

# Financial Intermediation as a Beliefs-Bridge between Optimists and Pessimists\*

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## **Financial Intermediation as a Beliefs-Bridge between Optimists and Pessimists**

This paper proposes a new framework for understanding financial intermediation. In contrast to previous research, we consider a setting in which intermediaries possess no inherent information processing or monitoring advantages. Instead, in an economy with overly optimistic entrepreneurs who require funding from pessimistic investors, we show that intermediaries can arise endogenously. In such a setting, only a rational intermediary will be sufficiently optimistic to find it worthwhile to invest in a technology for screening entrepreneurs' projects, and yet be pessimistic enough to use this technology. Our framework produces implications consistent with heretofore unexplained stylized facts, and conjectures which are thus far untested.

# 1. Introduction

It is almost an article of faith now that the *raison d'être* of financial intermediation is the resolution of pre-contract private information or post-contract moral hazard problems. This insight originated with Leland and Pyle (1977), followed by Diamond (1984), Ramakrishnan and Thakor (1984), Allen (1990), and others. Empirical support for these theories appears in James (1987), Lummer and McConnell (1989), and others.<sup>1</sup> This paper challenges such an information-based paradigm and provides an alternative theory that does not require the financial intermediary to have any information-processing or monitoring advantage over non-intermediated outcomes.

While the information-based theories have served us well, recent events present us with a bit of a conundrum and suggest a need for rethinking. Advances in technology have led to not only much more public availability of financial information, but also a greater availability of tools with which to analyze it. This raises a question about the comparative advantage of financial intermediaries in analyzing credit risks and resolving pre-contract private information problems, and there is reason to doubt that, except in special cases, financial intermediaries resolve informational problems at lower cost than possible with non-intermediated outcomes.<sup>2</sup> Moreover, advances in information technology have also spurred asset securitization, whereby originating financial institutions sell claims against their asset portfolios in the market, effectively removing these assets from their books (see, e.g., Esho, Lam, and Sharpe (2001) and Greenbaum and Thakor (1987)) and diluting their monitoring incentives. Consequently, asset securitization is dominated by assets such as mortgages and credit cards, assets for which monitoring to resolve post-lending moral hazard is relatively unimportant. It is worth noting that while the recent advent of asset-backed commercial paper has led to the securitization of inventories and receivables of mid-sized firms, cases for which one would expect intermediary monitoring to be of value, the monitoring problem is

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<sup>1</sup>See Bhattacharya and Thakor (1993) and Freixas and Rochet (1997) for comprehensive reviews.

<sup>2</sup>A variety of loans are now analyzed using neural networks and standard non-proprietary credit-screening programs that are not the exclusive domain of banks (see Greenbaum and Thakor, 1995). For example, Freddie Mac's "Loan Prospector" software, which is a part of its Automated Underwriting System (AUS), provides computerized screening of mortgage loan applicants. This software can be downloaded from the Internet. A view of the non-uniqueness of banks in screening and monitoring also appears in Dewatripont and Tirole (1993). In fact, based on the argument of informational advances and the notion that an information-processing advantage is critical for banks, many predicted the possible demise of a large percentage of the banking industry (see, e.g., Boyd and Gertler (1994) and Nolle (1995)). Bill Gates, for instance, is quoted as saying "Banks are dinosaurs." And John Reed, former Citicorp CEO, said, "Someday banks will be a line in an application code."

often resolved by “overcollateralizing,” which makes intermediary monitoring unnecessary.

In short, contemporary theories predict that financial intermediation should decline with advances in information technology. Yet, financial intermediaries continue to thrive in informationally-advanced economies like the U.S. Moreover, the current theories also predict that financial intermediaries would play a larger role in developing countries where credit transactions are plagued by all sorts of information problems and publicly available information is limited. Boyd and Smith (1996, 1998) argue that one problem in emerging economies is that borrowers have insufficient net worth, which creates severe (asset-substitution) moral hazard problems. This suggests a greater role for intermediaries to resolve moral hazard, and hence predicts that financial intermediation should be a higher percentage of GDP in emerging economies than in developed economies. The facts say otherwise, however. Financial intermediation as a percentage of GDP is actually higher in the more-developed countries. The level of financial intermediation (loans as a share of GDP) has been found to be positively associated with both the level of development (GDP per capita) and the rate of economic growth. See Gertler and Rose (1996), Goldsmith (1969), King and Levine (1993), Levine and Zervos (1998), and Rajan and Zingales (1998). In fact, a significant impediment to reviving emerging market economies is *insufficient* bank lending. Why?

As the above discussion highlights, it seems that there are important questions still unanswered on the fundamental intermediation issue of how funds get channeled from savers to borrowers to jump-start real sector projects. In particular, we ask the following questions: Why is financial intermediation thriving in advanced economies despite an apparent decline in the relative information-processing advantage of intermediaries over others? Can we have a theory of financial intermediation in which intermediaries possess no such advantage? And, why do intermediaries in many emerging market economies appear to participate insufficiently in lending to the real sector?

We depart sharply from the usual approach in addressing these questions. The economy we analyze has three types of agents: rational, optimistic, and pessimistic. Although we put these labels on agents, we can also view all agents as rational but possessing different prior beliefs. Every agent has an investment project, but insufficient personal wealth to cover the needed investment. The success probability of projects is correctly estimated by a rational agent, overestimated by an optimist, and underestimated by a pessimist. Projects

can be good or bad, thus a screening technology must be used to separate the wheat from the chaff. This technology is available to all agents at the same cost. Any agent wishing to invest in a project must expend a personal, non-recoverable cost to get to the stage where the project can be screened and the capital invested to realize project cash flows. Our starting point is that the optimists want to invest in their projects but given that they don't have enough capital, they must obtain additional capital from either the rational or the pessimistic agents.

When screening incentive constraints are accounted for, we show that neither the pessimists nor the rational agents are willing to finance the optimistic entrepreneurs because the entrepreneurs can't credibly pre-commit to screen. Optimists can only raise financing from each other and the economy gets stuck in a low-investment mode.

This is where financial intermediation helps. Aggregate investment is elevated if rational agents form an intermediary that raises funds from the pessimists and invests in the projects of optimistic entrepreneurs. The intermediary overcomes the pessimists' skepticism about project values by offering them credible (riskless) debt contracts whose payoffs are divorced from the pessimists' beliefs about project payoffs. The intermediary itself accepts junior (risky) debt claims on projects – which could also be interpreted as preferred stock – that compensate the intermediary for its screening cost, i.e., make it incentive compatible for the intermediary to screen projects. All optimistic entrepreneurs get funded. Thus, a financial intermediary arises to provide the screening service so commonly ascribed to it, even though it possesses no special advantage in doing so. Contrast this with Diamond (1984) and Ramakrishnan and Thakor (1984), where *in equilibrium* the intermediary has a monitoring or screening cost advantage over non-intermediated outcomes. Intermediary capital plays a key role in this analysis, and its importance increases as the fraction of pessimists rises.

The intermediary's contribution lies not in any special information processing or monitoring skills, but rather in its ability to both credibly commit to screen projects efficiently – something neither the optimists nor the pessimists can do – and design contracts that enable capital to be raised from the pessimists. In our analysis, the optimists cannot *credibly* commit to screen projects, whereas the pessimists, while credible, are not *efficient* in screening. In this sense, a financial intermediary serves as a bridge between the optimists'

excessively high beliefs about project success and the pessimists' excessively low beliefs. It is a bridge that permits the flow of funds from savers to borrowers and more efficient project financing in the real sector than possible in any other way, in a context in which each agent self-selects his type, i.e., the optimists choose to be entrepreneurs and take the most risk, the rational agents choose to become intermediaries and take the second-highest risk, and the pessimists become investors and take the least risk. Our model is consistent with the functional and structural finance perspective of Merton and Bodie (2004), in which financial institutions and structures emerge endogenously in response to market frictions and behavioral biases present in the economy.

An important aspect of our analysis is that agents have non-uniform prior beliefs. Morris (1995) argues that heterogeneity in priors is not inconsistent with standard theories of rationality or Bayesian decision theory, and many well-known models, such as the Arrow-Debreu-Mackenzie model as well as those of Diamond (1967), Lintner (1965), and Ross (1976), have allowed for differences in priors. More recently, Allen and Gale (1999) examine the comparative efficiencies of the stock market and of financial intermediaries in financing new technologies when there is diversity of opinion about these technologies. Allen and Gale find that intermediated financing may result in the underfunding of innovative projects, and that stock markets are superior in financing such projects because they aggregate diverse opinions more effectively. In contrast, we find that innovative projects, and the diversity of opinions associated with them, may in fact play a key role in giving rise to intermediated finance. Moreover, our basic model of financial intermediation may be interpreted either as one with irrational agents or as one with rational agents who have non-uniform priors.

Our use of optimism in explaining how “non-skilled” financial intermediaries can arise is consistent with the observation that entrepreneurs exhibit a cognitive bias toward optimistic expectations. Moskowitz and Vissing-Jorgensen (2001), for example, find evidence that entrepreneurs assume high risk and earn low returns. One reason why optimists may not eliminate their optimism by learning as quickly as rational-agent models suggest may be self-attribution bias, whereby people take excessive credit for their successes and blame external circumstances for their failures (see, e.g., Hirshleifer (2001)). Another reason may be related to psychological evidence that people with healthy minds tend to be “unrealistically” optimistic, which may be particularly important for entrepreneurs (see Taylor, 1989).

Despite this, there has been surprisingly little use of this assumption in economics, particularly in financial intermediation. One exception is Manove and Padilla (1999), who assume that entrepreneurs are optimistic, thereby precluding the existence of pessimistic agents by assumption, and examine the bank's problem of separating realistic entrepreneurs from the optimists. Manove and Padilla show that interbank competition may force banks to be insufficiently conservative in their lending, which in turn reduces capital market efficiency.

The venture capital literature is also relevant. Examples of theoretical contributions are Admati and Pfleiderer (1994) and Chan, Siegel, and Thakor (1990). This literature (e.g. Gorman and Sahlman, 1989; Kaplan and Strömberg (2001); Sahlman, 1990) has provided extensive evidence about venture capitalists' deep involvement with their firms, and lends support to our assumption/implication that venture capitalists are likely to be very well informed about the assets they finance; i.e., venture capitalists are "relationship financiers" (e.g. Boot and Thakor, 2000; Rajan, 1992). In fact, Gompers and Lerner (1998) provide direct evidence of informed (and legal) insider trading by venture capitalists. This is consistent with our model: because the intermediary screens projects, it knows more about project quality than other investors. This is also consistent with the evidence of Pence (1982), who documents the importance of another venture capitalist's willingness to invest given a lead investor's decision to invest. While the flavor of much of our discussion suggests that the intermediaries we have in mind are venture capitalists or start-up financing divisions of banks, we could also interpret someone like Warren Buffett as an intermediary in our model. Moreover, as we discuss below, there is nothing that precludes the interpretation of intermediaries in our model as depository institutions like banks.

Although we model entrepreneurs that seek funding, our theory transcends venture capital and includes depository and other intermediaries that channel funds from savers to borrowers. Savers supply funds by purchasing riskless debt contracts, which can be interpreted as bank deposits. Since the intermediary extends funds to borrowers by purchasing claims that are isomorphic to risky debt claims, one could interpret these claims as bank loans. Thus, our theory provides a novel perspective on the role of bank capital in assuring the viability of banks, as opposed to merely attenuating asset-substitution moral hazard. The role of bank capital in reducing the bank's propensity to take excessive risk relative to the social optimum is well known. See Bhattacharya and Thakor (1993).

Our theory implies that banks spur real-sector investments. Da Rin and Hellman (2002) make a similar point; they review empirical evidence that banks acted as catalysts for industrialization in many European countries. This evidence is consistent with the arguments of Gerschenkron (1962) and Schumpeter (1934, 1939) who assigned banks a pivotal role in economic growth. Da Rin and Hellman (2002), however, present a banking model that is very different from ours. In their model, a bank helps coordinate investment decisions if it is sufficiently networked to reach a diverse set of complementary firms and influence their investment decisions. Thus, the bank needs to have sufficient size and market power. By contrast, in our model, perfectly competitive banks facilitate real-sector investments.

The rest of the paper is organized as follows. Section 2 contains the basic model. Section 3 examines how financial intermediaries arise. Section 4 discusses an extension of the basic model and empirical implications that differentiate our theory from the current literature. Section 5 concludes. All proofs are in the Appendix.

## 2. The model

Consider an economy in which the risk-free rate is zero and the population is composed of three types of risk-neutral individuals: optimists (O), pessimists (P), and rational agents (R), where the optimists overestimate the probabilities of good outcomes, the pessimists underestimate the probabilities of good outcomes, and the rational agents estimate the probability of good outcomes correctly. Let  $\gamma$  be the fraction of agents that are optimistic,  $\gamma_r$  be the fraction of agents that are rational, and  $1 - \gamma - \gamma_r$  be the fraction that are pessimistic. While each agent knows his own type, and everybody knows that the three types of agents exist, no one knows any other agent's type.

Each individual has access to a single-period project that requires an investment of  $I$  dollars but each individual has an endowment of only  $0.5I$ . The project's NPV can either be  $N > 0$  or  $-N$ . Thus, project cash flows will either be  $N + I > I$  or  $-N + I < I$ . We will assume for later that  $0.5I < N$ . Effectively, this means that an agent would not invest in a negative-NPV project even if he cared only about his own capital investment in the project,  $0.5I$ . A priori, no one knows whether he has a good project (with NPV  $N$ ) or a bad project (NPV  $-N$ ). Optimists assess the probability that a given project is good as  $s_o$ , rational individuals view this probability as  $s$ , and pessimists view it as  $s_p$ , where  $s_o > s > s_p$ . Let  $n$  be the total number of potential projects in the economy and suppose these projects are



distributed across optimistic, rational, and pessimistic individuals. Finally, all individuals – who collectively number  $n$  – view the fraction of optimists in the economy as  $\gamma$ . To preclude the possibility of infinitely large short-sales positions, we assume that no short selling is allowed.

Given our agents have heterogeneous prior beliefs, it is a matter of interpretation as to whether we view them as rational agents with non-uniform priors or as a mix of rational and irrational agents. It all depends on what we assume about the learning opportunities available to agents. McKelvey and Page (1986) show that if  $n$  rational individuals start out with different prior beliefs and if there are sufficiently many public announcements of aggregate statistics, these individuals will converge to a common posterior belief. Thus, if we assume that the agents in our model have had sufficient learning opportunities of this sort and yet continue to maintain different beliefs, then some of them must be irrational. Alternatively, we could assume that information is so complex that it would take arbitrarily long to learn – this is the interpretation that Allen and Gale (1999) use in their analysis – in which case we could view our agents as rational agents who have not had enough time to learn. Similarly, the underlying parameters may keep changing so that learning can never be perfect. In the real world, of course, these possibilities are not mutually exclusive. The empirical evidence on entrepreneurs cited earlier suggests that they are irrationally optimistic, and the entrepreneurial projects we consider in our analysis are likely to be such that agents have experienced insufficient learning for posteriors to converge.

To get a project to the stage where it can be evaluated and possibly funded, the entrepreneur must expend a personal cost of  $t > 0$ . This cost is constant across individuals in the economy. This cost can be viewed as the entrepreneur’s personal cost of effort, but may include, for instance, the cost of conducting market research, feasibility studies, etc., i.e., costs necessary to prepare a business plan that can be presented to a bank or a venture capitalist in order to have the project evaluated for funding. The point is that this cost is incurred personally by the entrepreneur prior to seeking funding, so he will not be directly compensated for it in the contract that he negotiates with the financier.

Assume that the expected NPV of a project is negative, i.e.,

$$sN - (1 - s)N < 0 \Leftrightarrow s < 0.5; \tag{1}$$

so that a rational individual will never invest randomly in a project.

Suppose further that projects can be screened by setting up an investigation technology with a fixed cost equal to zero and a variable cost per project investigated of  $V > 0$ . When we examine incentive problems in screening, we will assume that whether  $V$  is incurred or not is only privately observed by the agent responsible for screening.

Let the screening technology be noisy, emitting a signal  $c \in \{g, b\}$ , where “ $g$ ” and “ $b$ ”, respectively, mean the signal indicates the project is good and bad, with

$$\Pr(c = i \mid \text{project } i) = \phi > 1 - s_p \forall i \in \{g, b\} \quad (2)$$

$$\text{and } \Pr(c = j \mid \text{project } i) = 1 - \phi \forall i \in \{g, b\}, i \neq j. \quad (3)$$

Note that the specification  $\phi > 1 - s_p$  also ensures that  $\phi > 0.5$ , which is a necessary condition for an informative signal. From the above, it follows that

$$\Pr(\text{ project } g \mid c = g) = \frac{\phi s}{\phi s + [1 - \phi][1 - s]} \equiv \hat{s} > s \quad (4)$$

$$\text{and } \Pr(\text{ project } b \mid c = g) = \frac{[1 - \phi][1 - s]}{\phi s + [1 - \phi][1 - s]} \equiv 1 - \hat{s}. \quad (5)$$

This means that the expected quality of a project for which  $c = g$  is

$$\hat{s}N - [1 - \hat{s}]N = [2\hat{s} - 1]N \equiv \bar{s}N \quad (6)$$

and the expected quality of a project for which  $c = b$  is

$$\hat{r}N - [1 - \hat{r}]N = [2\hat{r} - 1]N \equiv \bar{r}N \quad (7)$$

$$\text{where } \hat{r} \equiv \frac{[1 - \phi]s}{[1 - \phi]s + \phi[1 - s]} < s. \quad (8)$$

For the optimists, we replace  $\hat{s}$ ,  $\bar{s}$ ,  $\hat{r}$ , and  $\bar{r}$  by  $\hat{s}_o$ ,  $\bar{s}_o$ ,  $\hat{r}_o$ , and  $\bar{r}_o$ , respectively. Likewise, we replace  $\hat{s}$ ,  $\bar{s}$ ,  $\hat{r}$ , and  $\bar{r}$  by  $\hat{s}_p$ ,  $\bar{s}_p$ ,  $\hat{r}_p$ , and  $\bar{r}_p$  for the pessimists. The various expressions remain otherwise unaltered. Clearly,  $\bar{s}_o > \bar{s} > \bar{s}_p$ , and  $\bar{r}_o > \bar{r} > \bar{r}_p$ . We now have the following lemma.

**Lemma 1** *The expected NPV of a project for which the signal indicates  $c = b$  is negative even using the rational agent’s priors, i.e.  $\bar{r}N < 0$ ; the expected NPV of a project for which the signal indicates  $c = g$  is positive even using the pessimist’s priors, i.e.,  $\bar{s}_pN > 0$ . For the optimist, when  $c=b$ , the expected NPV of the project will be positive if  $s_o > \phi$  and negative if  $s_o < \phi$ .*

Lemma 1 says that an optimistic agent will reject a project when the signal indicates it is bad and  $s_o < \phi$ , and that a pessimistic agent will always accept a project when the signal indicates it is good. The consequence of this lemma is that as long as  $s_o < \phi$ , all types of agents will find screening to be informative if compelled to invest in the project, since even the pessimist accepts the project when  $c = g$  and even the optimist rejects it when  $c = b$ . When  $s_o > \phi$ , optimists will never screen since they accept the project regardless of what the signal indicates. The sequence of events is thus as follows: The entrepreneur first expends effort  $t$ ; the project is then screened, and if it is found acceptable, it is finally funded.

### 2.1. The assumptions

In this subsection, we highlight all of the assumptions we make on the parameters of the model and explain the roles these assumptions will play in the analysis that follows.

**Assumption 1** *The core assumptions on probabilities are:*

$$s < 0.5 \text{ and } s_o > \phi > 1 - s_p. \quad (9)$$

Assumption 1 ensures both that the rational agents will not randomly invest in projects without first investigating them, and that the signal of project quality is sufficiently informative, i.e., even the pessimists will accept a project that the signal indicates is good but not so informative that the optimists reject a project that the signal indicates is bad. Note that if a project is screened by a rational agent, then it will be accepted only if  $c = g$ , and thus its expected payoff is

$$\Pr(g)\Pr(c = g|g)N - \Pr(b)\Pr(c = g|b) = s\phi N - (1-s)(1-\phi)N = [s + \phi - 1]N \equiv s^\phi N, \quad (10)$$

where  $s^\phi \equiv s + \phi - 1$ . Clearly, given (9),  $s^\phi > 0$ .

**Assumption 2** *The success probability,  $s$ , assigned by a rational agent is sufficiently low that no rational entrepreneur wishes to invest to get to the funding stage; i.e.,*

$$s^\phi N - V - t < 0. \quad (11)$$

**Assumption 3** *The NPV of the good project,  $N$ , is sufficiently large.*

Precisely how large  $N$  has to be is specified in (38) in the Appendix. Essentially, this last assumption guarantees that at least the optimists (with sufficiently high  $s_o$ ) will wish to become entrepreneurs because they see the expected payoff from investing as sufficiently high to overcome the various costs. For later use, we define  $s_o^\phi \equiv s_o + \phi - 1$  and  $s_p^\phi \equiv s_p + \phi - 1$ .

**Assumption 4** *The variable cost of evaluating projects,  $V$ , is sufficiently small.*

Precisely how small  $V$  has to be is specified in (39) in the Appendix. As we will see in Section 3.2, this assumption ensures that any intermediary that chooses to purchase the screening technology will always have the incentive to use it. Put differently, so long as the individual rationality (participation) constraint binds for the intermediary, i.e., the intermediary expects to earn non-negative profits, the relatively low variable cost of screening will guarantee that its incentive compatibility constraint will also be met (it will incur the variable cost  $V$  to screen projects).

## 2.2. Equilibria without funding constraints and incentive problems

To provide a benchmark solution, let us first consider the case in which entrepreneurs have sufficient wealth to finance their projects and there are no incentive problems in screening, i.e., each entrepreneur can be assumed to screen his project and invest only if the project has positive NPV. The assumption that entrepreneurs possess the necessary funds for investment is patently unrealistic, but it allows for development of the case calling for a financial intermediary later.

Under these conditions, we have the following result.

**Proposition 1** *Assume that an entrepreneur who wishes to undertake a project will also choose to have it screened. Moreover, assume that all projects that are screened and determined to have positive NPV will be able to obtain the necessary financing. Under these conditions, if one views  $s$  as a “beliefs parameter” (rather than a fixed objective reality), there exists a cutoff in the degree of optimism,  $s^* > s$ , such that: (i) if  $s_o < s^*$ , there is a unique equilibrium in which no projects are funded; and, (ii) if  $s_o \geq s^*$ , there is a unique equilibrium in which all optimistic entrepreneurs get funded.*

This result says that no projects will be launched without sufficient entrepreneurial optimism. We know that if the degree of optimism is  $s$ , which is the probability of success assessed by the rational agents, then eschewing the project is strictly preferred to investing in it. Thus, by continuity, if  $s_o$  is slightly above  $s$ , projects will still not be funded and

$s^* > s$ . But if  $s_o$  rises sufficiently, project investment begins to look attractive to the optimists because at some point, Assumption 3 will guarantee that  $s_o^\phi N - V - t > 0$ .<sup>3</sup>

### 3. Financial intermediation with incentive and funding constraints

In this section, we drop the assumptions that entrepreneurs face no funding constraints and that there are no incentive problems in screening projects. We will first show that these constraints are binding in the sense that investment-constrained entrepreneurs, on their own, will never be able to raise the required capital to finance all of their projects. We will then show how a financial intermediary can solve this problem.

*The incentive problem in getting funded without intermediaries*

Assume that  $V$  is not observable to anyone but the entrepreneur himself. For now, we focus on the unique funding equilibrium scenario in which  $s_o \geq s^*$ . Proposition 1 assumes that each optimist has enough wealth to fund his own project. However, recall that each optimistic entrepreneur needs to raise  $0.5I$  per project from external finance sources to add to his endowment of  $0.5I$  to fully fund his project.

Suppose that the optimists form a coalition to screen projects. In this thought experiment, we are assuming that enough resources are gathered from the optimists in the coalition to also have the necessary resources for screening. This means the number of projects being funded will be smaller than the number of optimists in the coalition. Suppose further that the coalition approaches rational agents to invest  $0.5I$  per project. Note, however, that given (1), the rational individuals will never invest unless they believe the entrepreneurs will screen. Assumption 1 guarantees that the optimists will never screen. This leads to the following proposition.

**Proposition 2** *Without an intermediary, if entrepreneurs within the coalition are sufficiently optimistic, no projects get financed by rational or pessimistic agents. The coalition may self-finance its projects, but will be able to finance no more than half the projects in the coalition.*

This result turns on its head Proposition 1, which asserts that a sufficiently high degree

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<sup>3</sup>Note that we have also analyzed (but do not include here) the case in which screening projects involves a fixed cost,  $F$ , that can be spread out over projects if entrepreneurs collaborate to share this cost. In this case, Proposition 1 involves multiple equilibria because coordination among entrepreneurs affects each entrepreneur's screening incentives. An intermediary can help eliminate this multiplicity of equilibria.

of optimism leads to a unique funding equilibrium in the absence of incentive and funding constraints, with this equilibrium requiring that rational agents provide financing so that the projects of all entrepreneurs are funded. When incentive and funding constraints are accounted for, sufficiently high entrepreneurial optimism leads investors to shy away from lending to entrepreneurs. The intuition is as follows. As an entrepreneur's optimism grows, the probability that he attaches to encountering negative-NPV projects declines. Consequently, the cost he attaches to mistakenly investing in such a project also decreases. In other words, a sufficiently optimistic entrepreneur assigns too low a value to eliminating the negative-NPV project to make it worthwhile to pay the marginal screening cost. Of course, the rational and/or pessimistic investors do not share the optimistic entrepreneurs' rosy assessments, and are unwilling to invest in random project draws where the bad projects have not been sorted out. Thus, anticipating the screening behavior of the overly optimistic coalition of entrepreneurs, investors do not extend funds to the coalition. The consequence is that project funding is limited to the internal funds of the coalition itself, which means that no more than half the projects in the coalition can be funded.

### *3.2. The Role of a Financial Intermediary*

We want to analyze now if a financial intermediary that comes between the entrepreneurs and the investors can make it possible for investors to want to invest in projects through the intermediary. The main idea is to verify whether the intermediary can resolve the incentive problem in screening that the coalition of entrepreneurs cannot.

Suppose a group of rational investors forms a financial intermediary and commits to paying the variable cost  $V$  per project. The intermediary promises entrepreneurs that it will fund their projects in the amount of  $0.5I$  per project plus some additional up-front contractual payment. We will show later that this is in fact part of an optimal mechanism design. The contracts negotiated by the intermediary with investors and entrepreneurs are signed prior to the raising of capital and the financing of projects, and are assumed to be legally binding. Each entrepreneur will therefore have to provide the remaining  $0.5I$  as his own equity in the project. We assume that there is free entry into the market to form intermediaries, so intermediaries are perfectly competitive. This means that each intermediary will seek to maximize the surplus of the entrepreneurs subject to the constraints that the investors and the intermediary will choose to participate and the intermediary will screen.

We assume that it takes one agent in the intermediary to screen each project, so we need as many rational agents in the intermediary as there are projects being screened. This is not an indispensable assumption. Rather, the only role of this assumption is to ensure that no agent has unlimited screening ability, which is realistic.

What we want to do is to design the optimal mechanism. Thinking ahead, we note that optimal mechanism design here must obey a simple rule: the least risk must be imposed on those with the lowest beliefs about project quality. The reason is that the mechanism is being designed to maximize the surplus of the entrepreneurs, so the pricing of the contracts for the intermediary and the investors should be such that what is paid to these groups is minimized in expectation. The greater the risk imposed on these groups, the higher will be the payoffs that will have to be promised to them. Hence, the lowest-risk contract, which is a senior debt contract, should be offered to the pessimists. The contract with the next level of risk should be offered to the rational agents, and the optimists should take the most risk.

Given this intuition, it is apparent that if the optimists had enough capital to invest in the projects themselves, they would never want to raise capital from any other group. But assuming that the optimistic entrepreneurs do not have sufficient capital – which is a basic assumption of our model – there are two possible cases. The first case is one in which there are enough rational agents to provide the resources needed for operating the financial intermediary and to also be investors. The other case is one in which there are not enough rational agents to provide both intermediation and investors' capital. We will examine each case in turn. We will choose from among debt and equity contracts. Before doing so, however, let us stipulate the contracts.

Given the intermediary will be comprised of agents other than optimists, it should be offered a debt contract for providing its intermediation services. Let  $Z$  be the payment promised to the intermediary per project after project payoffs are realized. As a debt contract imposes less risk on the intermediary than an equity contract would, it is preferable to offer a debt contract to the intermediary. As we argue later, this risky debt contract could also be interpreted as preferred stock since these two contracts are payoff-equivalent in our model. Similarly, let investors be offered a debt contract that promises them a payment of  $Y$  after project payoffs are realized. Since investors will be either rational or

pessimistic agents, it is preferable to also give them a debt contract. In addition to these payoff-contingent payments, let  $K$  be an up-front payment from the intermediary to the borrower. The purpose of introducing  $K$  is to ensure that a solution exists that satisfies all the constraints of the mechanism design problem. We will interpret  $K$  in terms of real-world contracts later.

At this juncture, it would be useful to consider the equilibrium structure of the intermediary and the associated contracts that will emerge in the ensuing analysis. In the first case above (there are enough rational agents to constitute the intermediary and also become investors) in equilibrium, investors who provide the intermediary with financing are given senior claims on project payoffs and the intermediary takes a junior claim on project payoffs. This is equivalent to investors being sold claims on the intermediary itself – claims that must be settled before those who comprise the intermediary can be paid off. That is, the intermediary is similar in its contractual relationships to venture capitalists and banks. In the second case (rational agents comprise the intermediary and investors are pessimists) in equilibrium, investors receive riskless debt claims. These claims are supported both by project payoffs and intermediary capital, so they can be thought of as claims on the intermediary itself. This case corresponds even more closely to real-world depository intermediaries such as banks. Figure 1 summarizes these possible outcomes of our model.

### *3.2.1. Case A: Large number of rational agents*

Recall that  $\gamma$  is the fraction of agents who are optimistic,  $\gamma_r$  the fraction of agents who are rational, and  $1 - \gamma - \gamma_r$  the fraction of agents who are pessimistic. Suppose  $\gamma_r$  is sufficiently large in a sense that we make precise shortly. We *assume* for now that the investors are given the senior debt contract and the intermediary the junior debt contract. We verify later that this is the optimal mechanism, albeit a constrained optimal mechanism since we take as a given that the market will implement the mechanism – i.e., the market in our analysis plays the role that the arbitrator plays in Myerson (1979). For simplicity, we assume that the screening outcomes of all projects are all conditionally perfectly correlated, i.e., all the projects that are good are evaluated by the signal as either good or bad, and similarly, all projects that are bad are evaluated as good or bad.<sup>4</sup>

Now, let us examine the pricing of the debt contract for investors. Assuming that

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<sup>4</sup>Assuming conditionally identical and independently distributed signals makes the algebra much messier without changing the essential insights.



the incentive compatibility (IC) constraint for the intermediary to screen is satisfied, the per-project payoff to investors (who each provide  $0.5I$  per project) is

$$\begin{aligned} & \Pr(\text{project } g) [\Pr(c = g | \text{project } g) Y + \Pr(c = b | \text{project } g) Y] \\ & + \Pr(\text{project } b) [\Pr(c = g | \text{project } b) \{\text{Min}[I - N, Y]\} + \Pr(c = b | \text{project } b) Y]. \end{aligned} \quad (12)$$

Note that when  $c = b$ , the intermediary does not invest, so  $\$I$  (with  $0.5I$  raised from the entrepreneur and  $0.5I$  raised from investors) is kept idle in the intermediary, where  $I > Y$ . When  $c = g$  and the project is  $b$ , the payoff is  $I - N < 0.5I < Y$ . Thus, the individual rationality (IR) constraint is

$$\Pr(\text{project } g)Y + \Pr(\text{project } b) [\Pr(c = g|b) [I - N] + \Pr(c = b|b)Y] = 0.5I. \quad (13)$$

If the intermediary sells its bonds to pessimistic investors, the promised repayment will be

$$Y_p = \frac{0.5I - [1 - s_p] [1 - \phi] [I - N]}{1 - [1 - s_p] [1 - \phi]} \quad (14)$$

and if the bonds are sold to rational investors, the repayment will be

$$Y_r = \frac{0.5I - [1 - s] [1 - \phi] [I - N]}{1 - [1 - s] [1 - \phi]}. \quad (15)$$

Since  $s > s_p$ , it is clear that  $Y_p > Y_r$ . This means that if there are sufficiently many rational investors, the optimal mechanism involves selling these bonds to the rational investors. Let us now consider the intermediary. The intermediary, if it screens, is subject to a cost of  $V$  per project. So the IR constraint for the intermediary is

$$\begin{aligned} & \Pr(\text{project } g) [\Pr(c = g|g) Z + \Pr(c = b|g) \text{Min}\{Z, I - Y\}] \\ & + \Pr(\text{project } b) [\Pr(c = b|b) \text{Min}\{Z, I - Y\}] - K \geq V. \end{aligned} \quad (16)$$

Suppose  $Z_r > I - Y_r$ . We verify later that this inequality must hold for incentive compatibility. Note that in a competitive equilibrium, (16) must bind – i.e., the intermediary’s net expected profit should be zero. Then, assuming that those in the intermediary are rational, we can rewrite (16) as

$$s\phi Z_r + \lambda_r [I - Y] - K = V, \quad (17)$$

where  $\lambda_r \equiv s[1 - \phi] + [1 - s]\phi$  is the probability that the intermediary receives a signal to not pursue the project. This implies

$$Z_r = \frac{V + K - \lambda_r [I - Y]}{s\phi}. \quad (18)$$

If those in the intermediary are pessimists,

$$Z_p = \frac{V + K - \lambda_p [I - Y]}{s_p\phi}, \quad (19)$$

where  $\lambda_p \equiv s_p[1 - \phi] + [1 - s_p]\phi$ . Clearly, since  $s_p < s$ , we see that  $Z_p > Z_r$ .

This implies that if the goal is to maximize the surplus of entrepreneurs, the intermediary should consist of rational agents rather than pessimists if rational agents are available.

Next we need to consider the IC constraint for the intermediary to screen. This constraint is

$$\begin{aligned} & \Pr(\text{project } g) [\Pr(c = g|g) Z_r + \Pr(c = b|g) [I - Y]] + \Pr(\text{project } b) \Pr(c = b|b) [I - Y] - V - K \\ & \geq \max \{ \Pr(\text{project } g) Z_r + \Pr(\text{project } b) \cdot 0 - K, I - Y - K \}, \end{aligned} \quad (20)$$

where the left-hand side of (20) is the intermediary’s payoff given it screens and then invests in the project, conditional on the screening outcome. The right-hand side of (20) is the intermediary’s payoff per project if it does not screen. The first term inside the max operator is the intermediary’s payoff if it invests unconditionally in the project without screening, and the second term inside the max operator is the intermediary’s payoff if it does not screen and does not invest in the project. It is clear from inspecting (20) that  $Z_r > I - Y$

is a necessary condition for incentive compatibility since a failure of that inequality to hold means that  $I - Y - K$  will always exceed the left-hand side of (20).

We can write (20) as

$$s\phi Z_r + \lambda_r[I - Y] - V - K \geq \max\{sZ_r - K, I - Y - K\}. \quad (21)$$

We now have two cases to consider, given  $Z_r > I - Y$ : case (a),  $sZ_r > I - Y$ ; and, case (b),  $sZ_r < I - Y$ .

Case (a):  $sZ_r > I - Y$

Substituting case (a) and (18) for the IC constraint (21) and using the fact that the IC constraint will bind in equilibrium, we get

$$K = sZ_r; \quad (22)$$

and substituting (22) into (18) in turn yields

$$Z_r = \frac{\lambda_r[I - Y] - V}{s[1 - \phi]}. \quad (23)$$

Note that Assumption 4 guarantees that  $V < [2\phi - 1][1 - s][I - Y]$ , which ensures that  $sZ_r > I - Y$  and  $Z_r > 0$ .

Case (b):  $sZ_r < I - Y$  and  $Z_r > I - Y$

Substituting case (b) and (18) into the IC constraint (21) and using the fact that the IC constraint will bind in equilibrium, we get

$$K = I - Y; \quad (24)$$

and substituting (24) into (18) yields

$$Z_r = \frac{V + [I - Y][1 - \lambda_r]}{s\phi}. \quad (25)$$

Note once again that Assumption 4 guarantees that  $V < [2\phi - 1][1 - s][I - Y]$ , which in this case ensures that  $sZ_r < I - Y$ .

Thus, in either case,  $K$  is a payment made up-front by the intermediary. It is needed because satisfaction of the intermediary's IC constraint requires such a high promised payment to the intermediary that it would earn a positive expected profit, something not possible in a competitive equilibrium. Competition among intermediaries results in each dissipating a sure payoff of  $K$ . We can interpret  $K$  as an expense incurred on marketing inducements offered by the intermediary to attract entrepreneurs to borrow. Real-world banks offer subsidized cash management services and the like to borrowers, which are consistent with this interpretation of  $K$  in our model. It is unimportant for our analysis whether  $K$  is actually received by the potential borrower or it is just an expense incurred by the intermediary. Given the nonstochastic, up-front nature of  $K$ , it may be more appropriate to view  $K$  as a marketing expense incurred by the intermediary with the qualification that this expense has some positive benefit for the potential borrower. Our analysis also explains why the obvious alternative of lowering the bank's state-contingent payment – the interest rate paid by the borrower – is not feasible: any intermediary that attempts to compete by offering a lower interest rate (accepting a lower state-contingent payoff) would not be able to assure investors that it will screen potential borrowers.

Thus far we have established that if there are sufficiently many rational agents, they should form an intermediary and also be investors (depositors). The objective of the mechanism design is, therefore, to solve the following problem<sup>5</sup>

$$\begin{aligned} \text{Max} \quad & s_o\phi \{I + N - Y - Z_r\} - t - 0.5I + K \\ & Y, Z_r, K \end{aligned} \tag{26}$$

subject to  $Y$  satisfying (15) and  $\{Z_r, K\}$  satisfying  $\{(22), (23)\}$  or  $\{(24), (25)\}$ .

Let us now verify whether the maximization of (26) leads to case (a) or case (b). The following lemma is useful.

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<sup>5</sup>One could argue that the objective of the mechanism design should use the rational agents' beliefs rather than  $S_o$ . However, in equilibrium, both the rational agents and the pessimists will have their reservation utility constraints hold tightly and thus they will be indifferent across allocations that may have different utility implications for the optimistic entrepreneurs. Competition among intermediaries will then lead to the choice of the mechanism that is best for the optimistic entrepreneurs.

**Lemma 2** *The equilibrium mechanism design (that maximizes (26) subject to the relevant constraints) leads to case (b), i.e.,  $sZ_r < I - Y$  and  $Z_r > I - Y$ .*

The intuition is that the optimistic entrepreneur would like to minimize the up-front payment to himself since this increases the state-contingent payment to the intermediary that the rational agents in the intermediary value less than the optimist. We now have the following result.

**Proposition 3** *Suppose the fraction of rational agents,  $\gamma_r$ , is sufficiently large. Then a financial intermediary can restore a funding equilibrium in which all entrepreneurs are funded. In this equilibrium, all entrepreneurs are optimists, only rational agents run the intermediary, and all investors are rational. Investors fund through senior debt contracts, the intermediary receives junior debt in the entrepreneurs' projects, and the intermediary also credibly commits to screen projects before funding them.*

The intuition behind this proposition is as follows. Only the optimists are sufficiently bullish about projects to want to invest, and thus they become entrepreneurs. Because they need external financing, they turn to both the rational and pessimistic agents. It is efficient to have an intermediary between the optimistic entrepreneurs and the investors because an entity that credibly pre-commits to screen projects is a necessary precursor to investors providing the needed external capital. This intermediary must be provided incentives to incur the variable cost of screening when the actual screening activity is unobservable. This is done via a contract that imposes payoff risk on the intermediary. Rather than choosing equity to impose this risk, debt is chosen because the risk is priced using the beliefs of the group buying the debt contract (the intermediary), and these beliefs are more pessimistic than those of the (optimistic) entrepreneurs. Hence, entrepreneurs seek to minimize the risk on the intermediary and the investors, subject to the relevant individual rationality and incentive compatibility constraints.

This logic also explains why the intermediary consists of rational agents rather than the pessimists. Because the rational agents have more optimistic beliefs about finding good projects than the pessimists do, the expected payment made to the intermediary under its debt contract is smaller when rational agents run the intermediary.

Investors are also given a debt contract because equity would impose too much risk upon them. This debt contract is senior to that offered to the intermediary, i.e., investors are paid off before the intermediary collects its own payment. When there are sufficiently

many rational agents to provide the necessary intermediation services and also be investors, it is clear that the investors' bond will be priced using the beliefs of rational agents. Consequently, pessimists will not buy these bonds and all investors will be rational. Given there are rational agents in the intermediary and rational agents are investors, it matters little which group holds the more-senior claim. However, we will see that it is strictly preferable to give investors the senior debt claim when there is a scarcity of rational agents. This analysis also clarifies why investors are given a straight debt contract rather than a state-contingent debt contract. It might seem intuitive to simply return to each investor his  $0.5I$  investment when the intermediary decides not to invest in the project ( $c=b$ ), which would represent a state-contingent debt contract. Our equilibrium contract actually pays investors more than  $0.5I$  in this state, thereby reducing the risk exposure of investors to the noise in the signal. This is efficient because it transfers risk from investors to the more optimistic entrepreneurs. In what follows, we also explain that this straight debt contract can be interpreted as preferred stock.

### *3.2.2. Case B: Small number of rational agents*

Suppose now that  $\gamma_r$  is relatively small, so that once the intermediary is composed of rational agents, there simply are not enough rational agents left to provide adequate financing needed by entrepreneurs from investors. We can view this as a situation in which agents are bearish on the economy.

In designing the optimal mechanism, we now have a choice to make. Do we put the rational agents in the intermediary and make the pessimists the investors, or, do we let the pessimists run the intermediary and let the rational agents be investors?

Consider first the case of putting the pessimists in the intermediary. The state-contingent payment promised to them would have to be  $Z_p$ , assuming it satisfies the incentive compatibility constraint for screening. Investors would be rational and their promised payment would be  $Y_r$ . Investors would have a net expected payoff of zero, using the beliefs of the rational agents. But the expected payoff to the rational agents from becoming part of the intermediary would be strictly positive because they would assess a higher probability of being repaid in full than the pessimists whose beliefs were used to price the intermediary's payoff. Thus, nobody would become an investor, which violates the "self-selection" constraint for the optimal mechanism.

A similar problem occurs if we instead make the pessimists investors and let the rational agents run the intermediary. The rational agents will now covet the contract of the investors because that contract would give them a positive expected net payoff, whereas the intermediary's contract yields a zero expected net payoff. Giving the intermediary positive expected profit is not competitively sustainable either, because it would create incentives for competing intermediaries to arise.

One way to solve the problem in the latter case is to somehow make the senior debt claim of investors riskless; note that providing the intermediary a riskless claim instead would violate the incentive compatibility constraint for the intermediary to screen. With investors holding riskless debt, their beliefs become irrelevant and every group will value this debt claim in the same way, thereby eliminating incentive compatibility problems. Given this result, it is efficient to let the pessimists hold this debt because that would allow the rational agents to hold the junior (i.e. more risky) debt in the intermediary. Moreover, the pessimists would not covet the claims held by the rational agents. If the rational agents were investors, it would not affect the pricing of the riskless senior debt, but would force the intermediary's junior debt to be held by the pessimists. With the intermediary's debt being priced using pessimistic beliefs, the rational agents would covet it.

How do we make the investors' senior debt claim riskless? The only way to do so is to provide the investors some form of insurance against the state in which  $c = g$  when the project is  $b$ . In this state, the investors receive  $I - N < 0.5I$ . Thus, if the intermediary could keep capital in the amount  $0.5I - (I - N) = N - 0.5I > 0$  per project as idle cash, it would have at least  $0.5I$  per project in every state. Clearly, the intermediary would itself need to be promised a higher payoff now to satisfy its participation constraint, and thus this capital would be viewed as being costly by the optimistic entrepreneurs because the higher payoff would be priced using the beliefs of the rational agents rather than the optimists. But this is still efficient because we have essentially transferred the pricing of risk from the pessimists to the rational agents. As in the previous case, we continue to posit that the potential borrower receives an up-front payment from the intermediary, which we denote as  $\hat{K}$ .

With this, we see that investors are promised a repayment of  $Y = 0.5I$ . The IR constraint for the intermediary is now written as

$$\begin{aligned}
& \Pr(\text{project } g) [\Pr(c = g|g) Z + \Pr(c = b|g) \{\text{Min}[I + N - 0.5I - Y, Z]\}] \\
& + \Pr(\text{project } b) [\Pr(c = g|b) \cdot 0 + \Pr(c = b|b) \{\text{Min}[I + N - 0.5I - Y, Z]\}] - \hat{K} \\
& = V + N - 0.5I.
\end{aligned} \tag{27}$$

Since  $Y = 0.5I$ , we can write the above as

$$s[\phi Z + [1 - \phi][\min\{Z, N\}]] + (1 - s)[\phi[\min\{Z, N\}]] = V + \hat{K} + N - 0.5I. \tag{28}$$

Later we show that  $Z > N$  is a necessary condition for incentive compatibility, in which case (28) leads to

$$Z = \frac{V + \hat{K} + N[1 - \lambda_r] - 0.5I}{s\phi}. \tag{29}$$

The IC constraint for the intermediary to screen is the analog of (21):

$$s[\phi Z + [1 - \phi]N] + [1 - s]\phi N - V - \hat{K} \geq \max^n \{sZ - \hat{K}, N - \hat{K}^o\} \tag{30}$$

where the left-hand side of (30) is the intermediary's payoff from investing in screening and then investing in the project. The right-hand side of (30) is the intermediary's payoff from not investing in screening. The first term inside the max operator,  $sZ - \hat{K}$ , is the intermediary's expected payoff if it invests unconditionally in the project without screening, and the second term,  $N - \hat{K}$ , is the payoff if it does not screen and does not invest in the project. Again, inspecting (30) reveals that  $Z > N$  is a necessary condition for (30) to hold and that there are two cases to consider.

Case (a):  $sZ > N$

Substituting case (a) and (29) into the IC constraint (30) and using the fact that the IC constraint will bind in equilibrium yields

$$\hat{K} = sZ - N + 0.5I; \tag{31}$$



substituting (31) into (29) in turn yields

$$Z = \frac{\lambda_r N - V}{s[1 - \phi]}. \quad (32)$$

Case (b):  $sZ < N$  and  $Z > N$

Substituting case (b) and (29) into the IC constraint (30) and using the fact that the IC constraint will be binding in equilibrium yields

$$\hat{K} = 0.5I; \quad (33)$$

substituting (33) into (29) yields

$$Z = \frac{V + N[1 - \lambda_r]}{s\phi}. \quad (34)$$

Note that Assumption 4 guarantees that  $V < N[\lambda_r - [1 - \phi]]$ , which ensures  $sZ < N$  in case (b).

The objective of the mechanism design is to

$$\text{Max}_{Y, Z, \hat{K}} \quad s_o\phi \{I + N - Y - Z\} - t - 0.5I + \hat{K} \quad (35)$$

subject to  $Y = 0.5I$  and  $\{Z, K\}$  satisfying  $\{(31), (32)\}$  or  $\{(33), (34)\}$ .

As before, we need to verify whether case (a) or case (b) is consistent with maximizing (35).

**Lemma 3** *The equilibrium mechanism design (that maximizes (35) subject to the relevant constraints) leads to case (b), i.e.,  $sZ < N$  and  $Z > N$ .*

The intuition is similar to that of Lemma 2. We now have the following result.

**Proposition 4** *Suppose the fraction of rational agents,  $\gamma_r$ , is not so high that there are enough rational agents to populate the intermediary and become investors. Then, in the funding equilibrium attainable with an intermediary, and given all entrepreneurs are optimists, only rational agents run the intermediary and all investors are pessimists. Investors*

*fund through senior (riskless) debt contracts, and the intermediary receives junior (risky) debt or preferred stock in the entrepreneurs' projects and also credibly commits to screen projects before funding them.*

Notice how the three types of agents all end up self-selecting into different activities. Even though everyone is risk neutral, their respective degrees of optimism determine how much risk they will take. Also observe that while we have described the intermediary's claim as a risky debt contract, it could just as easily be described as preferred stock. Given the way  $Z$  is structured, there are essentially two states: (i) the project is bad and  $c=g$ ; and, (ii) the project is bad and  $c=b$ , or, the project is good. In state (i), the intermediary receives a state-contingent payoff of zero, whereas in state (ii), the intermediary receives  $Z$ . These would be the same payoffs the intermediary would receive in these two states with preferred stock held by the intermediary and common stock held by the entrepreneurs. The preferred stock would promise a dividend of  $Z$  that would need to be paid before any payout could be made to common shareholders. In state (i), both the holders of the preferred stock and the common stock would receive nothing, whereas in state (ii), preferred stockholders would receive their promised dividend. This interpretation may be more appealing in light of the empirical evidence regarding the types of contracts held by venture capitalists (see, e.g., Gompers and Lerner, 1999).

The viability of this whole mechanism rests on agents self-selecting appropriately. In this equilibrium, the rational agents prefer to participate in the intermediary because their expected payoff from forming an intermediary is zero, whereas they view direct project ownership as a negative-payoff proposition. They are indifferent between investing in the financial intermediary and being an intermediary themselves; both yield zero expected payoffs. Given this knife-edge, we are safe in assuming rational agents become intermediaries.

The pessimists strictly prefer to be investors because they get zero expected payoff from doing so, whereas if they become intermediaries, they would assess their payoffs as being negative, given their beliefs and the ownership fraction the rational agents in the intermediary are willing to accept. Clearly, pessimists see entrepreneurship as a losing proposition.

The optimists strictly prefer entrepreneurship, which they see as delivering a positive expected payoff, which exceeds their expected payoff if they become intermediaries. Because

the payoff from participating as investors is zero regardless of beliefs, the optimists prefer entrepreneurship to becoming investors in the intermediary.

**Corollary 1** *As long as the conditions needed for the formation of an intermediary are satisfied, the funding equilibrium in Proposition 3 is unique, as is the equilibrium in Proposition 4.*

The intuition is as follows. What can give rise to the possibility of multiple equilibria in this analysis is the context in which the funding decision of each entrepreneur or the screening decision of the intermediary depends on how many other entrepreneurs are seeking funding. Here, the payoff each entrepreneur gives to the intermediary is fixed in advance and is independent of how many entrepreneurs seek funding from the intermediary. Moreover, the incentive compatibility constraint for the intermediary to screen projects does not depend on how many entrepreneurs are being funded by the intermediary. Thus, an entrepreneur's beliefs about how many other entrepreneurs will seek funding do not affect the entrepreneur's decision of whether to seek funding himself, and thus seeking funding becomes a dominant strategy.

The two cases we have examined are distinguished by whether there are enough rational agents to form intermediaries and also serve as investors. When there are sufficiently many rational investors, we can say that there is relatively low pessimism. In this case, intermediaries don't need capital. When there are not enough rational investors, we can say that there is relatively high pessimism. In the latter case, intermediaries need capital, which is perceived as being costly by entrepreneurs. Thus, it takes a relatively high degree of investor pessimism (low  $\gamma_r$ ) to make intermediary capital necessary.

The result that intermediary capital is needed when there is a scarcity of rational agents and a surplus of pessimistic agents suggests a new way to think about capital. When pessimism grows among investors in the economy, intermediaries become more likely to require capital to bridge the beliefs gap between the rational intermediaries and their pessimistic investors. This makes financing more expensive for entrepreneurs. If the funding demand from entrepreneurs is downward sloping, then higher levels of intermediary capital will be correlated with lower levels of entrepreneurial funding.

We thus observe that capital may be needed for the *viability* of intermediaries. This is a different perspective from the ones presently in the literature about the role of intermediary

capital. In particular, one perspective holds that capital acts as a deterrent against the intermediary’s propensity to take excessive risk; this view is often used as a justification for capital requirements for banks with federally-insured deposits (see, for example, Calem and Robb, 1999; Keeley and Furlong, 1990; and Keeley, 1990). Another perspective is that higher bank capital may lead to less liquidity transformation – the ability to issue liquid deposit claims against a portfolio of relatively illiquid loans – by banks (Diamond and Rajan, 2000). Our analysis shows that a minimum level of intermediary capital may be necessary for intermediaries to provide any liquidity transformation at all.

### 3.3. *A numerical example*

Our analysis uses numerous parametric restrictions to focus on the economically interesting outcomes. Below we provide a numerical example to illustrate the model and show that the set of exogenous parameter values for which all the parametric restrictions are satisfied is nonempty.

Consider a setting in which  $N = 7$ ,  $I = 10$ ,  $s_o = 0.95$ ,  $s = 0.3$ ,  $s_p = 0.2$ ,  $\phi = 0.85$ ,  $V = 2$ ,  $t = 2$ , and the fraction of rational agents,  $\gamma_r$ , is not large enough for only the rational agents to populate the intermediary and become investors; i.e., this means pessimists will become investors. Note that these parameter values are consistent with the model setup: the expected NPV of a project is negative ((1)), and the model parameters are consistent with Assumptions 1 through 4.

Next, note that if the entrepreneurs require outside funding for their projects (e.g. if they borrow \$5 and promise to repay  $Z = \$5$ ), according to Assumption 1, entrepreneurs will never be able to convince investors that they will, indeed, screen: entrepreneurs do not perceive the benefits of screening as justifying their marginal cost,  $V = 0.2$ .

However, if an intermediary emerges that offers to invest in the project in return for a promised payment of  $Z = \$13.33$  (calculated from (29)), the entrepreneur will accept because he cannot raise the money on his own and his utility is still positive (i.e., his IR constraint, (29), is satisfied) and higher than if he joins the intermediary (i.e., his IC constraint, (30), is satisfied) or becomes an investor providing funds to the intermediary (since investors earn zero return regardless of beliefs). Note that under this parameterization, the entrepreneur will not be asked to put up any funds of his own ( $\hat{K} = 5$ ). This will ensure that the intermediary will screen (by making his payoff sufficiently state-dependent) and still earn

zero expected return. To convince the pessimists to provide \$5 in capital, the intermediary will need \$2 of capital to convince the pessimists that in the bad state of the world (when payoffs are  $I - N$ ) their investment will still be returned.

## 4. Extensions and implications

In this section, we discuss an extension of the model that deals with the consequences of a shortage of intermediary capital. Then we discuss empirical implications of the analysis.

### *4.1. Consequences of shortage of intermediary capital*

In the previous section, we consider a case in which pessimistic agents become investors and intermediaries are populated by rational agents. We assume in that analysis that there were enough rational agents in intermediaries to supply the capital needed to issue riskless debt claims to investors. An interesting question that this raises is: What happens if there are not enough rational agents to provide the capital needed for sufficiently many riskless debt claims to be issued to finance all entrepreneurial projects deemed worthy of funding?

To address this question we consider two cases: a moderate shortage of rational agents, and a more extreme shortage of rational agents. Consider the first case. In this case, there simply isn't enough intermediary capital to obtain enough riskless debt financing from investors to fund all projects. Consequently, intermediaries face a "capacity constraint" and it will be known a priori that some entrepreneurs whose projects have received good signals after screening will not be funded. Since all such entrepreneurs are observationally identical to intermediaries and the credit-granting decision has no incentive effects on any agents, the obvious mechanism to deal with this situation is for the intermediary to announce a priori that there is a probability that even entrepreneurs with affirmatively-screened projects will be rationed. This probability is random at the time it is announced because the actual probability of rationing will depend on how many entrepreneurs are affirmatively screened relative to the supply of funds; for each entrepreneur, this probability will equal the number of entrepreneurs affirmatively screened divided by the number of entrepreneurs whose projects can be funded, given the intermediary's capital.

Recall that each optimistic agent experiences positive expected utility as an entrepreneur, zero expected utility as an investor (because the investor's claim is riskless), and positive expected utility as an intermediary. In the equilibrium in which no entrepreneur with a

good signal is rationed, the optimistic agent's highest expected utility derives from being an entrepreneur. While the expected utility associated with entrepreneurship is now lower with rationing, it still exceeds the expected utility the optimist associates with being part of an intermediary, as long as the probability of entrepreneurs being rationed is sufficiently low. In this case, the principal effect of a shortage of rational agents and hence intermediary capital is a higher incidence of rationing and a lower level of project funding in the real sector.

More dramatic effects could arise if the shortage of rational agents is more severe. A sufficiently severe shortage will lead to such a high rationing probability that an optimistic agent will perceive a higher expected utility from being part of an intermediary than being an entrepreneur, particularly if the degree of optimism is not very high. Consequently, the incentive compatibility of the self-selection mechanism we have characterized breaks down as optimists rush to form intermediaries. Now, if all optimists are equally optimistic, the market collapses as there is an abundance of intermediaries but no entrepreneurs approaching them for financing. If there are varying levels of optimism among optimistic agents (i.e., more than three types of agents), the least optimistic agents prefer to join intermediaries, whereas sufficiently optimistic agents prefer entrepreneurship. But even in this case, there is a diminished entrepreneurial demand for funds.

Note that there is an interaction between the shortage of rational agents and the degree of optimism of the optimists. With varying levels of optimism, the greater the degree of optimism the higher is the demand for funds from entrepreneurs. Thus, the decline in demand for funds from entrepreneurs that accompanies a shortage of rational agents is exacerbated by any information shocks that serve to lower optimism. This would include real events in the economy such as widespread project failures as well as other signals such as the level of consumer confidence, the level of the stock market, or pronouncements by prominent policymakers like central bankers about excessive optimism or inflated expectations. This suggests that once the economy finds itself in a state in which there is relatively low entrepreneurial demand for funds, it may be difficult for it to pull itself out. This is because in this state, there are intermediaries populated by optimists masquerading as rational agents. These intermediaries do not screen projects, and consequently fund bad projects. This does not affect the supply of funds from the (pessimistic) investors because they receive riskless payoffs. In subsequent periods, a higher-than-expected number of projects fail, pos-

sibly leading to inferences and statements by prominent policymakers that further lower optimism, worsening the low-funding-demand situation.

#### *4.2. Policy implications*

The above discussion has strong policy implications. As we indicate, the degree of optimism displayed by agents is influenced by a variety of signals. What our discussion indicates is that if these signals collectively convey sufficiently adverse information, entrepreneurial activity could suffer a significant decline, and once a decline sets in, it may be difficult to reverse. This seems to correspond reasonably well to what we have observed in the U.S. in the past few years, and suggests a positive role for raising entrepreneurial optimism.

This may also shed light on why intermediaries in some emerging economies seem to be lending so little to finance projects in the real sector. Corruption (see, e.g., Shleifer and Vishny, 1993), poor enforcement of credit contracts, incompleteness in capital markets, debt overhang problems, and other factors that are outside our model may also contribute to restricted credit supply in emerging economies (see Mitchell, 2001, for example). However, these factors may also contribute to entrepreneurial pessimism about project profitability, explaining why entrepreneurial demand for funds may also be very low in these economies. If much of the information about the common element of project success is adverse and/or there is a shortage of intermediary capital (rational agents), the number of entrepreneurs that seek funding may be low to start with, or the equilibrium may be one that involves no funding.

Thus, emerging economies could find themselves in a “beliefs trap.” On the one hand, insufficient entrepreneurial optimism for starting projects may make it very difficult to revive entrepreneurship through intermediated external financing. The focus of government efforts in such cases should be on finding ways to subsidize the pre-investigation cost,  $t$ , that the entrepreneur faces – through initiatives like subsidized market research and feasibility-study assistance – and putting forward credible signals that fuel entrepreneurial optimism. On the other hand, if intermediaries themselves are insufficiently capitalized, entrepreneurs will face the specter of rationing, which will depress funding demand and counteract measures to increase this demand through greater entrepreneurial optimism.

#### *4.3. Empirical predictions*

Besides rationalizing financial intermediaries that have no special information processing or monitoring advantages, our analysis also produces the following empirical implications:

**Implication 1** *The importance of financial intermediation in an economy is associated with variables related to the level of entrepreneurial optimism and the relative heterogeneity of optimism within the population.*

This result follows from Proposition 3 because the intermediation characterized in that proposition is viable only if entrepreneurs are sufficiently optimistic and there exist agents with lower degrees of optimism, such as the rational agents. Thus, the proposition suggests that measurements such as the share of financial services as a percentage of GDP will be higher in economies that are more informationally advanced, to the extent that these advances elevate the level of entrepreneurial optimism in the economy. A positive correlation between informational advances and entrepreneurial optimism should be expected because informational advances make many projects more attractive than they would be in the absence of such advances. As examples, consider the emergence of firms like AOL and Yahoo, and the rapid growth of firms like Microsoft and Cisco during the years in which we experienced the most rapid informational advances.

**Implication 2** *A small negative shock or drop in confidence in an economy can lead to a shift from an equilibrium in which many projects are funded to one in which few projects are funded.*

This follows directly from Propositions 1, 3, and 4. In particular, we know that there is a cutoff level of optimism above which optimists prefer entrepreneurship above all else, and that below this level of optimism they prefer to join intermediaries. Suppose optimism is slightly above the critical level. Then we would observe a relatively high degree of entrepreneurial demand and a large number of projects being funded. Now consider a small negative signal that lowers optimism just below the critical level. This will make the optimists want to join intermediaries and entrepreneurial demand for funding will dry up altogether. Thus small negative signals can have significant power in predicting changes in the overall level of funding activity. As an example, many attribute Lehman bond analyst Ravi Suria's June 2000 report, in which he questioned Amazon's creditworthiness, as the catalyst that brought about the collapse of the Internet sector.<sup>6</sup> The implication

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<sup>6</sup>In June, Ravi Suria, who covers Amazon.com Inc. for Lehman Brothers Inc., dropped a bomb on



above predicts that signals such as this one, which on their own appear to be of marginal informational value, can impact future funding in a disproportionate way.

**Implication 3** *There should exist a strict rank ordering of the risk assumed by the various investors in entrepreneurial projects, such that investors in financial intermediaries assume the least risk (receive the most-senior claims), intermediaries assume greater risk and retain greater upside in the project (receive preferred stock or junior (risky) debt claims), and entrepreneurs retain the residual claims with both the greatest risk and upside (common equity).*

This follows from Proposition 4. It is highly consistent with the structure of most U.S. venture capital partnerships as well as banks' contracts with depositors and borrowers. Gompers and Lerner (1999) point out that under most agreements, the general partners (venture capitalists) do not receive a share of profits until the limited partners have been paid the return on their investment. Similarly, the claims of the intermediary in the project, usually taking the form of convertible debt, are senior to those of the entrepreneur.

**Implication 4** *Intermediary capital levels and entrepreneurial funding levels are negatively correlated.*

This follows from Proposition 4. The presence of pessimistic investors requires intermediaries to keep more capital than they otherwise would. This increases the cost of financing for entrepreneurs and diminishes their demand for funds.

#### *4.4. The effect of risk aversion*

Our analysis has been conducted in a risk-neutral setting. We briefly discuss the potential impact of introducing risk aversion.

At a general level, it is difficult to disentangle preferences from beliefs in terms of behavioral implications since an optimist's behavior relative to that of a pessimist will, in many circumstances, look similar to the behavior of a less risk-averse agent. In our analysis, the results characterized in the various propositions are qualitatively unaffected by introducing risk aversion, as long as all agents have identical preferences and can still be "rank-ordered" on the basis of their beliefs as in our analysis. Of course, a sufficient increase

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the Internet world with a report that likened Amazon to an Old Economy retailer and asserted that its creditworthiness was 'extremely weak and deteriorating.' It was sharp analysis in a market where most analysts seem to be press agents for investment bankers. And it was a needed wake-up call." - Marcia Vickers, Business Week, December 11, 2000.

in risk aversion may induce even the optimists not to become entrepreneurs because risk premia will be excessive relative to the risk-return tradeoff offered by available projects. This means that with risk aversion, there is a smaller set of exogenous parameter values for which intermediated financing of projects occur. However, it will still be true that intermediation permits more projects to be funded than possible without intermediation.

What impact would risk aversion have on the empirical predictions of Section 4.3? Implication 1 would have to be altered to include risk aversion as another variable on which the importance of financial intermediation would depend. Implication 2 is largely unaffected, other than the fact that an increase in risk aversion will have an effect similar to a drop in confidence. Implications 3 and 4 are qualitatively unaffected by risk aversion.

## 5. Conclusion

The basic thesis of this paper is that differences in opinions may suffice to give rise to financial intermediation. This theory of financial intermediation does not rely on any specific skills or advantages for the intermediary either in processing pre-contract private information via credit analysis or in resolving post-contract moral hazard problems via monitoring. The intermediary in our theory arises endogenously to act as a “beliefs bridge” between the optimists who become entrepreneurs and the pessimists who choose to become investors in the intermediary. Rational agents comprise the intermediary because they are the only participants who can credibly pre-commit to screen bad projects from good projects.

What emerges in this setting is an endogenous self-selection whereby the optimists, who have the rosier assessments of the prospects of their projects, become entrepreneurs and equityholders, thereby taking the most payoff risk. The rational agents, who take risky debt or preferred stock positions in the projects, take the second-highest degree of risk. The pessimists, who have the most-bearish beliefs about projects, provide financing to the intermediary via riskless debt contracts, thereby taking the least risk. This self-selection occurs despite the fact that everybody is risk neutral.

This theory allows us to explain financial intermediation in a way that seems more consistent with the stylized facts. In particular, we are able to explain why intermediation need not decline as the information processing advantage of intermediaries diminishes. Our theory also accounts for relative scarcity of intermediation activity in economies that are

rife with the private information and agency problems that provide the very rationale for the contemporary view of why intermediation exists.

We believe that the approach we have taken has the potential to permit a fundamental reexamination of how we think about financial intermediation. We hope that future research further explores this potential.

## 6. Appendix

### Proof of Lemma 1

Suppose an optimist observes  $c = b$ . Then his posterior belief about project quality is  $\hat{r}_o$ . To show  $\bar{r}_o < 0$ , we want to show that  $2\hat{r}_o < 1$ , i.e.,

$$\frac{2[1 - \phi]s_o}{[1 - \phi]s_o + \phi[1 - s_o]} < 1, \quad (36)$$

which is true only if  $s_o < \phi$ . Note that the above inequality always holds for the rational agent since  $s < 0.5 < \phi$ . The inequality is reversed for the optimist if  $s_o > \phi$ . Moreover, to show that  $\bar{s}_p > 0$ , we need  $2\hat{s}_p > 1$ , which requires

$$\frac{2\phi s_p}{\phi s_p + [1 - \phi][1 - s_p]} > 1 \quad (37)$$

which holds since  $\phi > 1 - s_p$ . ■

### Parametric Restrictions Corresponding to Assumptions 3 and 4

*Assumption 3:*

$$N > \max \{ \Psi_1, \Psi_2, \Psi_3, \Psi_4, \Psi_5 \} \quad (38)$$

where

$$\begin{aligned} \psi_1 &\equiv V + t \\ \psi_2 &\equiv \frac{t + 0.5I}{s_o\phi} \\ \psi_3 &\equiv \frac{0.5I}{1 - s} - \frac{st}{s_o[1 - s]} \\ \psi_4 &\equiv \frac{0.5I[s_o - s]}{s_o[1 - 2s]} - \frac{st}{s_o[1 - 2s]} \\ \psi_5 &\equiv \frac{0.5Is\phi - V - t}{[1 - \phi][1 - s]}. \end{aligned}$$

Assumption 4:

$$V < \min \{\zeta_1, \zeta_2, \zeta_3, \zeta_4, \zeta_5, \zeta_6\} \quad (39)$$

where

$$\begin{aligned} \zeta_1 &\equiv \frac{[2\phi - 1][1 - s] \{0.5I - N[1 - s][1 - \phi]\}}{1 - [1 - s][1 - \phi]^{\frac{1}{2}}} \\ \zeta_2 &\equiv \{N + I - Y_r\} - V + \frac{[I - y][1 - \lambda_r]^{\frac{3}{4}}}{s \text{ phi}} - \frac{t + 0.5I}{s_o \phi} \\ \zeta_3 &\equiv \frac{\phi s^{\frac{1}{2}}}{s_o} \{2 - s_o[1 - \phi] - \frac{s_o[1 - s][1 - \phi]^{\frac{3}{4}}}{\phi s}\} - \frac{0.5I - N[1 - s][1 - \phi]^{\frac{3}{4}}}{1 - [1 - s][1 - \phi]} \\ \zeta_4 &\equiv N\lambda_r + 0.5I \\ \zeta_5 &\equiv 0.5Is\phi - N[1 - \phi][1 - s] - \frac{ts}{s_o} \\ \zeta_6 &\equiv \frac{0.5s_o\phi I + N[1 + s_o\phi] - t}{s_o[1 + \phi]} - \frac{N[1 - \lambda_r]}{s\phi}, \end{aligned}$$

where  $\lambda_r \equiv \phi[1 - s] + s[1 - \phi]$ , and  $Y_r$  is defined as in (15).

## Proof of Proposition 1

Define  $\hat{s}^\phi$  as the solution to

$$\hat{s}^\phi N - V - t = 0. \quad (40)$$

We know that given (11) and (38) (particularly  $N > \Psi_1$ ),  $\hat{s}^\phi \in (0, 1)$ . If  $s_o^\phi < \hat{s}^\phi$ , then it is clear that no optimistic entrepreneur will seek funding. Since rational and pessimistic individuals never seek funding, we have a no-funding equilibrium. Now define  $s^* \equiv \hat{s}^\phi + 1 - \phi$ , so that it follows that there will be a no-funding equilibrium if  $s_o < s^*$ . Finally, if  $s_o \geq s^*$  then it is a dominant strategy for each optimist to seek funding. Thus, there is a unique funding equilibrium in this case. ■

## Proof of Proposition 2

If the rational agents are to provide funding, they know the optimists will not screen. Thus, to satisfy the individual rationality constraint of the rational agents that provide funding, they must be promised a payoff of

$$\hat{Y} = \frac{0.5I - [1 - s][I - N]}{s} \quad (41)$$

and the entrepreneur's expected utility is:

$$s_o^{\frac{1}{2}} I + N - \mu \frac{0.5I - [1 - s][I - N]}{s}^{\frac{1}{3}} - t - 0.5I < 0 \quad (42)$$

given (38) (particularly  $N > \Psi_4$ ).

Thus, entrepreneurs are willing to obtain funds at the price at which rational agents are willing to provide them, and no financing is raised from the rational agents. It follows trivially from this that funds would not be raised from the pessimists either. ■

## Proof of Lemma 2

Let  $EU_a^o$  and  $EU_b^o$  represent the entrepreneur's expected utilities associated with cases (a) and (b), respectively. Thus,

$$EU_a^o - EU_b^o = s_o \phi [I + N - Y_r] - s_o \phi Z_r^a + K_a - s_o \phi [I + N - Y_r] + s_o \phi Z_r^b + K_b, \quad (43)$$

where  $Z_r^a$  and  $Z_r^b$  correspond to the  $Z_r$  for cases (a) and (b), respectively. Similarly,  $K_a$  and  $K_b$  correspond to the  $K$  for cases (a) and (b), respectively. Thus, since  $K_a = sZ_r^a$  and  $K_b = I - Y$ , we have

$$EU_a^o - EU_b^o = sZ_r^a - [I - Y] - s_o \phi \left( Z_r^a - Z_r^b \right). \quad (44)$$

Now we can show that if expected utilities are evaluated using the rational agents' beliefs, we have  $EU_a - EU_b$ , which means that

$$sZ_r^a - [I - Y] = s\phi^h Z_r^a - Z_r^b{}^i . \quad (45)$$

It follows from (45) that

$$sZ_r^a - [I - Y] < s_o\phi^h Z_r^a - Z_r^b{}^i , \quad (46)$$

and  $EU_a^o - EU_b^o < 0$  or  $EU_b^o > EU_a^o$ . ■

### Proof of Proposition 3

The proof requires the following:

1. Each entrepreneur's expected utility, using the optimists' beliefs, is strictly positive for financing his project through a financial intermediary.
2. The incentive compatibility (IC) constraint that the optimist will not join the intermediary or become an investor holds.
3. The IC constraint that a rational agent will not become an entrepreneur holds.
4. The individual rationality constraint (IR) that a rational agent in an intermediary will earn at least zero expected profits holds.
5. The IC constraint that an intermediary will screen holds.
6. The IR constraint the rational agents will earn zero expected profits holds.
7. It is efficient to design the mechanism so that the rational agents, and not the pessimists, are induced to form the intermediary.
8. It is efficient to design the mechanism so that the rational agents, and not the pessimists, become the investors.
9. It is not efficient to design the mechanism so that the rational agents in the intermediary lend unconditionally without screening or eschew lending without screening.

Let us first consider step 1. If an entrepreneur finances his project through an intermediary, his expected utility is

$$EU_o = s_o\phi[I + N - Y_r] - s_o\phi Z_r - t - 0.5I + [I - Y_r], \quad (47)$$

where  $Y_r$  is given by (15),  $Z_r$  is given by (25), and we have used the fact that  $K = I - Y$ . From (39) (particularly  $V < \psi_2$ ), it follows that  $EU_o > 0$ .

Let us now consider step 2. We need to show first that the optimist will not join an intermediary. It is obvious that if the optimist joins the intermediary and decides not to screen or lend, then his payoff is zero and this is dominated by the alternative of being an entrepreneur. The relevant case to consider then is that of joining the intermediary and funding projects unconditionally without screening. If the optimist in the intermediary does this, his expected payoff is

$$s_o Z_r - [I - Y_r]. \quad (48)$$

If he joins the intermediary and screens and then funds conditional on screening, his expected payoff is

$$s_o\phi[I + N - Y_r] - s_o\phi Z_r + [I - Y_r] - t - 0.5I, \quad (49)$$

where  $Y_r$  is given by (15) and  $Z_r$  is given by (25). We need to show that (49) exceeds (48). We know from (39) (particularly  $V < \zeta_3$ ) that

$$[2 + s_o\phi][I - Y_r] > s_o Z_r \quad (50)$$

and from (38) (particularly  $N < \psi_3$ ) that

$$s_o\phi N > t + 0.5I. \quad (51)$$

From (50) and (51), it follows that (49) exceeds (48). It is quite clear that an optimist will not become an investor since the payment he would need to receive to break even,  $Y_o$ , would be below  $Y_r$  (to see this, note that  $\partial Y_r / \partial s < 0$ , where  $Y_r$  is given by (15)).



We now consider step 3. If a rational agent becomes an entrepreneur, his expected utility will be

$$EU(s) = \phi s[I + N - Y_r] + \lambda_r[I - Y_r] - V - t - 0.5I, \quad (52)$$

where  $\lambda_r \equiv [1 - s]\phi + [1 - \phi]s$ . It is clear that  $\partial EU/\partial s > 0$ . Moreover,

$$EU(s = 0) = -N[1 - \phi] - V - t < 0. \quad (53)$$

Since  $EU(s)$  is continuous in  $s$ ,  $EU(s) < 0$  for  $s > 0$  small enough.

Let us now go to step 4. This holds by the manner in which we obtain  $Z_r$  and  $K$ . Similarly, our method of solution guarantees step 5. Moreover, (15) ensures that step 6 holds. As for step 7, note that from  $Z_r$  in (25), we know that  $\partial Z_r/\partial s < 0$ . Thus, if the pessimists form the intermediary, the  $Z_r$  that would need to be promised to them would be larger, which would reduce the net expected payoff of the entrepreneurs. Further, from (14) and (15) we see that it is efficient to design the mechanism so that the rational agents rather than the pessimists become the investors. Finally, to take care of step 9, note that the net payoff to the entrepreneur is zero if the intermediary unconditionally eschews lending without screening. By Proposition 1, we also know that the net expected payoff of the entrepreneurs is negative if the intermediary lends unconditionally without screening.

■

### Proof of Lemma 3

Here,

$$\begin{aligned} EU_a^o &= s_o\phi[I + N - 0.5I - Z_a] + \hat{K}_a - t - 0.5I \\ &= s_o\phi[0.5I + N] - s_o\phi Z_a + sZ_a - N - t \\ &\quad \text{since } \hat{K}_a = sZ_a - (N - 0.5I) \\ EU_b^o &= s_o\phi[0.5I + N] - s_o\phi Z_b + \hat{K}_b - t - 0.5I \\ &= s_o\phi[0.5I + N] - s_o\phi Z_b - t \end{aligned}$$

$$\text{since } \hat{K}_b = 0.5I. \tag{54}$$

We can show that  $EU_a$  and  $EU_b$  are equal if we substitute  $s$  for  $s_o$  in  $EU_a$  and  $EU_b$ , so

$$sZ_a - N = s\phi[Z_a - Z_b]. \tag{55}$$

Thus,

$$\begin{aligned} EU_a^o - EU_b^o &= sZ_a - N - s_o\phi[Z_a - Z_b] \\ &< 0 \text{ since } s_o > s. \end{aligned} \tag{56}$$

Thus,  $EU_b^o > EU_a^o$ . ■

### Proof of Proposition 4

The proof is similar to that of Proposition 3. It requires showing that:

1. The entrepreneur's expected utility, using the optimist's beliefs, is strictly positive for financing his project through a financial intermediary.
2. The IC constraint that the optimist will not join the intermediary or become an investor holds.
3. The IC constraint that a rational agent will not become an entrepreneur or an investor holds.
4. The IC constraint that a pessimist will not become an entrepreneur or join the intermediary holds.
5. The IR constraint that a rational agent in an intermediary will earn at least zero expected profit holds.
6. The IC constraint that the intermediary will screen holds.

7. The IR constraint that the pessimist will earn at least zero expected profit, using his beliefs, as an investor holds.
8. It is efficient to design the mechanism so that it is the rational agents, rather than the pessimists, who form the intermediary.
9. It is not efficient to design the mechanism so that the intermediary either eschews lending without screening or lends unconditionally without screening.

Let us consider step 1. The entrepreneur's expected utility is

$$EU_o = s_o\phi[I + N - 0.5I - Z] + 0.5I - t - 0.5I \quad (57)$$

where  $Z$  is given by (34). Given  $\zeta_4$  and  $\zeta_5$ , we see that  $EU_o > 0$ .

Next, consider step 2. It is clear that the optimist will not become an investor since the net payoff from that is zero, whereas  $EU_o > 0$ . To show that the optimist will not join the intermediary, note that given previous arguments, we only need to compare the optimist's expected utility from being an entrepreneur with his expected utility from joining the intermediary and lending unconditionally without screening. That is, we need to show that

$$s_o\phi[0.5I + N] - s_o\phi Z - t > s_o Z - \hat{K} - [N - 0.5I], \quad (58)$$

where  $\hat{K} = 0.5I$  and  $N - 0.5I$  is the amount of capital the intermediary keeps. From (39) (particularly  $V < \zeta_6$ ), we see (58) holds.

We now go to step 3. The rational agent will get a net payoff of zero from being an investor, and thus will be indifferent between being an investor and joining the intermediary. If the rational agent becomes an entrepreneur, his expected utility will be

$$EU = s\phi[0.5I + N - Z] - t, \quad (59)$$

where  $Z$  is given by (34). It follows from (38) (particularly  $N > \psi_5$ ) that  $EU < 0$ .

Next we deal with step 4. Since  $\partial \text{EU} / \partial s > 0$ , it follows from the fact that  $\text{EU} < 0$  (with  $\text{EU}$  given by (59)) that the pessimist will not wish to be an entrepreneur either.

To see that a pessimist will not join an intermediary, note that the expected utility of a rational agent from joining an intermediary is

$$s[\phi Z + [1 - \phi]N] + [1 - s]\phi N - V - \hat{K} - (N - 0.5I) = s[\phi Z + [1 - \phi]N] + [1 - s]\phi N - V - N \quad (60)$$

since  $\hat{K} = 0.5I$ . Holding  $Z$  fixed, we see that this expected utility is increasing in  $s$  and it is zero when  $s$  represents the rational agent's belief. Thus,

$$s_p[\phi Z + [1 - \phi]N] + [1 - s_p]\phi N - V - N < 0. \quad (61)$$

Steps 5 and 6 have been taken care of in the solution of the problem to derive  $Z$  and  $K$ .

Step 7 is taken care of since  $Y = 0.5I$ .

Step 8 follows from the fact that  $Z$  is decreasing in  $s$ , so it would be larger with  $s_p$  than with  $s$ .

Finally, for step 9, it is clear from previous arguments that unconditional eschewing lending without screening is not efficient. To see this, we need to show that the entrepreneurs would not wish to design the intermediary's contract to induce unconditional lending. The contract that achieves this has

$$Z = \frac{N - 0.5I}{s} \quad (62)$$

and has  $K = 0$ . Thus, we need to show that

$$s_o N + 0.5I - \frac{N - 0.5I}{s} - 0.5I - t < 0. \quad (63)$$

We see that this is guaranteed by (38) (particularly  $N > \psi_3$ ). ■

## Proof of Corollary 1

For multiple equilibria to exist in this analysis, an entrepreneur's decision to seek funding should depend on how many other entrepreneurs also seek funding. Here, the intermediary signs a binding contract to provide funding to entrepreneurs whose projects are judged via screening to be acceptable and a binding contract with investors to provide them a riskless return. Neither of these contracts depends on how many entrepreneurs seek funding. So the only issue is whether the intermediary's ability to honor these contracts, i.e., its incentive to screen, is affected by how many entrepreneurs it is screening. From the IC constraints (20) and (30), we can see that screening incentives are independent of the number of projects being screened. So an entrepreneur that seeks funding can be assured that his project will be screened. Hence, neither the expected payoff an entrepreneur assessed nor the payoff assessed by investors is affected by any entrepreneur's beliefs about how many other entrepreneurs seek funding, which means that when the conditions for an intermediary to emerge are satisfied, we have a unique funding equilibrium. ■

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Figure 1: Possible outcomes with and without intermediation

