum. Nevertheless, I will show that the planner never needs to take advantage of the ability to circumvent intermediaries' collateral constraint.

5.2 Interpretation

While I allow the planner to observe the information available to unskilled investors in the transparent regime, the solution to the planner's problem can be interpreted as implementing an equilibrium with a mix of transparent and opaque projects. In order to understand how the planner's investment choice relates to equilibrium outcomes, note that for an opaque project (in equilibrium) investment goes forward regardless of whether skilled capital is available. The measure of opaque projects in the economy at time t corresponding to the planner's solution (x_{St}, x_{Ut}) will therefore be x_{Ut}. For a transparent project, investment proceeds only when skilled investors finance the project. The measure of transparent projects implemented by the planner's solution is then $x_{St} - x_{Ut}$. A fully transparent regime corresponds to no investment when skilled capital is unavailable ($x_{Ut} = 0$) and a fully opaque regime corresponds to investment in all projects regardless of whether skilled capital is available ($x_{Ut} = x_{St} = 1$), but the planner can implement intermediate outcomes as well. The choice of which projects to finance will be the only important decision margin for the planner– as it turns out, the planner will have no incentive to deviate from the equilibrium outcome on the consumption-savings margin.

Opaque intermediaries ensure their liabilities are liquid (allowing them to invest) by changing the information structure available to investors, but the planner may provide liquidity to intermediaries in other ways, so there could potentially be a wide range of tools that the planner could use to implement the solution to his problem. I will show that, despite the intricate control the planner has over agents' decisions, only two tools will be necessary to implement the planner's solution: a tool that I term *transparency regulation* and a tax on asset origination by intermediaries.

5.3 Characterization of the planner's solution

I now characterize the externality present in this model and the optimal policy that corrects it in the long run (i.e., at a steady state). First, I observe that there is never a cost to investing in projects for which skilled capital is available.

Lemma 3. *The planner always sets $x_{St} = 1$ at an optimum.*

All such projects are good, so investment does not lead to the accumulation of bad firms in the economy. Furthermore, the planner always chooses to consume the same constant fraction of the resources available as the family does in equilibrium.

Lemma 4. *The planner sets consumption equal to $c_t = (1 - \beta)k_t$.*

These two lemmas allow me to focus on the key decision made by the intermediary: the amount of investment to direct towards projects for which skilled capital is unavailable, x_{Ut}. I will interpret x_{Ut}, alternatively, as the measure of opaque and liquid projects, since it is the measure of projects that will be financed regardless of quality and regardless of whether skilled investors have the funds to do so themselves.

Next, I show that the planner's solution always converges to a steady state and characterize its properties.

Proposition 7. *The planner's solution converges to a steady state as $t \to \infty$. At an interior solution to the planner's problem, investment in projects for which unskilled capital is unavailable, x_U^{SS}, and the fraction of bad projects, δ^{SS}, satisfy*

$$\delta^{SS} = \frac{\kappa}{1 + \kappa - \theta_B x_U^{SS}}, \tag{29}$$

$$\theta_U^{SS} Z - 1 = -\frac{\beta\theta\delta^{SS}}{1-\beta\left(1-\frac{\kappa}{\delta^{SS}}\right)} \frac{\partial y(x_S^{SS}, x_U^{SS}|Z, \delta^{SS})}{\partial \delta} \tag{30}$$

at any interior solution.

The optimal level of unskilled investment x_U^{SS} is increasing in productivity Z. It can be positive only if the competitive equilibrium would feature an opaque regime at the steady state (Z, δ^{SS}).

The system of equations (29)-(30) defines a unique solution for the planner's optimal fraction of opaque projects x_{SS}^U, and the fraction of bad firms in the steady state, δ^{SS}. Equation 29 is the steady state condition coming from the law of motion of δ_t, while Equation 30 is the optimality condition that comes from the planner's tradeoff. In choosing the measure of opaque projects, the planner weighs the benefits of additional investment against the cost of worsening the pool of firms. The former is simply the static benefit of investing more in projects for which skilled capital is unavailable (the left-hand side of Equation 30). The static benefit consists of the increased output $\theta_U^{SS} Z - 1$ associated with increased investment in such projects. This benefit is internalized by private agents: the condition for the economy to be in the opaque regime in the dynamic equilibrium is just $\theta_U Z - 1 \geq 0$, meaning that in equilibrium, all issuance of financial assets is opaque whenever it is profitable to invest in projects for which skilled capital is unavailable.

The planner, however, also faces a dynamic cost of opacity, which captures the dynamic information externality: the planner recognizes that by unconditionally financing projects, bad firms are allowed to survive. The pool of firms is worsened over time, thereby reducing future output. Private investors do not internalize this force because they lend to different firms in each period; that is, they do not establish long-term relationships with firms. This force, which is the central externality in the model that yields a role for policy, is captured by the right-hand side of Equation 30.

With these results in hand, two natural questions arise. First, how does the optimal degree of opacity (or financial market liquidity) compare to that in equilibrium? Second, under what conditions is a high degree of opacity or transparency socially optimal?

In this model, the dynamic information externality is the only one. This externality captures a cost of opacity that private agents do not internalize. Proposition 7 implies that whenever the planner chooses a positive fraction of opaque projects at the steady state (Z, δ^{SS}), the competitive dynamic equilibrium would feature an opaque regime in state (Z, δ^{SS}), so there is a sense in which the socially optimal degree of opacity is (weakly) lower than what emerges in equilibrium. This result highlights that there is no role for any sort of public intervention to increase the liquidity of financial markets (public liquidity provision) in this

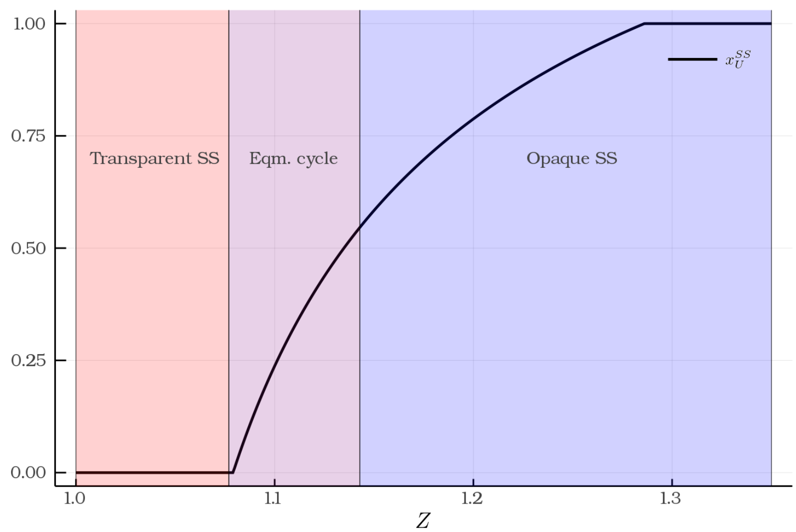

Figure 8: The planner's steady state choice of investment in projects for which skilled capital is unavailable, x_U^{SS}, as a function of productivity Z. The shaded areas represent different regimes characterizing the long-run behavior of the economy in the competitive equilibrium. The red area represents value of Z such that the economy converges to a transparent regime in steady state, the purple area represents values of Z for which cycles emerge in the long run, and the blue area corresponds to an opaque regime in steady state.

model. Intermediaries that back their lending by issuing opaque, liquid liabilities are always free to enter, and they internalize the entire benefit of liquidity creation. The dynamic information externality, however, is ignored by private agents, so the planner would like to reduce the liquidity of financial markets and mitigate the build-up of bad firms.

Despite the fact that the planner wants less opacity than what emerges in equilibrium, though, the static tradeoff between adverse selection and virtuous selection remains relevant for the planner: it is still costly to pass up good investment opportunities when productivity is high. In general, then, the measure of opaque projects implemented by the planner is larger for higher levels of productivity. This remains true even despite the fact that a high degree of opacity will lead to a deterioration of the quality of firms in the long run. Figure 8 illustrates the optimal fraction of opaque projects as a function of productivity and compares it to the long-run behavior of the economy in the dynamic equilibrium, showing that the static tradeoff determining whether asset origination is transparent or opaque in equilibrium is also present in the planner's problem. One way of viewing this result is as a statement that in a booming economy, financing some bad projects is constrained optimal– to the extent that it is impossible to finance all good projects without financing some bad ones, liquid financial markets that allocate funds to some both types of projects are desirable.

Finally, note that Proposition 7 implies that the planner's solution converges to a steady state in the long run. While, as shown in the previous section, the competitive equilibrium may oscillate between periods of full transparency and periods of full opacity, these cycles are constrained-inefficient. The socially optimal solution is to converge to a single ratio of opaque to transparent projects in the long run.

5.4 Implementation

In order to implement the constrained optimum, it may seem at first that it is sufficient for the planner to simply choose the fraction of opaque projects. This intuition is incorrect, however. The reason is that once the planner chooses a mix of transparent and opaque projects, there is no guarantee that transparent projects will be fully illiquid. Unskilled investors may still finance those projects despite the fact that they face adverse selection.

To implement the desired outcome, it is necessary to ensure that transparent projects remain illiquid and opaque ones are liquid. This can be achieved with a tax τ on intermediaries selling assets. If opaque intermediaries face an effective price $(1-\tau)p$ when selling assets (where p^O is the market price), they invest as long as $(1-\tau)p \geq \frac{1}{\xi}$. I now characterize the planner's implementation strategy.

Proposition 8. *To implement unskilled investment x_U^{SS}, the planner first chooses the fraction of opaque projects to be equal to x_U^{SS}. Then, if $\theta_U^{SS} Z > \frac{1}{\xi}$, the planner imposes a tax $\tau = \frac{1}{\xi \theta_U Z} - 1$ on the issuance of claims in the afternoon.*

The tax on asset issuance works by creating a wedge between the price that unskilled investors are willing to pay for assets and the price that intermediaries receive, effectively worsening asset market liquidity. However, any policy increasing the cost of asset origination would have the same effect. Such policies could include, for instance, an outright tax on investment. The Pigouvian tax of Proposition 8 could also be implemented through a combination of macroprudential and monetary policies. For instance, a given tax could be implemented by forcing intermediaries to hold a certain quantity of low-yielding assets (e.g. reserves) on their balance sheets per unit of risky assets held and adjusting the interest rate spread between those low-yielding assets and other risk-free assets. While the optimal policy may seem somewhat abstract, then, the prescription could map to a combination of transparency regulation as well as other common policies increasing the cost of credit provision for intermediaries. In conjunction, these types of policies neutralize the overheating of financial markets that causes bad projects to be financed and generates an externality.

5.5 Discussion of the externality and optimal policy

I conclude by discussing the key features of the model that underlie its policy prescriptions. In this model, there is an information externality because when firms raise capital in the afternoon, they cannot signal whether they have previously been identified as good (although they *can* signal their quality to a subset of agents). For tractability, I additionally assume that firms write only short-term contracts with intermediaries, which in turn borrow short-term from investors, but even with long-term contracts this externality would be present. The assumption that firms cannot necessarily signal their full credit history seems appropriate in many credit markets, especially markets in which smaller borrowers (such as SMEs) participate. However, for larger public firms with extensive credit histories, the externality may not be as relevant. Hence, some care needs to be taken in determining the situations in which the policy prescriptions apply.

The result that there is no role for public liquidity provision may seem stark given that models of adverse selection typically generate a role for policy to increase the liquidity of financial markets. The key features of this model that remove the need for public liquidity provision are that (1) intermediaries can effectively create their own liquidity by choosing the information structure available to investors, and (2) investors cannot countervail intermediaries' ability to keep information secret. In particular, my prescription usually does not hold in models of financial crises in which agents can acquire information about the collateral underlying opaque financial assets, thereby rendering them illiquid (e.g. Gorton and Ordoñez, 2014). My model, instead, focuses on fluctuations in the type of financial assets created by intermediaries in the medium run rather than the short-run breakdown of liquidity in financial markets, so I do not explicitly model information acquisition. However, if the model were extended to include information acquisition, I conjecture that under conditions in which the liquidity of opaque assets were to break down due to private information acquisition, the optimal policy would be to provide a public source of liquidity.

6 Conclusion

In this paper, I study the macroeconomic effects of opaque private liquidity creation. 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

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 can involve both transparency regulations and a tax on intermediary's asset sales, which in turn can be implemented using standard macroprudential tools. Increased transparency and taxes on asset sales 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.

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Appendix

Proofs for Section 3

Proof of Lemma 1:

Proof. Let λ be the multiplier on investors' budget constraint, and let μ_j be the multiplier on the short-sale constraint for asset j (with μ_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 μ_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 $x = p_j(a_S)a_S$. 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 ξ 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 $p_j \geq 1$. $\square$

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 endowments $\tilde{e}$, and intermediary's disclosure technology σ. Observe that under these conditions, aggregate demand for any particular asset will depend only on the signals of investors who have funds. Therefore, the demand for an asset j will depend on its type θ_j, the intermediary's disclosure technology σ_j, and the endowment $\tilde{e}_{n(j)}$ of investors on its island.

For opaque assets, information is symmetric among all agents. Investors with a positive endowment submit equal demand for all opaque assets:

$$a_B(p|s = N, \sigma = O, \tilde{e} = \frac{e}{\alpha}) = \begin{cases} 0 & p > \overline{\theta}Z \\ \overline{a}_{BO} & p = \overline{\theta}Z \\ \frac{e}{\alpha p} & p < \overline{\theta}Z \end{cases}$$

for some constant a_{BO} (which will be set such that markets for opaque assets clear).

For good transparent assets on surplus islands, there are investors who have the skill to evaluate the asset and a sufficient endowment to absorb the entire supply. I assume that these investors submit demand

$$a_B(p|s = G, \sigma = T, \tilde{e} = \frac{e}{\alpha}) = \begin{cases} 0 & p > \theta_G Z \\ \overline{a}_{BT,G} & p = \theta_G Z \\ \frac{e}{\alpha p} & p < \theta_G Z \end{cases}$$

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 two types of transparent assets must be pooled at a single price in equilibrium: good transparent assets on deficit islands as well as all bad transparent assets. Investors with no endowment must submit a demand of zero. Furthermore, investors on surplus islands who recognize an asset as bad must submit a demand of zero at any price $p \geq 1$, but intermediaries can never sell below a price of 1 (since they would not be able to finance their investments at that price). 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 surplus 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

$$p = \theta_U Z \equiv \frac{(1-\alpha)(1-\delta)\theta_G + \delta\theta_B}{(1-\alpha)(1-\delta)+\delta} Z$$

They submit demand

$$a_B(p|s = N, \sigma = T, \tilde{e} = \frac{e}{\alpha}) = \begin{cases} 0 & p > \theta_U Z \\ \overline{a}_{BT,U} & p = \theta_U Z \\ \frac{e}{\alpha p} & p < \theta_U Z \end{cases}$$

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. Intermediaries with opaque projects then sell assets at price $p^O = \overline{\theta} Z$, invest $x = 1$, and sell a quantity $a_{SO} = \frac{1}{p^O}$ of assets. Intermediaries on surplus islands with good transparent projects sell at $\overline{p}^T = \theta_G Z$, invest $x = 1$, and supply a quantity $a_{ST,G} = \frac{1}{\overline{p}^T}$ of assets. Finally, intermediaries with good transparent projects on deficit islands, or those with bad transparent projects, are able to sell at price $\underline{p}^T = \theta_U Z$. They invest $x = 1$ if $\theta_U Z \geq \frac{1}{\xi}$ and finance the entire investment with asset sales $a_S = \frac{1}{\underline{p}^T}$ in that case. However, if $\theta_U Z < \frac{1}{\xi}$, the intermediary does not invest and supplies no assets.

Finally, I derive the quantities of assets demanded at each market-clearing price. First, I assume that agents on surplus islands absorb the entire supply of good transparent assets from their islands, so if $1 - \omega$ is the fraction of transparent projects, they must purchase a quantity $a_{BT,G} = (1-\omega)(1-\delta)$ of assets. They also purchase all opaque assets, $a_{BO} = \frac{\omega}{\alpha}$. They purchase all available transparent assets from other islands as long as $\theta_U Z = 1$ (in which case $a_{BT,U} = \frac{((1-\alpha)(1-\delta)+\delta)(1-\omega)}{\alpha}$).

□

Proof of Proposition 2:

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 ($b(\tilde{e})$, $a_B(\tilde{e}, s, \sigma, p)$, $x(\theta, \sigma, p)$, $a_S(\theta, \sigma, p)$, $p(a_S|\theta, \sigma, \tilde{e})$, $\mathbb{E}[\cdot|s, \sigma, p]$) are derived in the proof of that proposition.

In this equilibrium, the value of an opaque intermediary, $v_j = v(\theta_j, \sigma_j = O, \tilde{e}_{n(j)})$ is

$$v(\theta_j, \sigma_j = O, \tilde{e}_{n(j)}) = \theta_j Z(1 - \frac{1}{p^O}) = \theta_j Z(1 - \frac{1}{\overline{\theta} Z}).$$

This implies that $V^O = \mathbb{E}[v_j|\sigma_j = O] = \overline{\theta}Z - 1$. The value of a transparent intermediary is

$$v(\theta_j, \sigma_j = T, \tilde{e}_{n(j)}) = \begin{cases} \theta_G Z - 1 & \theta_j = \theta_G \text{ and } \tilde{e}_{n(j)} = \frac{e}{\alpha} \\ (\theta_G Z - \frac{\theta_G Z}{\underline{p}^T})\mathbf{1}\{\underline{p}^T \geq \xi^{-1}\} & \theta_j = \theta_G \text{ and } \tilde{e}_{n(j)} = 0 \\ (\theta_B Z - \frac{\theta_B Z}{\underline{p}^T})\mathbf{1}\{\underline{p}^T \geq \xi^{-1}\} & \theta_j = \theta_B \end{cases}$$

After some algebra, this implies

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

Equations 13 and 14 imply that, whenever $\theta_U Z \geq 1$, opacity (weakly) dominates transparency: whenever the value of opaque and transparent intermediaries differ in this case, it is because $1 < \theta_U Z < \xi^{-1}$, in which case the value of an opaque intermediary is higher. Thus, in the region $\theta_U Z \geq 1$, it is without loss of generality to look for an equilibrium in which investors lend their capital only to opaque intermediaries. Whenever $\theta_U Z \geq \xi^{-1}$, investors are indifferent between holding claims on opaque or transparent intermediaries, but in this case, transparent intermediaries are always able to finance their investments even when they lack access to skilled capital, meaning they invest in the same set of states as opaque intermediaries. Given that outside investors always break even, the intermediary's payoff does not depend on whether it is opaque or transparent under these circumstances.

Overall, then, all equilibria are outcome-equivalent (in terms of aggregate investment) to one in which all intermediaries are opaque whenever $\theta_U Z \geq 1$. 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 $\theta_U Z < 1$, 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.

$\square$

Proof of Proposition 3:

Proof. The opaque regime consists precisely of the pairs (Z, δ) such that

$$\theta_U Z = \frac{(1-\alpha)(1-\delta)\theta_G + \delta\theta_B}{(1-\alpha)(1-\delta)+\delta} Z \geq 1.$$

Rearranging, we obtain

$$\delta \leq \frac{(1-\alpha)(\theta_G Z - 1)}{(1-\alpha)(\theta_G Z - 1) - (\theta_B Z - 1)},$$

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

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

□

Proofs for Section 4

Proof of Proposition 4:

Proof. Let $\overline{R}_{t+1} = \int_0^1 \mathbb{E}_t[R_{n,t+1}]dn$. Then the family's problem can be written as

$$\max_{c_t, k_{t+1}} \mathbb{E}\left[\sum_{t=0}^{\infty} \beta^t \log c_t\right] \text{ s.t. } c_t + k_{t+1} \leq n_t,\ n_{t+1} = \overline{R}_{t+1} k_{t+1},\ n_t \geq 0.$$

The first-order condition for the family's problem will take the form

$$1 = \beta\,\mathbb{E}\left[\frac{u'(c_{t+1})}{u'(c_t)}\overline{R}_{t+1}\right] = \beta\,\mathbb{E}\left[\frac{c_t}{c_{t+1}}\overline{R}_{t+1}\right].$$

I guess and verify the solution. With $c_t = (1-\beta)n_t$, we have

$$\begin{aligned}\beta\,\mathbb{E}\left[\frac{c_t}{c_{t+1}}\overline{R}_{t+1}\right] &= \beta\,\mathbb{E}\left[\frac{n_t}{n_{t+1}}\overline{R}_{t+1}\right] \\ &= \beta\,\mathbb{E}\left[\frac{n_t}{\overline{R}_{t+1}\beta n_t}\overline{R}_{t+1}\right] = 1,\end{aligned}$$

as desired. The transversality condition $\lim_{T\to\infty} \beta^T u'(c_T) \leq 0$ is also satisfied under this solution, so $c_t = (1-\beta)n_t$ is indeed optimal.

□

Proof of Proposition 5:

Proof. Within a period, investors discount payoffs with respect to the family's stochastic discount factor (which may be stochastic only through the realization of consumption, $u'(c_t)$). However, all aggregate uncertainty is resolved at the beginning of each period before investors are sent off to islands with their capital. This implies that the family's total consumption will be known to investors at the beginning of the period as well. All uncertainty faced by investors within a period is idiosyncratic and does not covary with the family's marginal utility, so investors effectively act as if they are risk-neutral, as in the static model. Therefore, the solutions to their decision problems in the dynamic model are identical to the solutions to those problems in the static model.

Likewise, intermediaries make their decisions so as to maximize profits (which are zero in equilibrium) with respect to the family's discount factor. 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. After investors return home, the family's consumption is given by Proposition 4, as claimed. □

Proof of Proposition 6:

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

$$\begin{aligned}\delta_{t+1} &= \theta_B \delta_t + \kappa(1-\delta_t) \\ &= (\theta_B - \kappa)\overline{\delta} + \kappa \\ &= (\theta_B - \kappa)\frac{\kappa}{1+\kappa-\theta_B} + \kappa = \frac{\kappa}{1+\kappa-\theta_B},\end{aligned}$$

so $\overline{\delta}$ is a steady state.

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

$$\begin{aligned}\delta_{t+1} &= \kappa(1-\delta_t) \\ &= \kappa(1 - \frac{\kappa}{1+\kappa}) = \frac{\kappa}{1+\kappa},\end{aligned}$$

so $\underline{\delta}$ is a steady state.

Finally, if $\underline{\delta} < \delta^* < \overline{\delta}$, neither $\underline{\delta}$ nor $\overline{\delta}$ is a steady state. For $\delta_t \in [\underline{\delta}, \delta^*)$, the law of motion is $\delta_{t+1} = \theta_B \delta_t + \kappa(1-\delta_t)$, whereas for $\delta_t \in (\delta^*, \overline{\delta}]$, the law of motion is $\delta_{t+1} = \kappa(1-\delta_t)$.

Let $\kappa(1-\hat{\delta}) = \delta^*$, and note that whenever δ_t is in the transparent regime and $\delta_t > \hat{\delta}$, $\delta_{t+1} < \delta^*$. Then $\hat{\delta} = 1 - \frac{\delta^*}{\kappa}$. If $\hat{\delta} < \delta^*$, then the transparent regime can last for only one period. The relevant inequality is

$$\delta^* \geq 1 - \frac{\delta^*}{\kappa} \;\Leftrightarrow\; \delta^* \geq \frac{\kappa}{1+\kappa} = \underline{\delta},$$

which is true by assumption.

We then look for a cycle that transits the transparent regime for only one period. Such a cycle is defined by K values δ_k for $k \in \{1, \ldots, K\}$ such that $\delta_k \leq \delta^*$ for $k < K$ and $\delta_K > \delta^*$, with $\delta^+(\delta_k) = \delta_{k+1}$ for $k < K$ and $\delta^+(\delta_K) = \delta_1$. The cycle will solve the system of equations

$$\delta_{k+1} = \kappa + (\theta_B - \kappa)\delta_k,\; k < K$$

$$\delta_1 = \kappa(1 - \delta_K).$$

For any K, it is possible to solve this (non-singular) system of equations. The second requirement for a solution is that the values δ_k satisfy the requirements $\delta_k \in [0,1]$, $\delta_k < \delta^*$ for $k < K$, $\delta_K > \delta^*$.

Observe that, for any $\delta \in [\delta^*, 1]$ there must exist some minimal $K(\delta)$ such that $(\delta^+)^{K(\delta)}(\delta)$ is also in the interval $[\delta^*, 1]$ (that is, $K(\delta)$ is the number of iterations of the law of motion until the fraction of bad firms returns to the transparent regime). Let $\tilde{\delta}(\delta) = (\delta^+)^{K(\delta)}(\delta)$, and note that $\tilde{\delta}$ is a continuous mapping from the interval $[\delta^*, 1]$ to itself. Therefore, it has a fixed point by Brouwer's Theorem. This fixed point corresponds to a cycle equilibrium.

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

□

Proofs for Section 5

I rewrite the planner's problem in Lagrangian form:

$$\mathcal{L} = \sum_{t=0}^{\infty} \beta^t \Big(\log c_t - \lambda_t(c_t + k_{t+1} - y_t k_t) - \mu_t(\delta_{t+1} - \theta_B x_t^U \delta_t - \kappa(1-\delta_t)) \Big). \tag{31}$$

The first-order conditions are

$$\frac{\partial}{\partial c_t} : \frac{1}{c_t} = \lambda_t \tag{32}$$

$$\frac{\partial}{\partial k_t} : \beta \lambda_t y_t = \lambda_{t-1} \tag{33}$$

$$\frac{\partial}{\partial \delta_t} : -\beta \lambda_t \frac{\partial y_t}{\partial \delta_t} = \mu_{t-1} + \beta(\kappa - \theta_B x_t^U)\mu_t \tag{34}$$

$$\frac{\partial}{\partial x_t^U} : \lambda_t \frac{\partial y}{\partial x_t^U} = \mu_t \theta_B \delta_t \tag{35}$$

Clearly, it is always optimal to set $x_t^S = 1$.

Proof of Proposition 7:

Proof. I look for a balanced growth path on which c_t grows at a constant rate $1+g$, $x_t^U = x^{U*}$, $\delta_t = \delta^*$, and $\mu_t = \mu^*$. The first-order conditions then imply

$$\beta y^* = 1 + g$$

as well as

$$\lambda_t \frac{\partial y}{\partial x^U} = \mu^* \theta_B \delta^*,$$

$$-\beta \lambda_t \frac{\partial y}{\partial \delta} = \mu^*(1 - \beta + \beta(1 + \kappa - \theta_B x^{U*})).$$

In order to simplify the second condition, I use the steady-state relationship for the law of motion,

$$\delta^* = \theta_B x^{U*} \delta^* + \kappa(1 - \delta^*) \;\Rightarrow\; (1 + \kappa - \theta_B x^{U*})\delta^* = \kappa. \tag{36}$$

The second condition above then becomes

$$-\beta \lambda_t \frac{\partial y}{\partial \delta} = \mu^*(1 - \beta + \beta \frac{\kappa}{\delta^*})$$

Combining the two conditions, then,

$$-\frac{\partial y / \partial x^U}{\partial y / \partial \delta} = \frac{\beta \theta_B \delta^*}{1 - \beta(1 - \frac{\kappa}{\delta^*})}$$

Finally, observe that

$$\frac{\partial y}{\partial x^U} = ((1 - \alpha)(1 - \delta^*)\theta_G + \delta^* \theta_B)Z - ((1 - \alpha)(1 - \delta^*) + \delta^*),$$

$$\frac{\partial y}{\partial \delta} = x^{U*}\theta_B Z + \alpha(1 - x^{U*}) - (\alpha + (1-\alpha)x^{U*})\theta_G Z.$$

I arrive at an optimality condition relating x^{U*} to δ^* in the steady state:

$$\frac{((1-\alpha)(1-\delta^*)\theta_G + \delta^*\theta_B)Z - ((1-\alpha)(1-\delta^*) + \delta^*)}{(\alpha + (1-\alpha)x^{*U})\theta_G Z - \alpha(1 - x^{U*}) - x^{U*}\theta_B Z} = \frac{\beta\theta_B\delta^*}{1 - \beta(1 - \frac{\kappa}{\delta^*})}. \tag{37}$$

The denominator of the left-hand side is increasing in x^{U*}, since its derivative with respect to x^{U*} is

$$\alpha + (1-\alpha)\theta_G Z - \theta_B Z \geq \alpha + (1-\alpha) - \theta_B Z = 1 - \theta_B Z \geq 0.$$

Equations 36 and 37 are sufficient to solve for the optimal level of investment by unskilled investors, x^{*U}. and the steady state fraction of bad firms, δ^*. Note that in Equation 37, the right-hand side is increasing in δ^* while the left-hand side is decreasing in δ^*. The left-hand side is also decreasing in x^{U*}. Thus, Equation 37 represents a decreasing relationship between the level of unskilled investment in equilibrium and the fraction of bad firms: when there are more bad firms, unskilled investment is less profitable. The steady-state relationship, instead, represents an increasing relationship between x^{U*} and δ^*: when there is more unskilled investment, the fraction of bad firms will be higher.

By Equation 35, whenever $x_t^U > 0$, it must be that $\frac{\partial y}{\partial x_t^U} > 0$ (since μ_t and λ_t are both positive). This is possible only if $\theta_{Ut}Z \equiv \frac{(1-\alpha)(1-\delta_t)\theta_G + \delta_t\theta_G}{(1-\alpha)(1-\delta_t)+\delta_t} Z > 1$. The dynamic equilibrium features an opaque regime for any state (Z, δ_t) such that $\theta_{Ut} > 0$. Thus, if $x_{Ut} > 0$ in the planner's solution at time t with state variables (Z, δ_t), it must be that in the competitive equilibrium, the economy would be in the opaque regime at (Z, δ_t).

In order to prove the last part of the result, it suffices to show that for any value of x^U, the left-hand side of Equation 37 is increasing in Z. Neither the right-hand side of that equation nor any part of Equation 36, the steady-state equation, depend on Z. Then proving the comparative static result reduces to proving that

$$\frac{d}{dZ}\log\Big(((1-\alpha)(1-\delta)\theta_G + \delta\theta_B)Z - ((1-\alpha)(1-\delta) + \delta)\Big) >$$
$$\frac{d}{dZ}\log\Big((\alpha + (1-\alpha)x^U)\theta_G Z - x^U\theta_B Z - (\alpha + (1-\alpha)x^U - x^U)\Big).$$

The left-hand side can be written as

$$\frac{\theta_L}{\theta_L Z - 1}, \; \theta_L \equiv \frac{(1-\alpha)(1-\delta)\theta_G + \delta\theta_B}{(1-\alpha)(1-\delta) + \delta}.$$

The right-hand side can be written as

$$\frac{\hat{\theta}}{\hat{\theta}Z-1},\ \hat{\theta}\equiv\frac{(\alpha+(1-\alpha)x^U)\theta_G-x^U\theta_B}{\alpha(1-x^U)}=\theta_G+\frac{x^U(\theta_G-\theta_B)}{\alpha(1-x^U)}.$$

Observe that the function $f(\theta)=\frac{\theta}{\theta Z-1}$ is decreasing in θ as long as $\theta Z>1$. But then the result obtains immediately, since, clearly, $\theta_L<\theta_G<\hat{\theta}$.

□

Proof of Proposition 8:

Proof. The planner seeks to implement a given level x_U^{SS} of unskilled investment. Recall that in the competitive equilibrium, opaque projects will always attract unskilled investment, whereas transparent ones attract unskilled investment only if the price at which intermediaries sell assets exceeds $\frac{1}{\xi}$. With a tax τ_t on issuance, transparent intermediaries without access to skilled capital will perceive an effective price $(1-\tau_t)\underline{p}_t^T=(1-\tau_t)\theta_U^{SS}Z$. Thus, if $(1-\tau_t)\theta_U^{SS}Z=\frac{1}{\xi}$, the tax is sufficient to dissuade them from selling assets. Solving, we obtain $\tau_t=\min\{1-\frac{1}{\xi\theta_U^{SS}Z},0\}$. It is simple to check that this tax is not large enough to prevent opaque intermediaries from investing. Thus, by directly choosing the fraction of opaque projects in the economy to be equal to x_U^{SS} and imposing a tax τ_t on issuance, the planner achieves an allocation in which a fraction x_U^{SS} of intermediaries without access to skilled capital are able to invest.

□