

# Monitoring and the acceptability of bank money

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## Abstract

This paper presents a simple environment where bank-like financial intermediaries endogenously emerge. The economy is one where the return of investment projects depend on monitoring, and where agents value the liquidity of their investments. Monitoring enhances the return of long term projects but also creates informational asymmetries that hamper their tradeability. This tradeoff creates a role for intermediaries who jointly perform delegated monitoring and create liquidity for their claim-holders. The analysis provides a unified explanation for the high acceptability of intermediaries' liabilities and the illiquidity of their assets.

*Keywords:* banking, financial intermediation, monitoring, liquidity creation, informational asymmetries.

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## 1. INTRODUCTION

The idea that banks are “special” seems to have now gained large audience in the profession. Spurred by advances in the microeconomics of imperfect information, researchers have developed formal arguments accounting for banking activities. On the asset side, banks closely monitor investment projects on which they have private information (Diamond, 1984; Boyd and Prescott, 1986). On the liability side, the literature emphasises liquidity provision through demand deposit (Diamond and Dybvig, 1983). These canonical models are being used as building blocks in the analysis of a broad set of issues ranging from financial fragility to macroeconomics.<sup>2</sup>

Whilst banks have historically performed those two functions—credit monitoring and liquidity creation—contemporary financial intermediation theory provides few explanations for this (Gorton and Winton, 2002). Yet economists such as Schumpeter (1934), Gurley and Shaw (1960) or Tobin (1963) all emphasised some link between bank credit and money creation.<sup>3</sup> Indeed, one can plausibly argue that banks are distinct in that they perform useful services on *both sides* of their balance sheet. Money market mutual funds provide liquidity services; venture capitalists fund and monitor investments projects. Banks do both. So, *Why is it that the very institutions granting the bulk of intermediated credit also provide liquidity?* Considering that some famous economists (Friedman, 1959, e.g.) advocate banking regulation separating those activities into different types of institutions, the insights economic theory can give into this issue have consequences far beyond mere theoretical interest.

The theory of the banking firm outlined in Diamond and Rajan (2001, 2002) offers a candidate answer to this puzzle. Their main insight is that the fragility of the balance sheet prevents the initial lender—labelled “the bank”—to use his relationship capital to extract future rent. A competing explanation is provided by Kashyap, Rajan and Stein (2002). The key idea is that lending and borrowing both entail some insurance against

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<sup>2</sup>To cite but a few papers see Allen and Gale (2000) on financial contagion, Bencivenga and Smith (1991) on finance and growth, and Dutta and Kapur (1998) on monetary policy.

<sup>3</sup>For discussions of banks multiple functions with different perspectives, see *inter alia* Fama (1985), Greenwald and Stiglitz (1991), Bhattacharya and Thakor (1993), Freixas and Rochet (1998) and Gorton and Winton (2002).

unobservable liquidity shocks. When firms and households shocks are not perfectly correlated, there are economies of scope between the two activities so that efficiency requires the joint production of both services.

This paper develops an alternative explanation for the combination of credit monitoring and liquidity creation in financial intermediation. The analysis builds on two key ingredients. First, we explore another route—informational asymmetries—to explain both the “moneyness” of banks liabilities and the illiquidity of their assets. As for the latter, banks’ superior information is often invoked as an explanation for why they hold mainly non marketable assets (Goodhart, 1987). As for the former, symmetry of information about quality has been used to rationalise the circulation of outside money (Alchian, 1977). We apply this argument to deposits (inside money). The second ingredient relates to the origin of informational asymmetries. We hypothesise that these arise as the consequence of agents’ decisions to monitor investment projects. This makes sense if one believes that information is not manna from heaven but comes from some agents engaging in costly information production activities. By embedding those two elements, we construct an environment featuring a tradeoff between liquidity and monitoring. This tradeoff is key to our theory.

More precisely, the basic ingredients of the model are as follows. Consider an environment where investors who value liquidity invest in long term projects that can be costly monitored. The decision to monitor is made after the launching of the project and is unobservable. Monitoring means learning specific information that can be used to enhance the future profitability of the project. However, it reduces the ability to sell the asset before maturity because it creates informational asymmetries with respect to outsiders. This is so because potential buyers may fear that the sell is motivated not by (unobservable) consumption need or investment opportunity but because of private information on the asset’s future payoff. Thus, information has a positive side for it improves future profitability but also a negative side because it destroys some exchange opportunities. One way to view this is as an extension of Akerlof’s (1970) classical analysis on the market for lemons where private information is endogenised and results from the efforts of car owners to learn mechanics in order to maintain their car’s quality. As we show, this “double value” of information creates a role for financial

intermediaries combining monitoring and liquidity creation activities. Assume that some agents specialise as delegated monitors, promising their claim-holders (henceforth “depositors”) a future payment in case of success. Only those agents will have some private information about some projects. On the one hand, this concentration creates liquidity because it shields depositors from the negative side of information. As they do not possess private information about their intermediary’s projects, they can easily exchange their rights over future goods. On the other hand, intermediaries’ assets are illiquid because of their private information. In an equilibrium with free entry, agents who specialise as intermediaries must be compensated for the cost associated with this illiquidity and must be incited to monitor. This agency problem is solved through the intermediary structure. The reason for this is twofold. First, keeping a project till completion gives strong incentives to monitor. Second, depositors who value liquidity are ready to accept lower future expected payments so that intermediaries can extract more long term profits.

To sum up, these financial intermediaries have the following bank-like appealing features. (a) They monitor their investments and consequently have private information about their quality. (b) Their assets are therefore illiquid. (c) Depositors have no private information as to the intermediaries’ assets. (d) Hence, intermediaries’ liabilities are easily exchanged. We think this is broadly congruent with what commercial banks do (or have historically done). In the first place, there is little doubt that banks’ private information accounts for the illiquidity of some of their assets. Second, (small) depositors at a given bank generally do not have specific information about the asset of that bank, suggesting a reason why banks deposits can be used as means of payments. Our analysis suggests that the concentration of information within the banking system protects final savers from the dark side of information, while allowing society to reap the benefits of monitoring.

With regard to methodology, we wish to emphasise two points. First, the analysis proceeds by constructing an environment with explicit frictions where institutions that perform the two aforementioned functions emerge. Intermediaries are not assumed initially, but derived as an equilibrium phenomenon. Following Townsend (1990) and Boyd and Prescott (1986), we view this as a necessary requirement for an *explana-*

tion of the phenomenon.<sup>4</sup> Second, no agent has any exogenous comparative advantage in project monitoring or liquidity provision. Contrarily, specialisation arises among (*ex ante*) identical agents, so that the story is one of endogenous comparative advantage. Importantly though, the driving force is not the presence of increasing returns in either monitoring or liquidity provision, but the genuine complementarity between the two activities. Without both problems being present there would be no scope for intermediation in our setting (see section 3).

This paper mainly contributes to the literature on the rationale for financial intermediation. We jointly analyse monitoring services on the asset side and liquidity provision on the liability side. Concerning the asset side, our intermediaries serve as delegated monitors despite the absence of economies in auditing costs and of diversification as per Diamond's (1984) model. Concerning liquidity creation, the emphasis is not on insurance through demandable deposits as in Diamond and Dybvig (1983) but on the higher acceptability of intermediaries' liabilities. We view this as an important, but understudied mechanism by which the banking system creates liquidity.<sup>5</sup> Specifically, a key feature of our analysis is that depositors can sell their claims directly to other (non bank) agents. This is in contrast to Diamond and Dybvig's (1983) model where the trading of deposits is precluded.<sup>6</sup> We share the idea that financial intermediaries can create information-insensitive claims with Gorton and Pennachi (1990). They consider a trading context with *ex ante* information heterogeneity and show that by creating risk-free debt, intermediaries protect uninformed investors from unfair trade with insiders. Specifically, by splitting the underlying cash flow into different securities, intermediaries prevent informed collusion in the market. Although they are particu-

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<sup>4</sup>However, contrary to those authors we do not state our analysis using the core as an equilibrium concept but in term of agent's incentives to act as intermediaries.

<sup>5</sup>Quite surprisingly, this is acknowledged in monetary macroeconomics (Bernanke and Blinder, 1988; Greenwald and Stiglitz, 1991), but is almost absent from modern microeconomic theories of banking (Bhattacharya and Thakor, 1993). Reviewing research on financial intermediation over the past two decades, Gorton and Winton (2002) argue that the circulation of some banks liabilities as inside money remains an empirical puzzle.

<sup>6</sup>Jacklin (1987) showed that without such restrictions a market mechanism could do as well as banks in the environment considered by Diamond and Dybvig. This and related issues are discussed in Jacklin and Bhattacharya (1988) and von Thadden (1999).

larly interested in the example of banks deposits, the application is not straightforward as they consider exogenous private information among investors. Furthermore in their setting a firm issuing different securities can do as well as intermediaries. In contrast to them, we have private information as an endogenous outcome related to the monitoring activity of intermediaries. Finally, this work is closely related to the strand of that literature which explains banks' activities on both sides of the balance sheet. There, the paper that is most related to ours is Diamond and Rajan (2001). In that paper, the illiquidity of assets is rooted in the inalienability of human capital. The issuance of demandable deposits raises the ability of the initial lender to commit this relationship capital because a threat to extract future rent would trigger a run by depositors. The message that the fragility of banks' balance sheet serves as a disciplining device is also in Calomiris and Kahn (1991), Flannery (1994) and Qi (1998). In some sense, our analysis is opposed to this view (see section 5.2). Another popular explanation for banks' combination of activities, rejuvenated by Nakamura (1993) and Berlin and Mester (1999), rests on the argument that managing firms' deposit account gives cheap access to information relevant to the lending activity. We develop a different explanation for this combination, based on the tradeoff between monitoring and liquidity. We are aware of no other work using such a tradeoff to build a rationale for financial intermediation.

Although the focus is quite different, this paper also relates to the literature on monetary exchange, and more precisely to the tradition using informational problems to explain the use of money. The idea traces back to the property of the recognisability of money and has been forcefully expressed by Brunner and Meltzer (1971) and Alchian (1977). More recently, Williamson and Wright (1994) and Berentsen and Rocheteau (2004) have embedded lemons problems about the quality of goods into a search-theoretic model, while Banerjee and Maskin (1996) have done a similar job in a more competitive framework. Uncertainty about assets is considered for instance in Freeman (1985) and Williamson (1992) within the overlapping generation model of money. While those papers deal with outside money, our analysis hints at why banks deposits can be used as means of payments (inside money).<sup>7</sup> One caveat of

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<sup>7</sup>In that respect, our analysis is complementary to the strand of literature introducing a banking

those papers is that they take private information on outside money and on goods or assets as given. In contrast in our analysis the distribution of information on any asset—including inside money—is endogenously determined.

Following the contribution of Gorton and Pennachi (1990), some authors have modelled security design as an optimal answer to Akerlof (1970) lemons problems. DeMarzo and Duffie (1999) consider the funding problem faced by an institution with private information about its assets, and show that the need to create liquid, information-insensitive securities leads to a preference for debt rather than equity. In a related work, Winton (2003) analyses how the liquidity needs of an institution providing monitored finance impact on the type of claims it holds on firms. Again, debt might be preferred because it is less sensitive to the institution’s private information, and therefore more easily sold in case of a high liquidity need. This line of research derives the optimal design of securities for a given distribution of information. One tentative conclusion is that debt-like securities are more liquid.<sup>8</sup> We abstract from security design issues and instead endogenise the distribution of information in the economy as another key determinant of assets’ degree of liquidity.<sup>9</sup>

The rest of the paper is organised as follows. Section 2 lays out the environment, and analyses the benchmark cases of autarky and perfect information. Section 3 describes a market arrangement for the economy and shows that it fails to improve on autarky. Section 4 analyses an equilibrium with financial intermediation. Some discussion is offered in section 5. Section 6 concludes. Proofs are relegated in an Appendix.

## 2. THE ENVIRONMENT

We consider a two periods (three dates,  $t = 0, 1, 2$ ) economy populated by risk-neutral agents. Throughout the paper subscripts refer to time.

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technology into models of monetary exchange. See, for instance, Williamson (1999), Kiyotaki and Moore (2003) and He, Huang and Wright (2005).

<sup>8</sup>See also the related papers by Boot and Thakor (1992) and Glaeser and Kallal (1997).

<sup>9</sup>Indeed, our intermediaries issue liabilities with the same risk characteristics as that of their assets. Hence, there is no clear relationship between liquidity and any measure of riskiness, contrary to Tobin’s (1958) suggestion.

## 2.1. Preferences

Population is divided into two groups, each one consisting of a unit mass continuum of agents.

Group 1 agents are born at  $t = 0$  and live for two periods. They have an initial endowment  $e_0 = 1$  and no endowment afterwards. These agents exhibit a preference for liquidity which, following much of the literature, we model by time preference shocks. Specifically, as of  $t = 0$  a group 1 agent maximises the expected utility

$$\mathbb{E}_{t=0} \left[ \tilde{\phi} c_1 + c_2 \right], \quad (1)$$

where  $c_t$  is the consumption at time  $t$  and the preference shock  $\tilde{\phi}$  obeys:

$$\tilde{\phi} = \begin{cases} 1 & \text{w.p. } 1 - \lambda, \\ \rho > 1 & \text{w.p. } \lambda. \end{cases} \quad (2)$$

Any agent has a rate of time preference for date  $t = 1$  consumption over future consumption given by  $\rho > 1$  with probability  $\lambda$  and by 1 with probability  $1 - \lambda$ . Preference shocks are realised at  $t = 1$ , publicly unobservable and i.i.d. across agents. Henceforth, we will refer to agents with  $\phi = \rho$  as being “impatient” and to those with  $\phi = 1$  as being “patient”. The above specification is used in Diamond and Rajan (2001).

Group 2 agents are born at  $t = 1$  and live for one period. They maximise date 2 expected consumption (their utility is given by  $v(c_1, c_2) = c_2$ ) and receive an endowment  $e_1 \gg y$  (defined below) at  $t = 1$ . This latter group is introduced as a simple way to have potential buyers at  $t = 1$  for the long term projects initiated by agents in the former group. Thus when no confusion results, we will refer to group 2 agents as simply “buyers” and to group 1 agents as simply “agents”.

## 2.2. Technology

There are two technologies: a perfectly divisible storage technology available to any agent, and long term indivisible projects available only to agents born at  $t = 0$ . Storing one unit of good yields one unit one period hence.

Long term projects have the following characteristics. A project requires an indivisible outlay of  $I_0 = 1$  at the initial date and yields an uncertain output  $\tilde{y}$  at  $t = 2$ . At

that time, the project can succeed and yield  $y$  or fail and yield nothing. The probability of success depends on the agent's action, *id est* whether he monitors or not. Without monitoring, a project succeeds with probability  $\pi^L$ . The agent investing in the project can choose to monitor the project, by exercising an effort  $t = 0$  which costs  $c$ . Monitoring is not publicly observable and has two effects. First, it raises the probability of success from  $\pi^L$  to  $\pi^H$ . Second, the agent receives at  $t = 1$  a perfect private signal on the success/failure of his project at time  $t = 2$ . These assumptions capture the idea that in order to monitor one needs to acquire specific information about the project. We make the natural assumption that a project has a positive net present value (NPV) when monitored, but a negative NPV otherwise. Specifically, it holds that

$$\pi^L y < 1, \tag{A1}$$

$$\pi^H y - c > 1. \tag{A2}$$

Together these assumptions imply  $(\pi^H - \pi^L) y > c$ , something we will use momentarily. Furthermore, throughout the paper we restrict consideration to the case where the following condition holds:

$$\frac{\lambda}{\lambda + (1 - \pi^H)(1 - \lambda)} \rho \pi^H < 1. \tag{A3}$$

Anticipating on Section 3, inequality (A3) states that the private information problem induced by monitoring is severe enough (in a sense to be made more precise later on). This assumption is satisfied if, for instance, projects have a high probability of failure (that is,  $\pi^H$  is low) or if agents' valuation of liquidity is low.

### 2.3. Discussion of the environment

From a general perspective, two points are noteworthy. First, the population structure implies that there is no aggregate shortage of date 1 goods. Hence, if the sole problem was unobservable preference shocks, the type of coalitions described by Diamond and Dybvig (1983) would not improve on the market outcome. Secondly, and not unrelatedly, the distinctive feature of the environment is the combination of private preference shocks *and* unobservable monitoring. More precisely, there are three sources of private information. (i) Individual preference shocks realised at  $t = 1$ ; (ii) the action of monitoring; and (iii), the signal received in case of monitoring.

It will be convenient in what follows to compare outcomes with the benchmark case of perfect information. Given the population structure, it is natural to focus on Pareto allocations that give group 1 agents the same *ex ante* payoff and group 2 agents their autarkic payoff. Absent informational problems, an impatient agent with a project worth  $y$  units of date  $t = 2$  good could trade it with a group 2 agent for  $y$  units of date  $t = 1$  good. It easily follows, using A1 and A2, that projects would be undertaken and monitored. The resulting *ex ante* utility for a group 1, which we will refer to as the first best level of welfare, is given by

$$V^* = (\lambda\rho + 1 - \lambda)\pi^H y - c. \quad (3)$$

Another useful benchmark is autarky, defined as the situation where exchange is precluded by assumption. From  $(\pi^H - \pi^L)y > c$ , an agent who undertakes a project optimally chooses to exert monitoring. Given that storage yields  $E[\tilde{\phi}c_1 + c_2] = \lambda\rho + 1 - \lambda$ , the expected utility of a group 1 agent in autarky is

$$V^0 = \max\left(\pi^H y - c, \lambda\rho + 1 - \lambda\right). \quad (4)$$

It is clear that  $V^0 < V^*$ . We interpret the loss compared to the first best,  $C^a = V^* - V^0$ , as the cost of autarky. Using (1) and (3), the cost of autarky is given by

$$C^a = (\lambda\rho + 1 - \lambda)(\pi^H y - 1) - c, \quad (5)$$

when it holds that

$$\pi^H y - c < \lambda\rho + 1 - \lambda, \quad (6)$$

and by

$$C^a = \lambda(\rho - 1)\pi^H y, \quad (7)$$

otherwise. In the first case, equation (5) states that the cost stems from agents not investing in socially efficient projects. In the latter, agents invest in (monitored) projects but cannot sell them by assumption. An impatient agent must therefore wait till  $t = 2$  to consume, yielding (5) as the welfare loss. The higher the probability of being impatient ( $\lambda$ ) or the bigger the impatience ( $\rho$ ), the higher the cost of autarky. The welfare loss reflects the fact that there are unexploited trading opportunities between impatient agents and buyers.

We next turn to the analysis of two institutional arrangements for this trading. In section 3, we describe a market arrangement and show that it does not improve on autarky. In section 4, we show that more desirable outcomes can be attained when agents are permitted to form financial intermediaries. The time lines for the market (ME) and the intermediated (IFE) cases are summarised in Figure 1.

Date 0	Date 1	Date 2
1. <i>IFE</i> : Activity choice and contracts offers $(N, R)$ . Depositors choose contracts.	1. Preference shocks $\phi_i$ are realised (private information). Agents that monitored their project observe private signal about success/failure.	1. Projects mature and yield 0 or $y$ (public information).
2. Agents decide whether to store or to fund a project (public information).	2a. <i>ME</i> : Projects are exchanged on the market at the price $l$ . 2b. <i>IFE</i> : Depositors exchange claims on intermediaries	2. <i>IFE</i> : Payments $R$ are made if projects successful.
3. Agents decide whether to monitor their project or not (private information).	3. Date 1 consumption takes place	3. Date 2 consumption takes place

Figure 1: Timing of events

### 3. THE MARKET OUTCOME

Suppose that at  $t = 1$  a market opens where impatient agents could sell their project to group 2 agents. This is the usual way a stock market is introduced in the Diamond-Dybvig model as a way to create liquidity (see for instance Jacklin (1987) and Ben-civenga and Smith (1991)).

Given that neither preference shocks nor monitoring are publicly observable, public information does not allow an outside agent to discriminate between projects at date  $t = 1$ . Consequently, any project that is offered on this market should obtain the same price (but see proposition 2 at the end of this section). We denote this price by  $l$ ,

defined as the number of units of date 1 good obtained in exchange for a project.

### 3.1. Investment strategy

As of date 0, agents must choose (i) whether to store or to undertake a project, and (ii) whether to monitor or not. To analyse this choice, let  $l^e$  denote the agent's expectation as to the price that will prevail on the market at date 1.

For the moment, we analyse the monitoring decision of an agent launching a project. His expectation  $l^e$  will bear on his monitoring strategy to the extent that he might want to sell his project before maturity. The probability to sell will in turn depend on the monitoring strategy. Specifically, the decision to monitor is taken so as to maximise

$$E_{t=0} [\max(\phi l^e, py)], \quad (8)$$

where  $p \stackrel{def}{=} \Pr[\tilde{y} = y | \mathcal{I}_{t=1}]$  summarises the agent's information at date 1 as to the project's date 2 payoff  $\tilde{y}$ . Expectation is taken with respect to the preference shock and to date 1 information about the project's outcome. Equation (8) asserts that the agent sells when his expected utility from date 2 consumption if he keeps his project till maturity,  $py$ , is lower than his utility from date 1 consumption if he sells the project,  $\phi l^e$ .

Let  $V^i(l^e)$  and  $V^u(l^e)$  be the investor's *ex ante* expected utility with and without monitoring, respectively. Consider first the no monitoring strategy. The agent's date 1 information as to the project's future value is simply  $p = \pi^L$ , so that (8) reduces to

$$V^u(l^e) = \lambda \max(\rho l^e, \pi^L y) + (1 - \lambda) \max(l^e, \pi^L y). \quad (9)$$

Consider next the monitoring strategy. As of date 1, the agent knows whether his project is worth  $y$  or 0. Importantly he learns with probability  $(1 - \pi^H)$  that the project is worthless, in which case he uses the market to sell it, regardless of his preference shock. Formally, the expected utility with monitoring writes

$$V^i(l^e) = (1 - \pi^H) (\lambda \rho + 1 - \lambda) l^e + \lambda \pi^H \max(\rho l^e, y) + (1 - \lambda) \pi^H \max(l^e, y) - c. \quad (10)$$

The two sides of monitoring are reflected in the difference  $V^i(l^e) - V^u(l^e)$ . On the one hand, monitoring raises the project's expected return. On the other hand, the

induced private information allows an agent to get rid of a worthless project before completion. Only the former effect is of positive social value, however. The latter has a negative effect on the economy as a whole.<sup>10</sup>

Using equations (9) and (10), and letting  $x \in [0, 1]$  denote the mixed strategy as to monitoring, the behaviour of a project holder can be formalised as

$$\max_{x \in [0,1]} (xV^i(l^e) + (1-x)V^u(l^e)), \quad (11)$$

from where it follows that his optimal monitoring strategy is given by

$$x^*(l^e) = \begin{cases} 0, & \text{if } V^i(l^e) - V^u(l^e) < 0, \\ [0, 1], & \text{if } V^i(l^e) - V^u(l^e) = 0, \\ 1, & \text{if } V^i(l^e) - V^u(l^e) > 0. \end{cases} \quad (12)$$

Finally, when the alternative (storage) technology is taken into account, the optimality requirement for the investment decision can be represented by

$$\max \left( \lambda\rho + 1 - \lambda, x^*(l^e)V^i(l^e) + (1-x^*(l^e))V^u(l^e) \right). \quad (13)$$

### 3.2. Market price

Buyers rationally anticipate the above lemon problem. Given their preferences and endowments, the market must clear at a price equal to the expected return on a project offered:

$$l = E_{t=1} [\tilde{y} | \phi l > py]. \quad (14)$$

The expectation on the right hand side of (14) depends on buyers' expectations as to the proportion of investors who monitored,  $x^e$ . To emphasise this, we write it as  $L(l, x^e)$ . For a given  $x^e$  the requirement (14) then amounts to the market price solving  $l = L(l, x^e)$ , with

$$L(l, x^e) = E_{t=1} [p | \phi l > py] \cdot y. \quad (15)$$

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<sup>10</sup>This wedge between the social and private values of information is quite general (Hirshleifer, 1971).

### 3.3. Equilibrium

We focus on equilibria in which agents' expectations are correct. A rational expectation equilibrium for the market economy can therefore be defined as a situation such that investment and (notional) monitoring strategies are optimal given the market price, and the market price satisfies (14) given investor's monitoring strategy. Formally,<sup>11</sup>

**Definition 1.** *An equilibrium for the market economy is an investment choice, a monitoring strategy  $x^*$  and a price  $l^*$  such that (i) The investment decision satisfies (13), and (ii) The pair  $(x^*, l^*)$  solves  $x^* = x^*(l^*)$  and  $l^* = L(l^*, x^*)$ .*

Even in this simple environment, the analysis of equilibria for general parameters specifications is cumbersome. For instance multiple (Pareto ranked) equilibria may exist because of the interplay between monitoring and market pricing. While such an analysis might be of interest in its own right, for the purpose of this paper we focus on configurations such that the market arrangement cannot improve on autarky. This is ensured by assumption (A3). The following proposition states the main result for the market economy:

**Proposition 1.** *There exists a unique equilibrium for the market economy. If Cond. (6) holds, agents invest in the storage technology. Otherwise they invest in projects and the market for secondary projects collapses (i.e.  $x^* = 1$  and  $l^* = 0$ ).*

*Proof.* See the Appendix  $\square$

Proposition 1 has a straightforward intuition. The private information obtained when monitoring hampers the ability of the market to create liquidity, because agents strategically use the market to get rid of worthless projects. Under assumption (A3) the resulting lemon effect is strong enough to lead to the shutdown of the market as per Akerlof (1970). More precisely if agents monitor and impatient agents with  $p = 1$  were to sell, the price would be given by

$$l^1 \stackrel{def}{=} \frac{\lambda}{\lambda + (1 - \pi^H)(1 - \lambda)} \cdot \pi^H y, \quad (16)$$

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<sup>11</sup>The second requirement uses the fact that by the law of large numbers the proportion of monitored projects equals the individual probability of monitoring,  $x^*$ .

where the first term in the product can be interpreted as the use of the market for liquidity, as opposed to strategic, motive. Assumption (A3) can now be interpreted as stating that the price given by (16) is too low for high quality sellers to participate, i.e.  $\rho l^1 < y$ .

The above result shows (in a crude way) that the market arrangement does not mitigate the liquidity-monitoring tradeoff. When condition (6) holds, agents overinvest in the short term technology and forego efficient long term investments. When (6) does not hold, agents undertake and monitor projects but have to bear the illiquidity of their projects. In this latter case, the loss from first best comes from the inability of the market to allocate date 1 goods to the agents who value current their consumption the most.

For the sake of exposition, we have taken for granted that investors sell all their stake in the market at date 1, and consequently that the price is the same for all projects. This eases the comparison with the usual stock market in a Diamond and Dybvig economy. It may appear unduly restrictive however, as under preferences (1)-(2) impatient agents still derive strictly positive utility for late consumption. An impatient agent owning a project worth  $y$  could thus try to signal his “good type” to the market by offering to consume some part of the project’s proceeds. Arguably, if the induced signaling game had such a separating equilibrium, the market could mitigate the tradeoff between monitoring and liquidity at the cost of some deferred consumption by impatient agents. One can easily check that assumption (A3) is sufficient (but not necessary) to rule such situations out. We show in the appendix that this can also be derived from standard restrictions on out-of-equilibrium beliefs along the lines of Banks and Sobel (1987) and Cho and Kreps (1987). More precisely, we have:

**Proposition 2.** *If buyers’ beliefs satisfy the Intuitive Criterion of Cho and Kreps (1987), the signaling game has no other equilibrium than that of proposition 1.*

*Proof.* See the Appendix  $\square$

It should be noted that proposition 2 holds irrespective of assumption (A3). This seemingly strong result ultimately relies on the logic of the Intuitive Criterion. For an intuition in our particular case, assume that investors monitor their project ( $x^* = 1$ ).

Then, there are always agents who know that their project is worthless and try to sell it. The attempts of impatient agents to separate from those then lead them to retain one hundred percent of the project (see Claim 2 of the proof). Anyhow, proposition 2 suggests that the analysis might extend to configurations where (A3) does not hold.

As outlined in the Introduction, the possibility of welfare improving intermediation rests on the presence of two frictions, i.e., unobservable liquidity needs and private information induced by monitoring. Indeed, if any of those frictions is removed the market generally implements the first best. Assume for instance that all information (that is,  $p$ ) about a project is public. A project holder can then obtain the true value of his project,  $py$ , on the market. Substituting for this equilibrium price in (8) yields the first best welfare  $V^*$ . Conversely, assume that preference shocks are observable. One can easily check that in this modified economy patient agents cannot sell their projects, and that the project of an impatient investors sell at a price  $\pi^H y$ , provided that  $\rho\pi^H > 1$ . Again, computation of (8) yields  $V^*$ .<sup>12</sup>

#### 4. AN EQUILIBRIUM WITH INTERMEDIATION

We go on to analyse the emergence of intermediaries as an original answer to the trade-off between monitoring and liquidity. The intuition hinges on the two-sided nature of information, as follows. Suppose that one agent (henceforth “intermediary”) makes the following offer to  $N$  other agents (henceforth “depositors”). He collects the endowments, monitors the  $N + 1$  projects, and promises a payment  $R$  per depositor in case of success. One consequence is that there are now two types of claims over future goods who differ both in terms of their contingent payoff and, more importantly, in the identity of the holder. Now, the concentration of information about projects in the hands of the intermediary shields the  $N$  depositors from the negative aspect of information: as they do not have *private* information about the intermediary’s projects, they can exchange at date 1 their rights over future goods directly with group 2 agents. This type of arrangement may be welfare enhancing provided that the intermediary be incentivated to monitor and compensated from any loss associated with private infor-

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<sup>12</sup>Condition  $\rho\pi^H > 1$  simply states that impatient agents with  $p = 1$  sell their projects. Otherwise, the equilibrium is given by proposition 1.

mation (see below). In the remainder, we show that this can indeed be sustained as an equilibrium with free entry, that is when agents can choose to act as intermediaries or depositors.

To analyse this situation, we need to specify the degree to which projects launched by the same agent are correlated. Two simple but unrealistic cases can be considered: either no correlation or perfect correlation. Because we want to highlight complementarity between liquidity creation and monitoring as the rationale for intermediaries, as well as for tractability reasons, we assume the latter. The discussion of this assumption is deferred till section 5. For the moment, simply note that we interpret this as stating that agents face limited diversification opportunities.<sup>13</sup> More specifically, we assume that when monitoring a portfolio of  $N$  projects with monitoring intensity  $e \in [0, 1]$ , all projects succeed with probability  $\Pi(e) = \pi^L + e \cdot (\pi^H - \pi^L)$ . We further assume that monitoring costs are linear,  $C(e) = e \cdot N \cdot c$ .

The equilibrium for an intermediated economy is found in two steps. First, we state some intermediate results for an intermediary with given characteristics. Then we characterise the candidate equilibria under free entry.

#### 4.1. *Intermediate results*

We consider a specific intermediary contracting with  $N$  depositors,<sup>14</sup> each of whom is entitled to  $R$  units of date 2 good if the intermediary's projects succeed. In the sequel, we refer to such an intermediary as a  $(R, N)$ -intermediary. In this section, we state some intermediate result for a  $(R, N)$ -intermediary, taking  $R$  and  $N$  as given.

In view of (A1), we restrict attention to the situation where projects are monitored (this will be insured in equilibrium, see below). We first characterise the equilibrium marketability of the claims on future goods owned by, respectively, depositors and intermediaries. Consider first the problem of a depositor selling his claim to a group 2 agent at date 1. Let  $l_D^*$  denote the equilibrium (market) value of this claim. Since depositors do not monitor, they have no private information about projects' expected

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<sup>13</sup>An alternative interpretation is that the projects' outcome depend on some (unknown) general ability of the agent to manage any project.

<sup>14</sup>With a continuum of agents,  $N$  is to be interpreted as the equilibrium proportion of depositors to intermediaries.

returns. Buyers therefore anticipate that a decision to sell is motivated by liquidity reasons uncorrelated with the value of the asset, implying that  $l_D^* = \pi^H R$ , where we use the fact that the probability of receiving  $R$  when the intermediary monitors is given by  $\pi^H$ .

Consider now the market where an intermediary could sell his portfolio. When intermediaries monitor, this market is plagued by the same informational problem as that of the market for secondary projects in the market case. Indeed the assumption of no diversification implies that the former strictly parallels the latter,<sup>15</sup> so that the argument (and proof) underlying proposition 1 applies straightforwardly. The market for intermediaries' assets collapses or, to put it differently, there is no securitisation in equilibrium. We summarise this in the following proposition.

**Proposition 3.** *If intermediaries monitor, their assets are illiquid and their liabilities are liquid (with equilibrium price given by  $l_D^* = \pi^H R$ ).*

Proposition 3 states that the agent acting as intermediary creates liquidity for his depositors. Using this intermediate result, we now compute the expected payoff of all agents in a  $(R, N)$ -intermediary. Let  $V_D(R, N)$  and  $V_{IF}(R, N)$  denote the expected payoff of the  $N$  depositors and that of the intermediary, respectively. Using proposition 3, those can be expressed as

$$V_D(R, N) = (\lambda\rho + 1 - \lambda) \pi^H R, \quad (17)$$

$$V_{IF}(R, N) = \pi^H ((N + 1) y - NR) - (N + 1) c. \quad (18)$$

Recall that projects are monitored in equilibrium. Consider first expression (17) for depositors' payoff. Proposition 3 states that a depositor can consume  $\pi^H R$  unit of good at either date 1 (by selling his claim at the price  $l_D^* = \pi^H R$ ) or at date 2 (in expectation), so that his expected utility,  $E_{t=0} [\max(\phi l_D^*, \pi^H R)]$ , reduces to the expression on the right hand side. Consider now the intermediary's payoff (18). Using the fact that an intermediary cannot sell at the interim stage even if he turns out to be impatient, and that the monitoring cost  $c$  is incurred for each project, the expression on the right hand

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<sup>15</sup>It is important to note though that while this assumption greatly simplifies the analysis, it could be relaxed somewhat while retaining the illiquidity result (see the discussion in section 5).

side is the expected utility of an intermediary managing  $N + 1$  projects on behalf of  $N$  depositors.

Next, we need to analyse the intermediary's incentives to monitor the projects. One consequence of proposition 3 is that in an equilibrium with monitoring, an intermediary that does not monitor cannot sell his projects at date 1. The payoff associated with not monitoring is therefore given by  $\pi^L ((N + 1) y - NR)$ . Using Eq. (18) for the payoff associated with monitoring, we obtain the following incentive compatibility constraint:

$$(\pi^H - \pi^L) ((N + 1) y - NR) \geq (N + 1) c. \quad (19)$$

Comparison of (19) with the analogous condition under autarky,  $(\pi^H - \pi^L) y > c$ , reveals a standard agency problem stemming from the fact that the intermediary monitors partly on behalf of other agents. Accordingly, we rewrite (19) as

$$R \leq \bar{R}(N) \equiv \frac{N + 1}{N} \left( y - \frac{c}{\pi^H - \pi^L} \right), \quad (20)$$

where  $\bar{R}(N)$  is the maximum (per project) payment to depositors compatible with incentives to monitor.<sup>16</sup>

We conclude this section by stating some conditions that a  $(R, N)$ -intermediary must satisfy to be viable, in addition to the incentive compatibility constraint (20). First, note that any agent can always ensure himself the autarkic payoff  $V^0$ , implying that the following individual rationality constraints must be satisfied in equilibrium:

$$V_D(R, N) \geq V^0, \quad (21)$$

$$V_{IF}(R, N) \geq V^0. \quad (22)$$

Finally, feasibility requires that

$$(N + 1) y \geq NR \geq 0. \quad (23)$$

In what follows, we may ignore the feasibility requirement as (23) is implied by the incentive constraint (19) and the individual rationality constraint (21).

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<sup>16</sup>In the terminology of Holmström and Tirole (1996),  $\bar{R}(N)$  is the maximum pledgeable income per project. The term  $\frac{N+1}{N}$  comes from the fact that the intermediary's endowment (invested in a project) serves as a capital cushion.

#### 4.2. Equilibrium characterisation

This section deals with the situation where agents are allowed to form intermediaries, prior to any other action (see Figure 1).

To be more precise, we assume that there is free entry into intermediation and we compute the (unique) intermediated equilibrium. Note that, because of the indivisibility of projects and the presence of the fixed monitoring cost, an intermediary should monitor a discrete number of projects. This discreteness in intermediaries' size may induce a role for lotteries. Keeping this in mind, we first formalize free entry as a situation in which no agent can improve his situation by proposing a non random offer to act as an intermediary. In a second step, we discuss how the introduction of (a small degree of) randomisation can overcome the inefficiency that arises because of the restriction  $N \in \mathbb{N}_+$ .

**Definition 2.** *An intermediated equilibrium with free entry is a set of intermediaries' contracts and sizes,  $\Gamma = \{(R, N) \in \mathbb{R}_+ \times \mathbb{N}_+ | \exists (R, N)\text{-intermediary}\}$  such that (i) any agent belongs to a  $(R, N)$  intermediary, with  $(R, N) \in \Gamma$  and (ii) there is no  $(R, N)$  such that an agent (intermediary or depositor) can strictly increase his payoff and that of  $N$  other agents by acting as a  $(R, N)$  intermediary.<sup>17</sup>*

Our definition of free entry embeds the notion that intermediaries compete for depositors, by requiring that an agent setting up an  $(R, N)$ -intermediary attracts  $N$  depositors. To characterise an intermediated equilibrium, it will be convenient to consider the maximum (expected) payoff that a size  $N$  intermediary can offer while having incentives to monitor and being no worse off than his claim holders. We denote this upper bound on depositors' payoff by  $\bar{V}(N)$ . Formally,

$$\bar{V}(N) = \max_{\substack{R \leq \bar{R}(N) \\ V_{IF}(R, N) \geq V_D(R, N)}} V_D(R, N). \quad (24)$$

The following straightforward properties are derived in the Appendix:

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<sup>17</sup>In the definition we impose that depositors in the same intermediary are treated symmetrically, which is consistent with the *ex ante* homogeneity of agents. All the argument go through without this restriction.

**Lemma 1.**  $\bar{V}$  is continuous and attains a maximum  $V^{**}$  on  $\mathbb{R}_+$ . It is strictly increasing on  $[0, \bar{n}]$  and strictly decreasing on  $[\bar{n}, \infty)$ , with  $\bar{n} = \arg \max_{n \in \mathbb{R}_+} \bar{V}(n)$  the unique solution to  $V_D(\bar{R}(n), n) = V_{IF}(\bar{R}(n), n)$ . Furthermore at the optimum in (24) the binding constraint is  $V_{IF}(R, n) \leq V_D(R, n)$  for  $n < \bar{n}$  and  $R \leq \bar{R}(n)$  for  $n > \bar{n}$ .

Further define  $\bar{N}$  and  $\bar{R}$  to be, respectively, the integer size and payment that maximise depositors' payoff. Formally,

$$\bar{N} = \arg \max_{N \in \mathbb{N}_+} \bar{V}(N), \quad (25)$$

$$\bar{R} = \arg \max_{\substack{R < \bar{R}(\bar{N}) \\ V_{IF}(R, \bar{N}) \geq V_D(R, \bar{N})}} V_D(R, \bar{N}). \quad (26)$$

Let  $[n]$  denotes the integer part of  $n$ , for  $n \in \mathbb{R}_+$ . Lemma 1 implies that  $\bar{N}$  is essentially unique,<sup>18</sup> and equal to  $[\bar{n}]$  or  $[\bar{n} + 1]$ . We now show that in an intermediated equilibrium with free entry intermediaries contract with  $\bar{N}$  depositors and offer payment  $\bar{R}$ .

**Proposition 4.** *In an intermediated equilibrium, all agents (except possibly a finite number out of the continuum of agents) belong to a  $(\bar{R}, \bar{N})$ -intermediary.*

*Proof.* Assume that the economy is intermediated. *Step 1.* We first show that there are no intermediary with size  $N > \bar{N}$ . Assume contrarily that  $\exists (R, N) \in \Gamma$  with  $N > \bar{N}$ . Clearly,  $R \leq \bar{R}(N)$  by the incentive condition. Thus, by the definition of  $\bar{N}$  and  $\bar{R}$ , any depositor can strictly raise his utility and make  $\bar{N}$  other depositors strictly better off by offering them to act as a  $(\bar{R}, \bar{N})$ -intermediary, a contradiction. *Step 2.* We show that depositors—except possibly  $\bar{N} + 1$ —must get at least  $V(\bar{N})$ . This follows from the simple observation that if there are  $\bar{N} + 1$  such depositors (possibly in several intermediaries), one of them can get at least  $V(\bar{N})$  and secure  $V(\bar{N})$  to  $\bar{N}$  other depositors by acting as a  $(\bar{R}, \bar{N})$ -intermediary. *Step 3.* We now argue that any intermediary—except possibly  $\bar{N}$ —has size  $\bar{N}$ . To see this, consider any intermediary with size  $N < \bar{N}$ . Given lemma 1 and the definition of  $\bar{N}$ , for such an intermediary  $V_{IF}(R, N) < V_D(R)$ , which by step 3 implies that  $V_{IF}(R, N) < V(\bar{N})$ . Now, assume that there exists (at least)  $\bar{N} + 1$  intermediaries with size  $\bar{N}$ , any intermediary can strictly raise his utility and that of  $\bar{N}$  other intermediaries by offering them to act as

<sup>18</sup>Ruling out the degenerate case where  $\bar{V}([\bar{n}]) = \bar{V}([\bar{n} + 1])$ .

a  $(\bar{R}, \bar{N})$  intermediary. This shows that all intermediaries—except possibly  $\bar{N}$ —have size at least  $\bar{N}$ . Combining this with step 1 terminates the proof of this step. *Step 4.* We conclude by showing that  $R = \bar{R}$ . First note that the reasoning in step 3 implies that  $V_{IF}(R, N) \geq V(\bar{N})$  must hold  $\forall (R, N) \in \Gamma$ . Given the definition of  $\bar{N}$  and step 2 this implies that depositors get  $V(\bar{N})$ . That  $R = \bar{R}$  then follows from the definition of  $\bar{R}$ .  $\square$

Uniqueness follows from lemma 1. We now characterize agents' expected payoff when the economy is intermediated. Without the restriction  $N \in \mathbb{N}_+$ , it is clear from the above reasoning that all agents would belong to a  $(\bar{R}(\bar{n}), \bar{n})$ -intermediaries and that depositors and intermediaries would enjoy the symmetric ex ante payoff (see the Appendix for the computation):

$$V^{**} = (\lambda\rho + 1 - \lambda) \pi^H \bar{R}(\bar{n}) = \pi^H (\lambda\rho + 1 - \lambda) y - c - \lambda(\rho - 1) \pi^H \frac{c}{\pi^H - \pi^L}. \quad (27)$$

When  $N \in \mathbb{N}_+$ , two cases need to be distinguished. Consider first the case in which  $\bar{N} = [\bar{n} + 1]$ . From lemma 1, the payment to claim-holders is  $\bar{R} = \bar{R}(\bar{N})$ , and depositors and intermediaries payoff are such that  $V_D(\bar{R}, \bar{N}) < V_{IF}(\bar{R}, \bar{N})$ . Averaging over depositors and intermediaries, and using expressions (17) and (18), welfare in an intermediated equilibrium can be expressed as

$$W^{IF} \equiv \frac{\bar{N}}{\bar{N} + 1} V_D(\bar{R}, \bar{N}) + \frac{1}{\bar{N} + 1} V_{IF}(\bar{R}, \bar{N}), \quad (28)$$

$$= \pi^H y - c + \lambda(\rho - 1) \pi^H \frac{\bar{N}}{\bar{N} + 1} \bar{R}(\bar{N}). \quad (29)$$

Substituting for  $\bar{R}(\bar{N})$  and using Eq. (27), this can be rearranged to

$$W^{IF} = \pi^H y - c - \lambda(\rho - 1) \pi^H \left( y - \frac{c}{\pi^H - \pi^L} \right) = V^{**}. \quad (30)$$

In this case,  $V^{**}$  corresponds to the average payoff in the economy. However intermediaries and depositors end up with slightly different expected payoffs because of the indivisibility issue. Consider next the case in which  $\bar{N} = [\bar{n}]$ . By lemma 1, all agents enjoy the same expected payoff  $\bar{V}(\bar{N})$  which is approximated by, but inferior to  $V^{**}$ . The departure from  $V^{**}$  arises only because the discreteness requirement.

We now argue that agents can allways attain the ex ante payoff  $V^{**}$  if one allows for some form of randomisation in the formation of intermediaries. To see this, consider

the following random proposition by one agent to  $[\bar{n} + 1]$  other agents. They all join to form a  $(\bar{R}([\bar{n} + 1]), [\bar{n} + 1])$ -intermediary. However, the agent who will act as the intermediary will be chosen randomly among them with equal probabilities. It easily follows from the analysis for the case  $\bar{N} = [\bar{n} + 1]$  that under such an arrangement all agents get ex ante—viz before knowing which agent will act as intermediary—the symmetric expected payoff  $V^{**}$ . Note that this is the sole role of lotteries in our setting.<sup>19</sup> In turn, if agents cannot commit to such random offers when forming intermediaries,  $V^{**}$  provides an approximation of agents payoff.<sup>20</sup> To summarise, we have proved:

**Proposition 5.** *In an intermediated equilibrium (with randomisation), all agents get the ex ante payoff  $V^{**}$ .*

Note that the precise way by which  $(\bar{R}, \bar{N})$ -intermediaries are formed is left unmodelled. Instead, we focus on the conditions that the outcome of such a process should meet. This could be thought of in more than one way. For instance, one can think of a first stage where agents are free to contact each other and agree on such  $\bar{N} + 1$  agents coalitions. Alternatively, this could come out of a game where agents post offers that specify whether they would act as intermediary or depositors and at which conditions. Essentially, what is required is that activity choice and contract offers be simultaneous so that the forces of free entry and competition for depositors are active in equilibrium.<sup>21</sup>

In the remainder of this section, we derive the condition for intermediaries to emerge and we comment on several features of the intermediated equilibrium.

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<sup>19</sup>We want to introduce the minimal amount of randomisation required to cope with the indivisibility issue. For this reason—and also because it would obscure the mechanism at play—we do not include lotteries in the formal definition of an intermediated equilibrium. With lotteries, the configuration in the text should be the only one robust to the introduction of arbitrarily small risk aversion.

<sup>20</sup>In both cases, depositors' payoff can be expressed as  $V_D(\bar{R}, \bar{N}) = \frac{\bar{R}}{R(\bar{n})} V^{**}$ . This follows from the definition of  $V_D(\bar{R}, \bar{N})$  and the first equality in (27). Therefore, the approximation is good when  $\bar{R}$  is close to  $\bar{R}(\bar{n})$ , which arises in particular when  $\bar{n}$  is not too small.

<sup>21</sup>An instance of such an abstract (non cooperative) game is in Townsend (1978). Free entry is formalised by the requirement that agents contracting with an intermediary have no incentive to propose a blocking strategy.

The argument underlying proposition 4 implies that intermediation arises if and only if  $V^{**} > V^0$ , that is when the intermediated allocation Pareto dominates autarky (the market allocation). If the converse holds the individual rationality constraints (21) and (22) cannot be satisfied. When  $V^{**} > V^0$  and if there are no intermediaries then one agent can form one and attract an infinite number of depositors by making them strictly better off than what they get on their own, so that the process of intermediaries formation will be initiated. This heuristic argument also suggests that the emergence of intermediaries should be more likely when the smallest size  $N$  such that  $\bar{V}(N) > V^0$  is low, if considerations like the cost of coalition formation were taken into account.

**Corollary 6.** *Intermediaries emerge if and only if  $V^{**} > V^0$ .*

Using proposition 4, in an intermediated equilibrium depositors and intermediaries all enjoy the symmetric *ex ante* payoff

$$V^{**} = \pi^H (\lambda\rho + 1 - \lambda) y - c - \lambda(\rho - 1) \pi^H \frac{c}{\pi^H - \pi^L}. \quad (31)$$

Compared to the first best, welfare can be expressed as (using Eq. (3))

$$V^{**} = V^* - C^{IF}, \quad (32)$$

with

$$C^{IF} = \lambda(\rho - 1) \frac{\pi^H}{\pi^H - \pi^L} c. \quad (33)$$

The loss from the first best,  $C^{IF}$ , can be interpreted as an agency (or delegation) cost as it is mainly explained by the necessity to provide the intermediaries with the incentives to monitor. Other things being equal, it is low when the agency problem is less stringent, for example when the cost of monitoring,  $c$ , is low or when the gain from monitoring,  $(\pi^H - \pi^L)$ , is high. For instance when  $c \rightarrow 0$  intermediation implements the first best as  $C^{IF} \rightarrow 0$ . Note however that  $\lim_{\pi^L \rightarrow 0} C^{IF} \neq 0$ , contrary to what one might expect if only agency considerations were present. The second effect embedded in formula (33) is that intermediaries must be compensated from holding illiquid assets. The burden of illiquidity is proportionate to the probability of being impatient times the magnitude of impatience,  $\lambda(\rho - 1)$ .

We can now use (33), (5) and (7) to write  $V^{**} > V^0$  in term of the exogenous parameters. By the definition of  $C^{IF}$  and  $C^a$ , the intermediated equilibrium improves on autarky when  $C^{IF} < C^a$ , which yields

$$\lambda(\rho - 1) \frac{\pi^H}{\pi^H - \pi^L} c < \min \left( \lambda(\rho - 1) \pi^H y, (\lambda\rho + 1 - \lambda) (\pi^H y - 1) - c \right). \quad (34)$$

The above condition is clearly satisfied for low enough  $\pi^L$ , implying that the economy is intermediated. Likewise when the monitoring cost  $c$  goes to 0, the cost  $C^{IF}$  converges to 0 while  $C^a$  is bounded away from zero. Intermediation then implements the first best which is not attainable by the market arrangement. This short discussion shows that situations such that  $V^{**} > V^0$  do arise. Indeed, when the converse of condition (6) holds (that is, when  $\pi^H y - c - 1 > \lambda(\rho - 1)$ ), intermediation strictly improves on the market outcome as  $C^a$  is given by the first term in the right hand side of (34), which is always higher than  $C^{IF}$  by (A1)-(A2). This corresponds to the case where monitoring has high social value. When (6) holds, configurations of parameters such that intermediation cannot improve on autarky and therefore does not emerge can be constructed (this is the case when monitoring has low social value, viz  $\pi^L y \simeq \pi^H y - c \simeq 1$ ).

To conclude, the model predicts that intermediaries are of finite size (when they emerge). More specifically, it is shown in the Appendix that

$$\bar{n} = (\lambda\rho + 1 - \lambda) \frac{\pi^H (\pi^H - \pi^L) y - c}{\pi^L c}, \quad (35)$$

so this property holds as soon as  $c \cdot \pi^L > 0$ . This result can be intuitively explained by the endogenous choice of activity as follows. The agency problem implies that the share of per-project profits that accrues to the intermediary is bounded away from zero. Consequently an intermediary's profit is strictly increasing with its size. When  $N$  is large (i.e.  $N > \bar{N}$ ), entry into intermediation makes size adjust so that intermediaries' profit are driven down to depositors' maximum payoff  $V^{**}$ . The equilibrium size  $\bar{N}$  can therefore be interpreted as the minimum size for intermediation to be profitable, taking into account that the outside option of an intermediary is endogenous.

## 5. DISCUSSION

Under appropriate parameters configurations, the model predicts the emergence of Pareto improving intermediaries that jointly provide liquidity and monitoring services.

In that sense, the analysis provides an explanation of banks and their combination of activities.

In this section, we offer some discussion of what we view as our main assumption, and we briefly comment on the generality of the mechanism by which our intermediaries create liquidity. Before doing so, we want to highlight the complementarities between liquidity creation and monitoring that explain why a subset of agents specialise. On the one hand, intermediaries acting as delegated monitors concentrate (private) information in their hands. This distribution of the information about projects implies that depositors can easily exchange their claims with other non-intermediary agents. The counterpart is that intermediaries' assets are illiquid. Monitoring therefore accounts for the “transformation” of illiquid assets into more liquid assets (Gurley and Shaw, 1960). On the other hand, this liquidity differential mitigates the agency problem associated with monitoring. First, illiquidity means that an intermediary must keep any project till completion. Second, depositors (who value liquidity) are ready to accept a lower expected future payment, raising the share that can be retained by the intermediary. Both effects tend to align the intermediary's profit with the productive gains from monitoring, thereby mitigating the agency problem.

### 5.1. *Diversification*

Although we view diversification as an important feature of financial intermediation, we have assumed that the returns of all the projects launched by one individual are perfectly correlated. We want to make three comments on this stark assumption. First, note that ruling out diversification makes the emergence of intermediaries less likely. Indeed, in this risk-neutral economy perfect diversification would allow the monitoring effort to be perfectly inferred from the return of the intermediary's pool of projects, implying that in the limit  $N \rightarrow \infty$  an intermediary could provide his depositors with a payoff arbitrarily close to the first best level  $V^*$ . The robustness of this mechanism is debatable, however, and we view it more as a consequence of the modelling choice than as a realistic feature. Second, we know from received theory that diversification can explain intermediation in the presence of transaction costs (Townsend, 1978) or of *ex*

*post* verification costs (Diamond, 1984).<sup>22</sup> In contrast, our results suggest that there is more to financial intermediation than diversification. Finally, a number of arguments limit the scope for diversification. Countervailing forces include, *inter alii*, increasing returns to specialisation and diminishing returns to monitoring with the number of projects (Cerasi and Daltung, 2000).

Now, this assumption greatly simplifies the analysis as the informational problem intermediaries face when trying to sell their assets strictly parallels that of investors in the market economy. Intuition (as well as proposition 2) suggests that this result should hold under less-than-perfect correlation. Increased diversification may mitigate the informational problem, however, by reducing the sensitivity of the intermediary's portfolio with respect to his private information. Some insights into this can be gained by considering a finite economy as in Winton (1995) or Bond (2004). Under a condition similar to, but more stringent than (A3), the illiquidity result in proposition 3 holds. There may be other situations where, by bundling the assets together, an impatient intermediary can market some of his shares. In such cases, an intermediary with "good" assets cannot realise at date 1 the full NPV of his portfolio but has to pay a lemon premium. In that sense, intermediaries' assets are still less liquid than their liabilities. Observe however that the marketability of assets might be reduced by the type of argument underlying proposition 2, as well as by the negative impact it may have on monitoring incentives.

## 5.2. *Alternative arrangements*

The main result of the paper is that under some non empty condition on parameters an equilibrium with intermediation dominates the market equilibrium.

One may wonder whether there are alternative arrangements without specialization that can dominate our intermediated equilibrium. In this section, we provide a (partial) answer to this, by showing that an arrangement where any agent simultaneously runs a project and holds contingent claims on projects run by other agents cannot attain

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<sup>22</sup>Contributions relying on diversification include Diamond and Dybvig (1983), Ramakrishnan and Thakor (1984), Boyd and Prescott (1986), Williamson (1986), Krasa and Villamil (1992), and Hellwig (2000).

more than  $V^{**}$ .

More precisely, assume that an agent owns rights to  $y - R$  date 2 goods on the output of the project he runs (henceforth, simply ‘his project’), and contingent claims to  $R'$  date 2 goods on the output of (possibly many) projects that he does not run. Given that an agent has no private information on projects run by others, in case of impatience he can always sell these claims to obtain  $\pi^H R'$  date 1 goods (provided agents monitor). Indeed, we can show that  $\pi^H R'$  is the maximum amount of liquidity that an impatient agent can obtain at date 1. Hence, even though an impatient may use his outside claims as a collateral to signal the profitability of his project, this never arises in equilibrium, due to the underlying adverse selection problem.

**Proposition 7.** *In an equilibrium in which agents monitor, no agent can consume more than  $\pi^H R'$  units of goods on the market at date 1. More precisely, any equilibrium is payoff equivalent to the equilibrium in which no agent sells (a fraction of) his share on ‘his’ project at date 1.*

*Proof.* See the Appendix.  $\square$

Using proposition 7, the ex ante utility for an agent that monitors can be easily computed as

$$\hat{V}^1 = (\lambda(\rho - 1) + 1)\pi^H R' + \pi^H(y - R) - c. \quad (36)$$

In view of (36), welfare under this arrangement should be higher when agent hold relatively more claims on outside projects on which they do not have private information ( $R'$  high), and less on their own project ( $y - R$  low) on which they do have private information. Given that  $R' \leq R$  by feasibility, we note that in equilibrium

$$\hat{V}^1 \leq \pi^H y + \lambda(\rho - 1)\pi^H R - c. \quad (37)$$

We now argue that the incentive problem associated with monitoring puts an upper bound on  $R$ , the future output that can be pledged on a project at date 0. To see this, consider an agent deviating to no monitoring. By selling all his contingent claims at date 1 irrespective of his preference shock,<sup>23</sup> such an agent can obtain at least

$$\hat{V}^0 = (\lambda(\rho - 1) + 1)\pi^H R' + \pi^L(y - R). \quad (38)$$

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<sup>23</sup>This amounts to mimicking the action of an impatient agent.

Hence, a necessary condition for monitoring to arise in equilibrium is that  $\hat{V}^1 \geq \hat{V}^0$ . Using expressions (36) and (38), this is equivalent to

$$R \leq y - \frac{c}{\pi^H - \pi^L} \equiv \bar{R}. \quad (39)$$

A direct consequence of the above incentive condition is that this arrangement cannot attain more than  $V^{**}$ :

**Proposition 8.** *In equilibrium,  $\hat{V}^1 \leq V^{**}$ .*

*Proof.* Plugging (39) into (37), one obtains  $\hat{V}^1 \leq \pi^H y + \lambda(\rho - 1)\pi^H \left(y - \frac{c}{\pi^H - \pi^L}\right) - c$ . Rearranging and using (31) yields the desired inequality.  $\square$

This shows that an arrangement where any (Group 1) agent simultaneously act as a ‘depositor’ and as an ‘intermediary’ does not do better than the intermediated arrangement analysed in section 4. Indeed, it also suggests that once less than perfect correlation among the projects run by the same agent is introduced, the intermediated arrangement does strictly better. To see this, note that this would not affect the analysis of the non intermediated arrangement, in which each agent runs one project. On the other hand, less than perfect correlation would raise welfare under the intermediated arrangement, by softening the incentive constraint (see the discussion in section 5.1).

### 5.3. *Bank deposit and liquidity*

Following the early contributions of Bryant (1980) and Diamond and Dybvig (1983), most of contemporary banking theory emphasises that banks deposits are liquid as they are demandable. In contrast, along with Gorton and Pennachi (1990), our analysis rejuvenates the idea that banks deposits are liquid in the sense that they are easily exchanged among non-bank agents. More fundamentally, we argue as they do that deposits are liquid because they are immune to private information. As already mentioned, Gorton and Pennachi (1990) illustrate this in a trading (that is, market microstructure) context with *ex ante* informed and uninformed investors, while we study an economy with productive opportunities and have private information resulting from intermediaries’ monitoring decisions.

In some sense, this concept of liquidity makes our analysis opposed to the work of Diamond and Rajan (2001), as well as other contributions building on the disciplining role of demandable deposits to explain the combination of liquidity provision and credit granting. We make this point by discussing the implications for deposit insurance. In Diamond and Rajan's (2001) model, intermediation is value enhancing because the threat of a run prevents the initial lender from using his relationship capital to extract more payments than contractually specified. Somewhat differently, Calomiris and Kahn (1991) argue that this threat provides informed depositors with the incentives to monitor banks' behaviour. Both papers therefore imply that deposit insurance may have damaging effects, because it undermines the underlying disciplining scheme. Although an analysis of banking regulation is beyond the scope of this paper, we argue that our theory suggests a very different effect. To see this, note that what matters for liquidity is not the amount of information society has about assets, but the *distribution* of that information. Therefore, by reducing depositors' incentives to acquire private information about their banks' portfolio, deposit insurance may reduce informational asymmetries between depositors and other non-bank agents, thereby fostering the liquidity of deposits. Note that this case for deposit insurance does not rely on bank runs.<sup>24</sup>

One should be cautious in interpreting this last point, though. While the analysis highlights the absence of interim private information about banks' portfolio as a source of the use of deposits as payment instruments, it should be noted that it abstracts from informational asymmetries about projects' realised payoffs. For a bank, one way to interpret this is the following: 'If as a depositor I had private information on the probability of failure of my own bank, then I could not use my deposits as means of payments'. With this interpretation in mind, the assumption that the realised returns are publicly observed is not unrealistic. Relaxing it would be a way to analyse the interplay between the acquisition of information by depositors on banks' assets to discipline banks and the liquidity of deposits. Such a challenging task is left for future research.

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<sup>24</sup>Gorton and Pennachi (1990) show that a government deposit insurance scheme may be welfare-improving because it helps create default-free securities. Our argument is complementary to theirs.

#### 5.4. *Liquidity and the value of delegation*

While our preferred interpretation is in term of bank-like intermediaries, the mechanism we emphasise may be at play in other situations. To be more precise, the analysis points to a value of delegation. In the model, the fact that monitoring is delegated to the intermediary (banker) creates liquidity for his claim-holders (depositors). To put it differently, delegation creates value because it insulates investors from the dark side of private information. This sole effect can explain why investors with a preference for liquidity may choose to delegate the management of an asset to a third party.

In a corporate finance context, this value of delegation suggests that investors who exert corporate control create liquidity for passive investors. As an example, consider the situation of a large shareholder exerting corporate control on behalf of dispersed shareholders. Aside from contractual issues, this situation is similar to that of a banker monitoring on behalf of depositors. There, our analysis suggests that the large shareholder creates liquidity for small shareholders, which is in line with the common wisdom that the latter have a more liquid position than the former (Bhide, 1993; Cofee, 1991). More speculatively, delegating the running of the firm to a manager may create liquidity for stock owners. It is worth noting, however, that monitoring is not necessary for delegation to create liquidity, contrary to what these examples might suggest. All that is required is that the (direct) management of the asset involves the development of private information over time, say, because of learning. It is therefore plainly consistent with this value of delegation that some financial intermediaries who are not involved in any kind of monitoring may nevertheless provide liquidity services.

## 6. CONCLUSION

This paper has presented an environment with explicit frictions explaining bank-like intermediation. Financial intermediaries who combine liquidity creation with project monitoring are not assumed exogenously but derived as an endogenous response to the tradeoff between monitoring and liquidity built in the environment. A key element of the analysis is the distribution of information as the main determinant of assets' degree of liquidity.

The focus of the paper has been on the emergence of financial intermediaries. To this end, we have adopted a framework with *ex ante* homogeneous agents and had to make some simplifying assumptions. However, we think that the tradeoff we emphasise may be useful in analysing other issues in banking theory, such as banks' discipline or the recent evolution in banks' activities. Another, though less natural extension relates to the circulation of bank deposits. As the analysis accounts for the higher acceptability of intermediaries' liabilities, embedding those intuitions into an explicit monetary framework could yield some insights as to the interplay between the circulation of private debt and the monitoring of creditors.<sup>25</sup>

## APPENDIX

A. *Proof of proposition 1.* We first check that the proposed strategies are equilibrium outcomes. Consider first the case  $\pi^H y - c > \lambda\rho + 1 - \lambda$ , and assume as indicated that  $x^* = 1$ . Then by (14) the market price must solve

$$l = \frac{\pi^H \lambda \delta(\rho l \geq y)}{\pi^H \lambda \delta(\rho l \geq y) + 1 - \pi^H y}, \quad (40)$$

where  $\delta(\rho l \geq y) = 1$  if  $\rho l \geq y$  and 0 otherwise accounts for the selling strategy of impatient agents owning a good project. Given assumption (A3), the R.H.S. of Eq. (40) is strictly inferior to  $l$  for any  $l > 0$ , implying that  $l^* = 0$  is the unique root to (40). Now substituting  $l^* = 0$  in (12) yields  $x^* = 1$  as the optimal monitoring strategy. As  $V^i(0) = \pi^H y - c$ , investment in projects is indeed optimal. Consider now the case  $\pi^H y - c < \lambda\rho + 1 - \lambda$ . By the above discussion, storage can be supported as an equilibrium outcome with  $x^* = 1$  and  $l^* = 0$ .

We now show that no other equilibrium exists. Note first that we can restrict attention to equilibria with (positive) investment in projects. The case  $x^* = 1$  have been analysed above. The case  $x^* = 0$  can be easily ruled out by  $\pi^L y < 1$ . To see this, note that in such an equilibrium it must hold that  $l^* = \pi^L y$  by (14), implying that the prescribed strategy is dominated by investing in the storage technology as  $V^u(\pi^L y) < \lambda\rho + 1 - \lambda$ . It thus remains to consider candidate equilibria with  $0 < x^* < 1$ .

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<sup>25</sup>For a discussion of the issues at stake, see Kahn and Roberds (2002) and Schnabel and Shin (2004).

Assume that such an equilibrium exists. Then  $V^i(l^*) = V^u(l^*)$ . We first argue that this implies  $l^* \geq 1$  and  $l^* \geq \frac{y}{\rho}$ . If the former does not hold, then  $V^i(l^*) = V^u(l^*) < \lambda\rho + 1 - \lambda$  and investing in a project cannot be optimal; if the latter does not hold, then at most projects worth  $\pi^L y$  are sold and  $l \leq \pi^L y$  so that the former condition cannot hold. Optimal selling strategies then imply that (14) reduces to

$$l^* = \frac{x^* \lambda \pi^H + (1 - x^*) \pi^L}{x^* [\lambda + (1 - \pi^H)(1 - \lambda)] + 1 - x^*} y. \quad (41)$$

Let  $l(x)$  denote the R.H.S. of (41). Then  $l(x)$  is monotonic and continuous on  $[0, 1]$  implying that  $\max_{x \in [0, 1]} l(x) = \max(l(0), l(1))$ . As  $l(1) < \frac{y}{\rho}$  by (A3) and  $l(0) = \pi^L y < 1$ , it follows that  $l^*$  cannot satisfy both requirements  $l^* \geq 1$  and  $l^* \geq \frac{y}{\rho}$ . The result follows.

B. *Proof of proposition 2.* Some further notations are required to analyse the signaling game and its Bayes-Nash equilibria. Let  $z \in [0, 1]$  be the stake that a seller keeps in his project. This is the message that he can use to (mis)represent his type. The type of a seller is  $\theta \equiv (p, \phi)$  with  $p \equiv \Pr[\tilde{y} = y | \mathcal{I}_{t=1}]$  his information as to the project's value and  $\phi$  his realised rate of time preference. With no loss of generality, there are 5 potential types of sellers in the market:  $\theta \in \Theta \equiv \{(1, \rho), (\pi^L, \rho), (\pi^L, 1), (0, \rho), (0, 1)\}$ .

Denote by  $\mu(\theta|z)$  buyers' beliefs<sup>26</sup> as to the seller's type upon observing the action  $z$  and define  $\mu(z) \equiv \sum_{(p, \phi) \in \Theta} \mu((p, \phi) | z) p$ . A seller retaining stake  $z$  gets

$$l_1(z) = \mu(z) y \quad (42)$$

unit of date 1 good for each promised unit of date 2 good. Eq. (42) is simply the extension of Eq. (14) and asserts that the price for message  $z$  is equal to the fundamental value given public information. Accordingly, a type  $\theta$  seller behaves so as to maximise

$$\max_z \phi(1 - z) l_1(z) + pzy. \quad (43)$$

We proceed in two steps.

**Claim 1.** *In any equilibrium of the market economy, the "high-type"  $(1, \rho)$  is pooled with some other type.*

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<sup>26</sup>With the obvious restriction that  $\mu(\theta|z) \geq 0$  and  $\sum_{\theta} \mu(\theta|z) = 1$ .

*Proof.* Consider an equilibrium where  $(1, \rho)$  is perfectly discriminated. Then for any message  $z_\theta$  sent with strictly positive probability by a type  $\theta \neq (1, \rho)$ , one has  $\mu(z_\theta) \leq \pi^L$ . We first show that  $x^* = 1$  in such an equilibrium, and then that “low-type” sellers must pool with high-type sellers. First, the expected payoff of an investor who do not monitor is

$$V^u = \mathbb{E}_{t=0} [\phi (1 - z_{(\pi^L, \phi)}) \mu(z_{(\pi^L, \phi)}) y + \pi^L z_{(\pi^L, \phi)} y] \quad (44)$$

where expectation is taken w.r.t.  $\phi$  and the (possibly mixed) equilibrium strategy of type  $(\pi^L, \phi)$ . Hence,  $\mu(z_{(\pi^L, \phi)}) \leq \pi^L$  implies  $V^u \leq (\lambda\rho + 1 - \lambda) \pi^L y$ . As  $\pi^L y < 1$  this strategy is strictly dominated by investing in the storage technology so that  $x^* = 1$ . Now low-type sellers maximising  $\max_z (1 - z) \mu(z)$  necessarily mimic high-type sellers. A contradiction.  $\square$

Now fix a supposed equilibrium, and let  $\bar{z}$  be the equilibrium stake of  $(1, \rho)$ . We endeavour to prove that  $\bar{z} = 1$  under standard restrictions on out-of-equilibrium beliefs hold by buyers.

**Claim 2.** *If type  $(1, \rho)$  is pooled in equilibrium and  $\bar{z} < 1$  then the equilibrium does not survive the Intuitive Criterion of Cho and Kreps (1987).*

*Proof.* That  $(1, \rho)$  is pooled with some other type in equilibrium means that  $\mu(\bar{z}) < 1$ . We shall prove that if  $\bar{z} < 1$  then there exist some out-of-equilibrium message  $z^e$  that only a  $(1, \rho)$  seller has an incentive to send as a way to separate from other types. Plugging Eq. (42) into (43), a  $(p, \phi)$ -seller acts to maximise

$$\max_z \phi (1 - z) \mu(z) + pz \quad (45)$$

Formally, if there exists  $z^e \in [0, 1]$  such that

$$\rho(1 - \bar{z}) \mu(\bar{z}) + \bar{z} < \rho(1 - z^e) + z^e \quad (46)$$

$$\phi(1 - \bar{z}) \mu(\bar{z}) + p\bar{z} > \phi(1 - z^e) + pz^e \quad \forall \theta \neq (1, \rho) \quad (47)$$

then the equilibrium fails to satisfy the Intuitive Criterion. Now, Eq. (46)-(47) write

$$(1 - \bar{z}) \frac{\rho\mu(\bar{z}) - 1}{\rho - 1} < (1 - z^e) \quad (48)$$

$$(1 - \bar{z}) \frac{\phi\mu(\bar{z}) - p}{\phi - p} > (1 - z^e) \quad \forall \theta \neq (1, \rho) \quad (49)$$

Such a  $z^e$  exists if and only if  $\bar{z} < 1$  and

$$\frac{\rho\mu(\bar{z}) - 1}{\rho - 1} < \frac{\phi\mu(\bar{z}) - p}{\phi - p} \quad \forall \theta \neq (1, \rho) \quad (50)$$

Define  $F(\phi, p) = \frac{\phi\mu(\bar{z}) - p}{\phi - p}$ . One can easily check that for  $\mu(\bar{z}) < 1$  one has  $F'_\phi(p, \phi) < 0$  and  $F'_p(p, \phi) < 0$ . Hence,  $F(p, \phi) > F(1, \rho) \forall \theta \neq (1, \rho)$ . This terminates the proof.  $\square$

The proof of the proposition follows by combining claims 1 and 2. The argument involved in applying the Intuitive Criterion in claim 2 is as follows. In a candidate equilibrium with  $\bar{z} < 1$ , buyers have to hold “unreasonable” beliefs as to some out-of-equilibrium message, in the sense that they should put strictly positive weight on this message being sent by types who would strictly suffer from doing so.

C. *Proof of lemma 1.* First note that using (17) and (18), the constraint  $V_{IF}(n, R) \geq V_D(n, R)$  is equivalent to  $R \leq R(n)$ , with

$$R(n) = \frac{n + 1}{n + \lambda\rho + 1 - \lambda} \left( y - \frac{c}{\pi^H} \right). \quad (51)$$

Solving (24) thus amounts to finding the maximum  $R$  such that  $R \leq \bar{R}(n)$  and  $R \leq R(n)$ . Now,  $R(n)$  is strictly increasing over  $[0, +\infty)$  with  $\lim_{n \rightarrow \infty} R(n) = y - \frac{c}{\pi^H}$ . On the other hand,  $\bar{R}(n)$  is strictly decreasing over  $(0, +\infty)$ , with  $\lim_{n \rightarrow 0} \bar{R}(n) = +\infty$  and  $\lim_{n \rightarrow \infty} \bar{R}(n) = y - \frac{c}{\pi^H - \pi^L} \leq y - \frac{c}{\pi^H}$  with strict inequality when  $\pi^L > 0$ . It follows that there exists a unique  $\bar{n} \in \mathbb{R}_+$  such that  $R(\bar{n}) = \bar{R}(\bar{n})$  and that  $\bar{V}(n) = (\lambda\rho + 1 - \lambda)\pi^H R(n)$  for  $n \leq \bar{n}$  and  $\bar{V}(n) = (\lambda\rho + 1 - \lambda)\pi^H \bar{R}(n)$  for  $n \geq \bar{n}$ . The lemma easily follows from the definition and properties of  $R(n)$ .

We now derive the expressions for  $\bar{n}$  and  $V^{**}$  used in the text. Using (51) and (20) and rearranging,  $R(\bar{n}) = \bar{R}(\bar{n})$  yields

$$\bar{n} \left( y - \frac{c}{\pi^H} \right) = (\bar{n} + \lambda\rho + 1 - \lambda) \left( y - \frac{c}{\pi^H - \pi^L} \right). \quad (52)$$

Solving for  $\bar{n}$  and rearranging, we obtain

$$\bar{n} = (1 + \lambda(\rho - 1)) \frac{\pi^H (\pi^H - \pi^L) y - c}{\pi^L c}. \quad (53)$$

Now,  $V^{**} = \bar{V}(\bar{n}) = (\lambda\rho + 1 - \lambda)\pi^H \bar{R}(\bar{n})$ . Using successively Eq. (20) and (53), and rearranging, we get

$$V^{**} = (\lambda\rho + 1 - \lambda)\pi^H \frac{\bar{n} + 1}{\bar{n}} \left( y - \frac{c}{\pi^H - \pi^L} \right) = \frac{c\pi^L}{\pi^H - \pi^L} (\bar{n} + 1), \quad (54)$$

$$= (1 + \lambda(\rho - 1))\pi^H y - c - \lambda(\rho - 1) \frac{\pi^H}{\pi^H - \pi^L} c. \quad (55)$$

D. *Proof of proposition 7.* Using the notation introduced in Appendix B, we denote an agent's date 1-type by  $\theta = (p, \phi)$  where  $p$  denotes private information *about the specific project run by the agent*. Given that agents monitor, and that a patient agent knowing that 'his' project will succeed with probability one will never sell, there are 3 potential types of sellers in the market:  $\theta \in \Theta \equiv \{(1, \rho), (0, \rho), (0, 1)\}$ . Also, we denote by  $z \in [0, 1]$  be the stake that a seller keeps in his project, and by  $z' \in [0, 1]$  the stake that he keeps in (outside) contingent claims. Buyers form rational (Bayesian) beliefs as to the projects' worth upon observing  $(z, z')$ .

The situation in which all types play  $(z, z') = (0, 1)$  is clearly an equilibrium. In this equilibrium, a type  $(1, \rho)$  (hereafter, 'high type') seller gets payoff  $\bar{v}_{(1,\rho)} \equiv \rho\pi^H R' + y - R$ ; type  $(0, \rho)$  and type  $(0, 1)$  sellers get, respectively,  $\bar{v}_{(0,\rho)} \equiv \rho\pi^H R'$  and  $\bar{v}_{(0,1)} \equiv \pi^H R'$ .

Consider now any other candidate equilibrium. To induce different payoffs it must be the case that (some) high type sellers play  $(z, z') \neq (0, 1)$  with strictly positive probability. Accordingly, we now restrict attention to such equilibria. Denote by  $\mathcal{Z}$  the set of  $(z, z')$  actually played by high type sellers in the candidate equilibrium, and let  $C(z, z')$  be the amount of date 1 good obtained in the market by a seller retaining stakes  $(z, z')$ . A high type seller playing  $(z, z')$  gets utility

$$v_{(1,\rho)}(z, z') \equiv \rho C(z, z') + (1 - z)(y - R) + (1 - z)\pi^H R'. \quad (56)$$

Note that a high type seller can allways obtain  $\bar{v}_{(1,\rho)}$  by playing  $(0, 1)$ , as information asymmetries are irrelevant in that case (indeed, this is true for any seller type  $\theta \in \Theta$ ). Hence, optimality requires that  $v_{(1,\rho)}(z, z') \geq \bar{v}_{(1,\rho)}$ .

To show proposition 7, it suffices to prove that  $C(z, z') = \pi^H R'$  for all  $(z, z') \in \mathcal{Z}$ . We first show that  $C(z, z') \leq \pi^H R' \forall (z, z') \in \mathcal{Z}$ . Assume the contrary, that is there exists  $(z^*, z'^*) \in \mathcal{Z}$  such that  $C(z^*, z'^*) > \pi^H R'$ . To streamline the exposition, assume that there is only one such  $(z^*, z'^*)$ . (Otherwise, the argument that follows holds for at

least one such equilibrium action). Type  $(0, \rho)$  and type  $(0, 1)$  sellers also play  $(z^*, z'^*)$  in equilibrium, because (by  $C(z^*, z'^*) > \pi^H R'$ ) this strategy strictly dominates all other strategies and in particular the strategy  $(0, 1)$  consisting in selling only outside claims. Buyers' beliefs as to a seller playing  $(z^*, z'^*)$  being a high type seller are therefore given by

$$p^* \equiv \frac{s^* \lambda \pi^H}{s^* \lambda \pi^H + (1 - \pi^H)(1 - \lambda)}, \quad (57)$$

where  $s^* \in (0, 1]$  is the (equilibrium) probability that a high type plays  $(z^*, z'^*)$ . Observe that  $\rho p^* < 1$  by assumption (A3). Now, by buyers' rationality we have that  $C(z^*, z'^*) \leq p^* z^* (y - R) + z'^* \pi^H R'$ . Using (56) and rearranging, this implies that

$$v_{(1, \rho)}(z^*, z'^*) \leq \rho \pi^H R' + (y - R) + (\rho p^* - 1) z^* (y - R) - (\rho - 1)(1 - z) \pi^H R'. \quad (58)$$

As  $\rho p^* < 1$  and  $\rho > 1$ , (58) implies that  $v_{(1, \rho)}(z^*, z'^*) < \rho \pi^H R' + (y - R) = \bar{v}_{(1, \rho)}$ , contradicting optimality. Therefore,  $C(z, z') \leq \pi^H R' \forall (z, z') \in \mathcal{Z}$ . We now rule out the existence of a  $(z^*, z'^*) \in \mathcal{Z}$  such that  $C(z^*, z'^*) < \pi^H R'$ . Again, we proceed by contradiction. Using (56) and the definition of  $\bar{v}_{(1, \rho)}$ , and rearranging we obtain

$$v_{(1, \rho)}(z, z') - \bar{v}_{(1, \rho)} = (\rho - 1)(C(z, z') - \pi^H R') + (C(z, z') - z(y - R) + z' \pi^H R') \quad (59)$$

Now, by buyers' rationality we have that  $C(z, z') \leq z(y - R) + z' \pi^H R'$ , with equality only if no other type plays  $(z, z')$  with strictly positive probability in equilibrium. It therefore follows from (59) that  $C(z^*, z'^*) < \pi^H R'$  implies  $v_{(1, \rho)}(z^*, z'^*) < \bar{v}_{(1, \rho)}$ . But this contradicts optimality. This completes the proof that  $C(z, z') = \pi^H R'$  for all  $(z, z') \in \mathcal{Z}$ . Proposition 7 easily follows. Indeed, one implication of (59) is that in any candidate equilibrium in which some  $(z, z') \neq (0, 1)$  is played with positive probability by a high type seller, it must hold that  $C(z, z') = \pi^H R' = z(y - R) + z' \pi^H R'$ . In particular, this requires that other types do not play  $(z, z')$ . Such situations are easily seen to be payoff equivalent to the equilibrium in which all types play  $(0, 1)$  with probability one.

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