Banks as Secret Keepers *

Tri Vi Dang[†] Gary Gorton[‡] Bengt Holmström[§] Guillermo Ordoñez[¶]

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PRELIMINARY AND INCOMPLETE

Abstract

Banks are optimally opaque institutions. They produce debt for use as a transaction medium (bank money), which requires that information about the backing assets not be revealed, so that bank money does not fluctuate in value, reducing its efficiency in trade. This need for opacity conflicts with the production of information about investment projects, necessary for allocative efficiency. How can information be produced and not revealed? Financial intermediaries exist to hide such information; they are created and structured to keep secrets. For the economy as a whole, this can be accomplished by a separation in how firms finance themselves; they divide into bank finance and capital market/stock market finance based on how well they can be used to maintain information away from liquidity markets. Firms with large projects, risky projects or projects easy to evaluate are less likely to be financed by banks.

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†Columbia University (e-mail: td2332@columbia.edu)

‡Yale University and NBER (e-mail: gary.gorton@yale.edu)

§MIT and NBER (e-mail: bengt@mit.edu)

¶University of Pennsylvania and NBER (e-mail: ordonez@econ.upenn.edu)

1 Introduction

A defining characteristic of privately-produced money-like securities is that agents accept them at par when transacting and expect to be able to redeem them at par. The value of the money is not in doubt when transacting and it does not vary in value over time. In other words, bank money is not sensitive to information, either public or privately-produced. But, how can banks produce such money when it must be backed by risky assets, and when investment efficiency requires that information be produced to select and monitor these investments? The conundrum is that information needs to be produced, but not revealed. In this paper we ask two questions: Why do banks produce private money (rather than the agents themselves)? And, what are the optimal assets for backing private money?

Our answer is that financial intermediaries produce private money because they can keep the information that they produce about the backing assets secret. Without banks, information about investments comes out and reduces the efficiency of private money. So, banks are optimally opaque. Moreover, banks select backing assets that minimize information leakage. For example, banks lend to small firms and to households. There is a complementarity between the production of private money and assets that minimize information leakage. Thus, the raison d'etre of banking is secret-keeping for the production of private money.

In the setting we study, a firm has an investment opportunity but no funds, while an agent – the "early consumer" – has a "liquidity" need at an interim date. Initially the early consumer has enough endowment to cover the investment needs of the firm at the initial date or its own liquidity needs in the intermediate period, but not both. If the early consumer finances the firm's needs, he can cover his liquidity needs by selling the claims in the intermediate period. The liquidity need makes the early consumer (effectively) risk averse to changes in the value of the claim he holds. Furthermore, he does not want the seller of goods to produce private information about the assets backing the claim, as in Gorton and Pennacchi (1990) and Dang, Gorton, and Holmström (2013).

We assume that information about the project is socially valuable. Only if the initial project is good it is efficient to finance an extension of the project. The problem is that there is a tradeoff between socially valuable information production and its negative externality on liquidity provision. The model displays the basic problem that information is needed for investment efficiency, but not wanted for trading efficiency.

We begin by analyzing how two polar institutional arrangements can handle socially valuable information production and its negative externality on liquidity provision. First, in an informationally-efficient market system, the extension is financed with a security issued in the capital market where all agents can observe the price. In the second, there is a banking system, where the bank finances the project extension and can hide this information. We show that capital markets are not optimal in providing liquidity services because they reveal too much information about the project, which backs the private money. However, a bank can hide information and implement the first best allocation. In the basic model agents cannot produce private information and the bank is a benevolent social planner.

Then we allow agents to produce and trade on private information, potentially creating another information leakage. Now the bank may not be able to implement first best, i.e., avoid information production, and may have to force the early consumer to inefficiently bear risk, or alternatively inefficiently invest less in the initial project. These distortions may be able to prevent private information production, but may be so large that banks do not exist. Instead, firms finance in the capital markets, and money inefficiently varies in value. But, the bank can also prevent such information leakage through its choice of assets. The bank's optimal portfolio consists of assets for which private information is very costly to produce. The optimal backing assets that we determine correspond to those we observe in reality (difficult to evaluate, small, and relatively safe assets), but the reason is unrelated to any special ability of the bank to oversee these assets.

The model we analyze is related to Dang, Gorton, and Holmström (2013), but extended to include an interim investment decision, socially valuable information production and banks. They show, among other results, that the optimal trading security is debt and that the optimal backing collateral is also debt. Their setting is one in which there is the possibility of some agents producing private information, creating possible adverse selection in trading, which then reduces the value of private money. We analyze a further information externality, one due to possible public information. This extension allows us to study why banks exist and how they optimally choose their portfolio structure

The definition of a bank depends on complementarities between the two sides of the balance sheet. The usual view sees the uniqueness of banks in terms of their activities with respect to making loans. Banks are viewed as producing information about potential borrowers (screening) and producing information after the loan is made (monitoring); see, e.g., Boyd and Prescott (1986). In order for the bank itself to be monitored its liabilities are designed as a short leash, e.g., demand deposits that can be withdrawn at any moment. See Diamond (1984), Diamond and Rajan (2001) and Gorton and Winton (2003) for a survey of the banking literature. In this view, the structure of bank liabilities is dictated as a mechanism to ensure that the unique activities of making loans are undertaken. In Kashyap, Rajan, and Stein (2002) deposit withdrawals and loan commitment draw-downs are imperfectly correlated, and so they can be optimally combined.

Our argument for the existence of financial intermediation is very different from other explanations explored previously by the literature. The most important difference is that the bank debt is used to conduct trade; it is money. Banks are unique in producing debt used as private money. In the model, there is nothing special about the banks' activities on the asset side. However, there is still an important complementarity between bank assets and bank liabilities. In order to produce money, the banks' assets are selected to minimize information leakage, publicly or privately.

The paper is also related to the justification of financial intermediaries by Diamond and Dybvig (1983). In their paper, in the initial period the return of the illiquid asset is known but the liquidity needs of investors are stochastic, unknown and privately observed in the intermediate period. As highlighted by Jacklin (1987) and Haubrich and King (1990), if there are trading opportunities in the intermediate period, such information reduces the possibility of insurance against liquidity needs. Critically, since liquidity needs are hardwired into the preferences of investors in Diamond and Dybvig, information about those needs cannot be avoided, and the only possibility to sustain insurance is to restrict trading in the model.

In contrast, our paper assumes that in the initial period the liquidity needs of investors are known but the return of the illiquid asset is stochastic, unknown and privately observed by firms in the intermediate period. If there are trading opportunities in the intermediate period, such information also reduces the possibility of insurance against liquidity needs. However, banks are useful in hiding this information from investors, which is not feasible in the setting of Diamond and Dybvig.

An empirical literature documents that banks are opaque firms even under deposit insurance. Hirtle (2006) examines the abnormal stock returns to 44 bank holding companies in response to the SEC mandate that CEOs certify the accuracy of their financial statements. This mandate resulted in no abnormal response in the case of non-financial firms, but bank holding companies did experience positive and significant abnormal returns. Hirtle also finds that the abnormal returns are related to measures of opacity. Haggard and Howe (2007) find that banks have less firm-specific information in their equity returns than matching industrial firms. They also show that banks with higher proportions of agricultural and consumer loans are more opaque. Morgan (2002) and Iannota (2006) look at the bond ratings of banks and find that bond rating agencies are more likely to disagree on the ratings of banks compared to other firms, suggesting that banks are harder to understand. Also, see Jones, Lee, and Yeager (2012). Flannery, Kwan, and Nimalendran (2010) examine microstructure evidence (bid-ask spreads and trading volumes) for banks and a matched non-bank control sample. They conclude that banks are not so opaque, compared to non-banks. When they examine measures of opacity, controlling for the microstructure variables, they find evidence that loans are the contributing factor to bank opacity.[1]

In the next Section we introduce the model, calculate the first best allocation, and then show the first best can be implemented by intermediation and not capital markets. In Section 3 we study what happens if agents can privately produce information, reducing the possibility of intermediaries to keep secrets. In Section 4 we determine the optimal portfolio choice of banks that allows them to hide information most effectively. Finally, Section 5 concludes.

2 Model

In this section we present the model. Then, we derive the first best allocation and study the allocations achievable with capital markets and with a banking technology (or contract environment) that enables banks to keep secrets.

[1]There is a related literature on the potential for market discipline to complement bank supervision. The market discipline might occur via improved disclosure or mandatory subordinated debt requirements. See Flannery (1999).

2.1 Setting

Consider an economy with a single good, three dates, $t \in \{0, 1, 2\}$, and four agents: a Firm (F), an Early consumer (E), a Late consumer (L), and a Bank (B). Preferences and endowments are as follows:

$$
\begin{aligned}
U_F &= \sum_{t=0}^{2} C_{Ft} & \omega_F &= (0, 0, 0) \\
U_E &= \sum_{t=0}^{2} C_{Et} + \alpha \min\{C_{E1}, k\} & \omega_E &= (e, 0, 0) \\
U_L &= \sum_{t=0}^{2} C_{Lt} & \omega_L &= (0, e_L, 0) \\
U_B &= \sum_{t=0}^{2} C_{Bt} & \omega_B &= (0, 0, 0)
\end{aligned}
$$

where C_{ht} denotes the consumption of agent $h \in \{F, E, L, B\}$ at date $t \in \{0, 1, 2\}$ and α and k are positive constants. The firm has no endowment of goods; the early consumer has e units of goods at $t = 0$ and nothing at other dates and the late consumer has e_L units of goods at $t = 1$ and nothing at other dates. In other words, all agents are risk neutral and indifferent between consuming in any period, with the exception of the early consumer, who prefers to consume up to k at $t = 1$.

Even though the firm does not have any endowment, it has an investment opportunity. At $t = 0$ the firm can invest, at a cost w, in a project that generates $x > w$ at $t = 2$ with probability λ, and zero otherwise, all in terms of the single good. At $t = 1$, the firm has the opportunity to expand the original investment, at a cost $\widehat{w}$, which generates $\widehat{x} > \widehat{w}$ at $t = 2$ only if the original investment is successful, and zero otherwise. This implies the original project and its extension are perfectly correlated.

We assume the original project has a positive net present value and its operation is ex-ante efficient (i.e., $\lambda x > w$), while the expansion has a negative ex-ante net present value (i.e., $\lambda \widehat{x} < \widehat{w}$). We assume the firm has hard information at $t = 1$ about whether the original project is successful, and hence whether the expansion is profitable or not. The firm can communicate this information to the other agents at no cost.

We also assume that the endowments of the early consumers are not enough to cover both their liquidity needs and firms' investment needs, while total endowment in the economy (the endowments of both early and late consumers) is enough to cover both liquidity and investment needs. This implies that early consumers face the risk of not consuming k in $t = 1$ if financing the original project at w, but late consumers could provide enough resources to eliminate such a risk. In summary, these restrictions are:

Assumption 1 *Projects and endowments*

1. *Projects are ex-ante efficient but extensions are not.*
   $\lambda x > w$ *and* $\lambda \widehat{x} < \widehat{w}$.

2. *Early consumers can cover their liquidity and investment needs, but not both.*
   $e > k$, *and* $e > w$ *but* $e < k + w$.

3. *Total endowment is enough to cover both liquidity and investment needs.*
   $e_L + e > k + w + \widehat{w}$.

Some further assumptions are worth noting. First, endowments are fixed and storable, which implies that banks will not be necessary to move endowment inter-temporally. The early consumer can store up to k of his endowment to guarantee its consumption at $t = 1$. However, in this case, the early consumer would not have enough resources to invest in the project, since $e - k < w$. In contrast, if the early consumer finances the project at $t = 0$, since claims on the project pay at $t = 2$, the only possibility is to consume k at $t = 1$, and then trade a fraction of those claims with late consumers. Late consumers have enough resources to potentially finance profitable project extensions and to buy the claims from early consumers to cover their liquidity needs.

The trade between early and late consumers that would implement first best, however, is hindered by information revelation about the project at $t = 1$. The information about the realization of the original project could be positive, which allows the extension to be financed, since that is optimal. The information, however, would have a negative impact on the early consumers' ability to trade its claims on the original project, if the original project was unsuccessful. In that case the claims held by early consumers are worthless and then late consumers would not be willing to buy them. Early consumers would not be able to cover their liquidity needs.

We will show that even though the bank is a neutral agent without any endowment or special abilities, it will be able to improve welfare by participating as an opaque intermediary, which uses the information to allocate investment resources optimally, while hiding information to avoid it interfering with trade. In a sense, a bank that keeps secrets can eliminate the negative externality imposed on trade by information.

2.2 Autarky and First Best

In autarky early and late consumers just store their endowment and do not interact with the firm, then $E(U_F^A) = E(U_B^A) = 0$, $E(U_E^A) = e + \alpha k$ and $E(U_L^A) = e_L$.

Clearly it is possible for the economy to do better than autarky. Consider the problem of a social planner. At $t = 0$, it is socially efficient for the firm to invest in the project. The planner would then like to transfer an amount w from the early consumer, who has the required endowment at $t = 0$, to the firm. It is also optimal for the early consumer to consume k in period $t = 1$, but the early consumer has only $z \equiv e - w < k$ remaining to consume at $t = 1$. Then it is optimal for the planner to commit transferring $k - z$ resources from the late consumer to the early consumer. It is also optimal to use $\widehat{w}$ from the late consumer to finance an expansion in case the original project is successful.

These allocations are feasible because $e_L > k - z + \widehat{w}$, from Assumption 1. Note that relaxing this assumption is not critical; it just restricts the first best outcome, introducing a trade-off between reducing investment (allocating less than w to the project or less than $\widehat{w}$ to the extension) or distorting consumption (making early consumers consume less than k at $t = 1$).

The next question is how to split the surplus. We choose to assign the surplus from these efficient transfers to firms. This assumption just allows for a clear welfare comparison across scenarios with and without intermediaries, but it is irrelevant for the results. As we discuss later, banks create value regardless of who keeps the surplus. Define $\mu = x + \widehat{x} - \widehat{w}$ the total gains of the firm conditional on the original project suceeding. Then, under this first best allocation the ex-ante expected utilities of the agents are $E(U_B^{FB}) = 0$, $E(U_E^{FB}) = e + \alpha k$, $E(U_L^{FB}) = e_L$ and $E(U_F^{FB}) = \lambda\mu - w$.

The gains from trading are clear in this comparison. First, the project gets funded, which generates an expected gain $\lambda x - w$. Second, the extension of the project gets funded only if the original project is good, in which case the extension generates a positive net gain $(\widehat{x} - \widehat{w})$. Then expected gains are $\lambda\mu - w$. Once the project is financed, there are gains that arise from late consumers transferring resources to early consumers to cover with certainty their liquidity needs k of consumption at $t = 1$.

In summary, it is optimal to finance the project at $t = 0$, and to finance the extension if the original project is successful at $t = 1$. There is trade between the early and the late consumer for $k - z$ at $t = 1$. As we will show, if the information about the results of the original project leaks out, it may hinder the trade between early and late consumers. This leakage happens in capital markets, but not with ”secret keeping” intermediaries.

2.3 Capital Markets

We now show that capital markets cannot implement the efficient allocation.

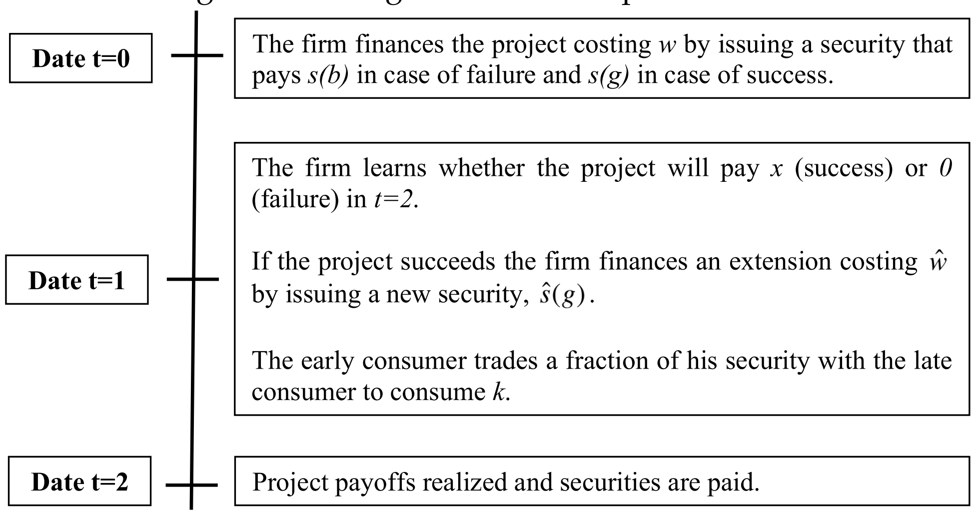
At $t = 0$ the firm finances the project by issuing a security to the early consumer in exchange for w. Define $s(b)$ to be the contingent claim on the project at $t = 2$ if the project fails and $s(g)$ the contingent claim on the project at $t = 2$ if the project succeeds. Assuming the firm faces limited liability, $s(b) = 0$.

At $t = 1$ two transactions may occur. First, the firm may seek financing for an extension of the project if the original project is good by issuing a new security, which we denote as $\widehat{s}(g)$, which can be bought by the late consumer. We assume that finance is specific, i.e. the security issued is backed by the specific project. This assumption simplifies the analysis but it is not crucial. Second, since the early consumer prefers to consume k at $t = 1$, but only has $z \equiv e - w < k$ available, he sells part of his security to the late consumer. Figure 1 shows the sequence of events in the case of a capital market.

Since information is hard, the firm cannot lie about the project's results. In capital markets, all agents observe whether a firm is raising funds for an extension or not, so all of them observe whether the original project was successful or not. This leakage of information from the financing of the extension to the information about the original project's expected payoffs has an impact (an externality) on trade between the two consumers. The next proposition shows that capital markets do not internalize this negative effect of information about projects on trade, hence not implementing the first best allocation.

Proposition 1 *Capital markets do not implement the first best allocation.*

Figure 1: Timing Model with Capital Markets



Proof We proceed by backward induction. If the project fails, the firm does not look to finance an extension, revealing that the original project was a failure. If the project succeeds, the firm seeks to finance an extension by issuing a security that pays $\widehat{s}(g) = \widehat{w}$ in $t = 2$. This is because we assume the firm has hard information about the project's results, and also the bargaining power such that it keeps the surplus $(\widehat{x} - \widehat{w})$ of the extension.

The previous stage is critical to define the optimal choices of the late consumer. If the late consumer learns the project is bad (because the firm never shows up asking for a loan to finance the extension), then he is better off just consuming (or storing to consume later) his endowment e_L.

If the late consumer learns the project is successful, then he chooses to finance the extension and to buy a fraction θ of the claims on the original project from the early consumer, at a price $s(g)$. Since the early consumer only needs to sell up to $k - z$ to consume in period $t = 1$, the budget constraint for the late consumer in case the original project is successful is:

$$\widehat{w} + \theta s(g) \leq e_L.$$

This implies that

$$\theta s(g) = \min\{k - z, e_L - \widehat{w}\} = k - z \tag{1}$$

from Assumption 1. This means that late consumers have enough funds to cover the investment needs of firms and also the remaining liquidity needs of early consumers.

Now we can study the choices of the early consumer. If the early consumer does not finance the original project, he stores his endowment and obtains a certain utility of $U_{E|Store} = e + \alpha k$. In contrast, if the early consumer decides to finance the project, then he faces a lottery because the project is risky. Then the expected utility for the early consumer when financing the project is:

$$U_{E|Finance} = (1+\alpha)z + \lambda[(1+\alpha)\theta s(g) + (1-\theta)s(g)].$$

Substituting equation (1) and assuming the firm has the bargaining power, the early consumer should be indifferent between financing the project or storing the endowment (this is $U_{E|Finance} = U_{E|Store}$), which implies

$$(1+\alpha)z + \lambda s(g) + \lambda\alpha(k-z) = e + \alpha k,$$

and then, the price $s(g)$ of the security that makes early consumers indifferent between financing the project or not (considering also the restriction of limited liability such that $s(g) \leq \mu \equiv x + \widehat{x} - \widehat{w}$) is

$$s(g) = \min\left\{\frac{w}{\lambda} + \frac{\alpha(1-\lambda)}{\lambda}(k-z), \mu\right\}. \tag{2}$$

The first component of the first argument corresponds to the certainty equivalent cost of the loan. The second component corresponds to the compensation to the early consumer for taking the risk of not consuming k (but only $k-z$) in period $t=1$, losing the additional utility α with probability $1-\lambda$, when the project fails. The minimum just captures limited liability since the claim cannot payout more than the underlying payoff of the project in case of success, μ, imposing that $\widehat{s}(g) = \widehat{w}$.

Naturally, when $s(g) = \mu$, and limited commitment binds, then $U_{E|Finance} < U_{E|Store}$ and the project (and then the extension) would not be financed. In this case, early consumers would rather store the endowment since the expected surplus from the project is not enough to compensate for the risk from financing the project. In this case the project is not financed at all, resulting in autarky.

By construction (bargaining power to the firm) the expected utility of the two consumers and the bank do not change with respect to the first best (or autarky). However, the expected utility for the firm is:

$$E(U_F^{CM}) = \lambda x - \lambda s(g) + \lambda(\widehat{x} - \widehat{w}) < E(U_F^{FB}) = \lambda\mu - w$$

since, as is clear from equation (2), $\lambda s(g) > w,$ because the firm has to compensate the early consumer for taking the risk of not consuming as much as desired in period 1. In the extreme, when $s(g) = \mu$ and there is no financing of the project, then $U_F^{CM} = 0.$

The costs of capital markets vis-a-vis the first best outcome is the reduction in firm's consumption to compensate early consumers for facing the possibility of not covering their liquidity needs. Specifically, the gap between the welfare of first best and capital markets is

$$E(U_F^{FB}) - E(U_F^{CM}) = \lambda s(g) - w = \min\left\{\alpha(1-\lambda)(k-z), \lambda\mu - w\right\}.$$

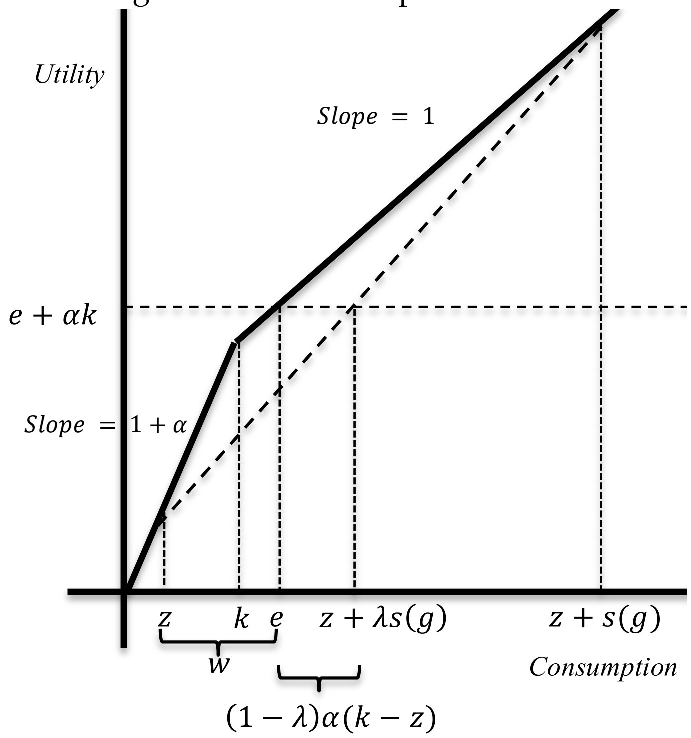
Q.E.D.

Intuitively, the securities of the early consumer are subject to information revelation about the project's result, creating the risk of bad news such that they cannot sell those securities, leaving insufficient resources to meet their liquidity needs. The next figure illustrates the source of risk aversion given by the limited liquidity needs of the early consumer.

Since early consumers' liquidity needs effectively make them risk averse, the firm has to compensate for that risk by promising in expectation more than the loan size, w, inducing the same ex-ante utility when early consumers choose to store their endowments. The implication is that liquidity needs induce an inefficient transfer of resources. Even though it is feasible for the late consumer to cover the liquidity needs of the early consumer, the late consumer is not willing to do that in case of learning the project is bad. Hence the firm needs to compensate the early consumer to take the risk by financing the project.

In essence, capital markets reveal *too much* information, reducing the expected utility of early consumers since their money cannot buy as much when the bad state is revealed. On the one hand, information about the project is valuable because in its absence some good extensions of the project would not be financed given their ex-ante negative net present value. However, such information generates an externality by revealing bad news about the original project, hence inefficiently reducing trade

Figure 2: Costs of Capital Markets



at $t = 1$ between early and late consumers. To compensate the early consumer for the risk of not covering his liquidity needs, the firm has to sell a larger share of total cash flow. In summary, when firms raise funds in capital markets there is inefficient risk-bearing in the economy – those with liquidity needs are the ones who face the risk, rather than those without those needs.

2.4 Financial Intermediation

The previous analysis shows that capital markets may not implement the efficient investment if the early consumer cares about liquidity, and, even if there is efficient investment, there is inefficient risk bearing in the economy. Now we show that intermediation dominates capital markets in providing financing and can potentially implement first best.

Since intermediaries create value by providing liquidity and reallocating risk, they can offer a rate for loans to firms such that they prefer to finance through intermediaries. However, there are limits to these results since some projects cannot be exploited by intermediaries to provide liquidity, given that they introduce incentives for information acquisition by lenders even though banks try to hide such information. In this section we assume consumers cannot privately acquire information about the quality of the project, so there are no limits to the possibilities of financial intermediaries to improve welfare. In the next Section we relax this restriction.

An essential assumption is that bankers do not want or cannot use information about the quality of the project in their own interest. In such an equilibrium, information would be revealed and the whole purpose of banks would be eliminated. We simply assume that a banking technology, fixed contracts or other commitment devices exist. This is the difference between banks and markets, so that banks do not reveal information.

Figure 3 shows the sequence of events, which we now describe. The game now has four active agents. At $t = 0$ the early consumer deposits e in the bank, which then lends w to the firm to invest in the original project. The firm issues a contingent security that pays $s(b)$ in case of failure and $s(g)$ in case of success at $t = 2$. At the time the bank receives the deposit from the early consumer, it promises to pay $r_1^E = k$ at $t = 1$ and a contingent claim that pays $r_2^E(b)$ at $t = 2$ if the project fails and $r_2^E(g)$ at $t = 2$ if the project succeeds. The state is common information to all agents at $t = 2$.

At $t = 1$, the late consumer deposits e_L in the bank, which issues a security that promises to pay $r_2^L(b)$ if the state is bad (the original project ends up failing and the bank is liquidated) and $r_2^L(g)$ if the state is good (both the original project and its extension are successful). Meanwhile, the early consumer withdraws k from the bank. If the bank determines that the firm has a good project, then it lends $\widehat{w}$ to the firm for the extension of the project which issues a security that pays $\widehat{s}(g)$. If the bank determines that the firm has a bad project, then the loan to the firm for an extension is not made and the additional $\widehat{w}$ is stored until $t = 2$.

Note that the early consumer does not need to trade directly with the late consumer, but just withdraws k from the bank. Alternatively, and equivalently, the early consumer could trade with the late consumer directly by writing a check or using a bank note issued by the bank. The key is that none of the consumers observe whether the bank has given the loan to the firm to finance the extension of the project or not. The intermediary, by hiding such information, allows for efficient trade between consumers at $t = 1$ which then covers early consumers' liquidity needs.

Financial intermediaries achieve a first best allocation by channeling funds to firms

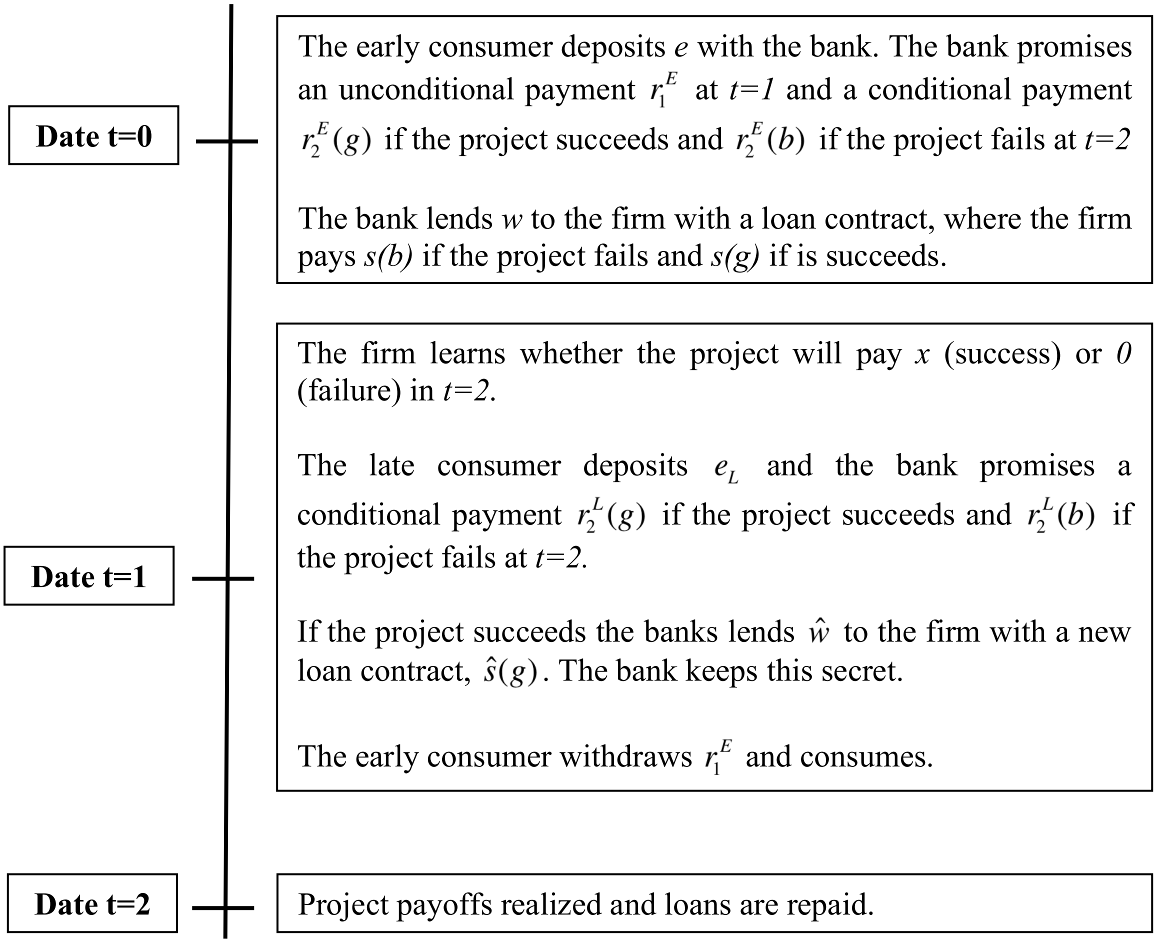


Figure 3: Timing Model with Financial Intermediaries

efficiently and permitting trade across consumers, exploiting information to make efficient loans, and hiding that same information to allow for efficient trade. The next proposition summarizes this result.

Proposition 2 *Financial intermediaries implement the first best allocation.*

Proof We work backwards. At $t = 1$, if the project succeeds the bank gives a loan $\widehat{w}$ to the firm, which issues a security that pays $\widehat{s}(g) = \widehat{w}$ in $t = 2$. If the project fails, the best alternative for the bank is to not finance the extension and store the additional endowment $\widehat{w}$.

Since consumers are risk neutral, the bank's promises to consumers are not determined, and there are many alternatives that make the consumers indifferent. Here we assume $r_2^E(b) = 0$ and in the next section we justify this choice by showing it is the one that minimizes the incentives for late consumers to acquire information, making promises more credible.

In the proposed first best contract, in which the bank promises $r_1^E = k$, the assets of the bank at $t = 2$ depend on whether the project fails or succeed. When the project fails assets are,

$$A_b \equiv e_L + z - k \qquad \textit{where} \quad z = e - w.$$

When the project succeeds, considering that $\widehat{s}(g) = \widehat{w}$, assets are

$$A_b + s(g).$$

Since $r_1^E = k$ and $r_2^E(b) = 0$, we can compute $r_2^E(g)$ from the indifference condition of the early consumer. This is,

$$(1 + \alpha)k + \lambda r_2^E(g) = e + \alpha k.$$

Then

$$r_2^E(g) = \frac{e - k}{\lambda}. \tag{3}$$

Since $r_2^E(b) = 0$, from the resource constraint of banks when the project fails,

$$r_2^L(b) = A_b < e_L, \tag{4}$$

and, from the indifference condition of the late consumer,

$$\lambda r_2^L(g) + (1 - \lambda) r_2^L(b) = e_L,$$

we can obtain the value of the last promise, which remains to be determined:

$$r_2^L(g) = e_L + \frac{(1 - \lambda)}{\lambda}[w + k - e] > e_L. \tag{5}$$

Finally, we have to check that these payments are feasible when the project succeeds

$$r_2^E(g) + r_2^L(g) \leq A_b + s(g).$$

Then, the restriction on the claim for a successful projects has to be

$$s(g) \geq \frac{w}{\lambda}.$$

Since the firm has all the bargaining power, $s(g) = \frac{w}{\lambda}$, which is always feasible given our assumption that $\lambda x > w$. This implies that the surplus for the firm is $E(U_F^{FI}) = \lambda(x - s(g)) + \lambda(\widehat{x} - \widehat{s}(g)) = \lambda\mu - w$, and then

$$E(U_F^{FI}) = E(U_F^{FB}) = \lambda\mu - w.$$

Since by construction we guarantee $E(U_B^{FI}) = 0$, $E(U_E^{FI}) = e + \alpha k$ and $E(U_L^{FI}) = e_L$, then financial intermediation implements the first best allocation.

Q.E.D.

Intuitively, a bank that credibly commits to hide information about the quality of the project can implement the first best because it allows information to be used at $t = 1$ for investment purposes, but delays its revelation until $t = 2$ to prevent such information from detering the efficient trade across consumers at $t = 1$. In this way banks transfer the risk-bearing from the early consumers who want to consume in $t = 1$ to the late consumers who do not have any preference about when to consume. In essence banks eliminate the negative externality that information has on liquidity.

This is a stark result because we have assumed it is impossible for late consumers to learn about those secrets. We relax this assumption in the next two sections.

3 Private Information Acquisition

In this section we assume that late consumers can privately learn about the project's results by exerting costly efforts γ in terms of consumption. First we study the conditions that limit the use of a banking structure to improve welfare. Basically the potential late depositors have incentives to acquire information about the quality of the project on their own. Then, we introduce a continuum of heterogeneous projects to study how the financing of firms sorts into banking or capital markets. Finally, we show how banks can avoid private information acquisition, not only by choosing the right projects to finance (small, safe and low information costs), but also by financing many, asymmetric and uncorrelated projects.

When the bank makes one loan, producing information about the value of the bank is the same as producing information about the value of the project. While the cost of producing information is γ, the benefits are given by the possibility of avoiding depositing in a bank with a failing firm in its portfolio. Specifically, if late consumers do not acquire private information about the project and deposit in the bank, their expected gains are

$$\lambda r_2^L(g) + (1-\lambda) r_2^L(b).$$

In contrast, if late consumers acquire information at a cost γ and find out that the project is successful (with probability λ) then they prefer to deposit in the bank, being certain they will obtain $r_2^L(g) > e_L$ at $t = 2$ (from equation 5). If they find out the project is a failure (with probability $1-\lambda$), then they prefer to store their endowment e_L rather than depositing and obtaining $r_2^L(b) < e_L$ at $t = 2$ (from equation 4). This implies the expected gains from acquiring information are

$$\lambda r_2^L(g) + (1-\lambda) e_L - \gamma.$$

Comparing these two expected gains, late consumers prefer to deposit their endowment without acquiring information if

$$(1-\lambda)[e_L - r_2^L(b)] \leq \gamma. \tag{6}$$

At this point, the optimality of our assumption that $r_2^E(b) = 0$ is clear. Banks want to maximize the payments to late consumers when the project fails to minimize their incentives to acquire information. This leads to the following proposition.

Proposition 3 *When consumers are able to learn privately about the quality of projects at a cost γ, banks can implement the first best outcome only if*

$$k - z \leq \frac{\gamma}{1-\lambda}.$$

The proof just requires replacing $r_2^L(b) = A_b = e_L + z - k$ from equation (4) into condition (6). Naturally, if this condition is not fulfilled, banks cannot credibly promise to pay k to the early consumer. The late consumer would have an incentive to learn about the quality of projects, not depositing in the bank if the project fails. In this case the bank would not always obtain the deposits at $t = 1$ to pay k to early consumers.

In other words, if the condition above is not fulfilled, the use of banks to achieve the first best is unsustainable.

In essence, banks are more likely to sustain a contract proposed in the previous section when projects have a low probability of default (high λ), they are difficult to monitor (high γ), they are relatively small (low w), the liquidity needs are relatively small (low k) or the early consumer is relatively rich (high e). That is, relatively safe, small and complex projects are more likely to be observed in the portfolio of banks.

The natural question is, can the bank still improve welfare if this condition is not fulfilled? We show that the bank can improve welfare but it cannot achieve the first best allocation. When condition (6) binds, banks need to either distort risk-bearing or distort the investment to avoid information production by late consumers. We next show the conditions under which banks still dominate capital markets if they distort the risk-bearing in the economy and then if they distort investment. Then, we discuss the condition under which banks prefer to distort risk-bearing rather than investment.

3.1 Distorting the Provision of Private Money

If late consumers have incentives to acquire information about the banks' assets when the bank offers the contract that implements the first best, banks can distort risk-bearing and the provision of private money in a way such that they still dominate capital markets.

Proposition 4 *If $k - z > \frac{\gamma}{1-\lambda}$ banks still improve welfare relative to capital markets if*

$$\lambda(k - z) \leq \frac{\gamma}{1 - \lambda},$$

which is implemented by distorting risk-bearing in the economy, promising early consumers a certain return $r_1^E < k$ in $t = 1$.

Proof How can banks distort risk-bearing to avoid information acquisition? Since expected benefits for late consumers to acquire information are given by $(1 - \lambda)[e_L - r_2^L(b)]$, and their costs are γ, a way for banks to discourage information acquisition is to promise late consumers no less than

$$r_2^L(b) = e_L - \frac{\gamma}{1-\lambda}, \tag{7}$$

in case the project is a failure.

However, under our assumption that $w - z > \frac{\gamma}{1-\lambda}$, total assets when the project fails are not enough to promise both k to early consumers and $e_L - \frac{\gamma}{1-\lambda}$ to late consumers because

$$A_b \equiv e_L + z - k < e_L - \frac{\gamma}{1-\lambda}.$$

The only possibility to guarantee the resource constraint and avoid information acquisition is to promise early consumers $r_1^E < k$. From the inequality above,

$$r_1^E = z + \frac{\gamma}{1-\lambda} < k. \tag{8}$$

The bank has to distort risk-bearing because it has to offer a contract that makes a non-contingent payment at $t = 1$, otherwise information would be revealed. Since the bank promises a lower payment at $t = 1$, it has to to offer a larger payment at $t = 2$ in case the project succeeds, which compensates for not completely covering the liquidity needs of the early consumers, but still making them indifferent between storing or depositing. This is

$$(1+\alpha)r_1^E + \lambda r_2^E(g) = e + \alpha k.$$

Replacing r_1^E (from equation 8) above

$$r_2^E(g) = \frac{e-k}{\lambda} + \frac{(1+\alpha)}{\lambda}\left[k - z - \frac{\gamma}{1-\lambda}\right]. \tag{9}$$

From the indifference condition of the late consumer,

$$\lambda r_2^L(g) + (1-\lambda)r_2^L(b) = e_L,$$

and using equation (7)

$$r_2^L(g) = e_L + \frac{\gamma}{\lambda}. \tag{10}$$

Now, we have to check that these payments are feasible when the project succeeds, this is, bank's assets when the project succeeds are enough to cover the promises,

$$r_2^E(g) + r_2^L(g) \leq e_L + z - r_1^E + s(g).$$

Then, the restriction on the claim for a successful project, together with the firm having the full bargaining power implies:

$$s(g) = \frac{w}{\lambda} + \frac{\alpha}{\lambda}\left[k - z - \frac{\gamma}{1-\lambda}\right]. \tag{11}$$

Note that in the first best $s(g) = \frac{w}{\lambda}$. When risk-bearing is distorted, banks have to charge the firm the gap $k - z - \frac{\gamma}{1-\lambda}$ adjusted by making the early consumer consume in period $t = 2$ rather than in $t = 1$ (adjusted by $\frac{\alpha}{\lambda}$). This is not feasible if $s(g) > \mu$.

Again, by construction, the utilities of the bank and the two consumers are the same as in all previous cases. However, the firm's utility when risk-bearing is distorted is

$$E(U_F^{Dist}) = \lambda(x - s(g)) + \lambda(\widehat{x} - \widehat{w}) = E(U_F^{FB}) - \alpha\left[k - z - \frac{\gamma}{1-\lambda}\right].$$

Assuming it is feasible for firms to raise funds in capital markets, comparing the firm's utility when risk-bearing is distorted with the firm's utility when raising funds in capital markets, banks can still implement higher welfare if:

$$\alpha\left[k - z - \frac{\gamma}{1-\lambda}\right] < \alpha(1-\lambda)(k-z),$$

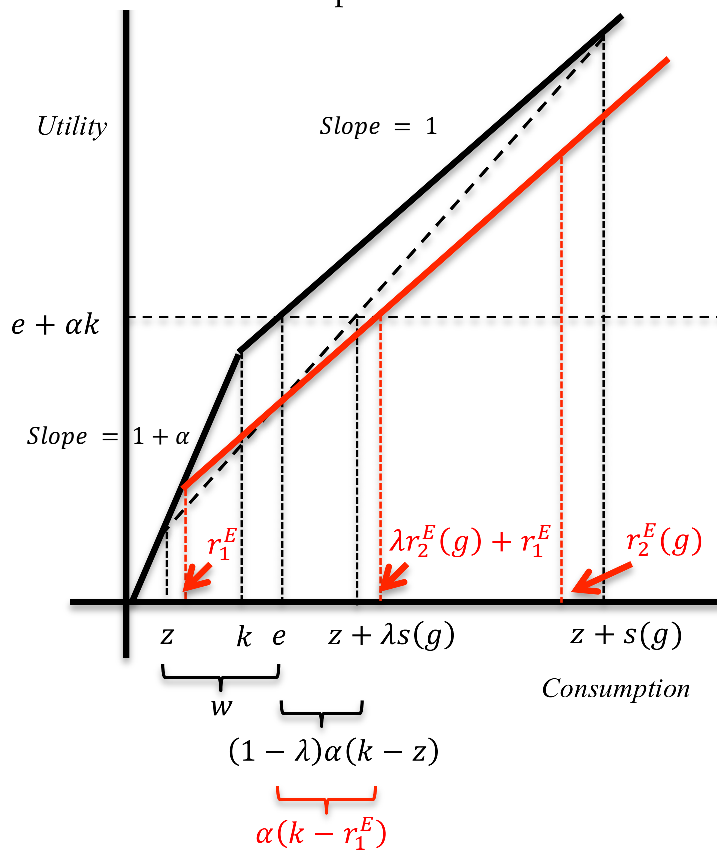
or

$$\lambda(k - z) < \frac{\gamma}{1-\lambda}.$$

Q.E.D.

In Figure 4 we show intuitively why, in case the condition in Proposition 4 is not fulfilled, it is preferable to finance the project through capital markets rather than distortionary intermediaries. In the figure we depict a case in which capital markets dominate distorting financial intermediaries. When intermediaries distort risk-bearing in the economy effectively the utility function changes. The reason is that the bank pays $r_1^E = z + \frac{\gamma}{1-\lambda} < k$ with certainty in the first period (delivering marginal utility $1+\alpha$) and then provides a lottery that pays in the second period (delivering a marginal utility of just 1). The utility function then becomes as depicted in red, with a kink located at r_1^E.

Figure 4: Case in which Capital Markets Dominate Banks



In both cases the welfare loss is given by $\lambda s(g) - w$. In capital markets, $s(g) = \frac{w}{\lambda} + \frac{\alpha(1-\lambda)}{\lambda}(k-z)$ and the loss is given by $\alpha(1-\lambda)(k-z)$. With distorting financial intermediaries $s(g) = \frac{w}{\lambda} + \frac{\alpha}{\lambda}\left[k - z - \frac{\gamma}{1-\lambda}\right]$ and the loss is given by $\alpha(k - r_1^E)$. When the condition in Proposition 4 is not fulfilled, the loss from capital markets is smaller than the loss from distortionary intermediaries, and then firms can raise funds at a lower rate in capital markets.

3.2 Distorting Investment

Assume now that the project is divisible and it is possible for the bank to invest in just a fraction η of the original project and to store the rest of the deposits (for example in

Treasury bonds or other safe assets).[2] An alternative view is that a bank finances the project only with probability η, which can be interpreted as credit rationing. In this case banks can distort investment in order to discourage information acquisition.

Proposition 5 *If $k - z > \frac{\gamma}{1-\lambda}$ banks can still improve welfare relative to capital markets if*

$$\psi(k - z) \leq \frac{\gamma}{1-\lambda},$$

where $\psi \equiv \left(1 - \frac{\alpha w(1-\lambda)}{\lambda\mu - w}\right)$, which is implemented by providing funds for only a fraction η of the original project.

Proof How can the bank distort investment in the project to avoid information acquisition? Since expected benefits for late consumers from acquiring information are given by $(1-\lambda)[e_L - r_2^L(b)]$, and their costs are γ. A way for banks to discourage information acquisition is to promise late consumers no less than equation (7).

A way for banks to discourage information acquisition is to publicly store a fraction $(1-\eta)$ of the endowment e of the early consumer, and promising to repay them deposits k. Another interpretation is that the bank invests in the project with probability η, even when it is ex-ante efficient to always invest in the project.

This implies that, in expectation, if the bank promises to pay k to the early consumer, what remains for the late consumer in case of a bad shock is $r_2^L(b) = \eta(e_L + z - k) + (1-\eta)(e_L + z - k + w) = e_L + z - k + (1-\eta)w$ (with probability η we have the same situation as above, and with probability $(1-\eta)$ the bank stores the endowment of early consumers without spending w on the project and then it does not need as much money from late consumers to compensate early consumers).

In this case, the condition for late consumers not acquiring information is

$$(1-\lambda)[e_L - e_L - z + k - (1-\eta)w] < \gamma,$$

and then, the investment distortion that allows for optimal risk-bearing (always paying $r_1^E = k$ to early consumers), assuming $k - z > \frac{\gamma}{1-\lambda}$ is given by

$$\eta = 1 - \frac{k-z}{w} + \frac{\gamma}{w(1-\lambda)} < 1.$$

[2]This analysis is isomorphic to imposing capital requirements under which banks are regulatory mandated to invest a fraction of deposits in safe assets.

Since the rest of the original first-best contract remains unchanged, by construction, the utilities of the bank and the two consumers are the same as in the previous cases, while for the firm

$$E(U_F^{Dist}) = \eta E(U_F^{FB}).$$

This implies that the loss from distorting investment is

$$(1-\eta)(\lambda\mu - w) = \left(\frac{k-z}{w} - \frac{\gamma}{w(1-\lambda)}\right)(\lambda\mu - w).$$

Banks that distort investment dominate capital markets if

$$\left(k - z - \frac{\gamma}{1-\lambda}\right)\frac{\lambda\mu - w}{w} < \alpha(1-\lambda)(k-z).$$

Then

$$\left(1 - \frac{\alpha w(1-\lambda)}{\lambda\mu - w}\right)(k-z) < \frac{\gamma}{1-\lambda},$$

Q.E.D.

Finally, we obtain the conditions under which it is better to distort risk-bearing than to distort investment, just from comparing λ and ψ from Propositions 4 and 5.

Proposition 6 *Banks prefer to distort risk-bearing rather than investment if*

$$\lambda\mu > (1+\alpha)w.$$

Proof The costs of distorting risk-bearing are smaller than the costs of distorting investments if

$$\alpha\left[k - z - \frac{\gamma}{1-\lambda}\right] < \frac{\lambda\mu - w}{w}\left[k - z - \frac{\gamma}{1-\lambda}\right].$$

Q.E.D.

Intuitively, banks would distort risk-bearing rather than investment when the welfare costs of risk-bearing (captured by $(1+\alpha)w$) are lower than the welfare costs of not financing the projects (captured by the net gains per unit of investment μ times the probability of success λ). Then, it is clear that banks are more likely to distort risk-bearing when liquidity needs are small (low α), when the relative cost of the projects is small (low w), or when projects are very likely to succeed and pay a lot in case of success (high λ and high μ).

4 Optimal Portfolio

In this section we assume there are many, potentially heterogenous, projects that need financing in the economy. First, we study the case in which each project seeks financing from a single bank. In essence there are many matches of one firm and one bank, which replicates the previous analysis for a continuum of heterogenous projects. We characterize which projects are financed by banks that replicate first best, which ones are financed by banks that have to distort risk-bearing or investment (not implementing the first best because they need to avoid information acquisition) and which ones are financed by capital markets.

After this discussion about the coexistence of banks and capital markets we study the problem of a single bank that has to choose between two projects to finance and we analyze the portfolio that minimizes the probability of information acquisition and preserves secrets. In particular, we show that banks prefer to finance two projects that are not very correlated with each other and that banks can cross subsidize across different projects to avoid information acquisition and distortions.

4.1 Continuum of Heterogenous Projects

We replicate the previous analysis performed for a single early consumer, a single late consumer, a single bank and a single project in an economy with a continuum of early consumers, a continuum of late consumers, a continuum of banks and a continuum of projects i characterized by pairs (λ_i, γ_i), their probability of success and monitoring costs.

Assume a mass 1 of each agent and assume that each bank forms a match with a single early and a single late consumer and finances a single project. The cost of financing each project is w; each early consumer has endowment e at $t = 0$, and each late consumer has endowment e_L at $t = 1$. Preferences, technologies and the problem for each single individual are exactly the same as specified in the case for a single project.

If the projects are i.i.d., then effectively financing each project has exactly the same characterization as the previous analysis. Hence, we divide projects along their two dimensional characterization among those that are financed by banks implementing first best allocations, those that are financed by banks that distort risk-bearing or investment and, finally, those that are financed by capital markets.

Proposition 7 *Coexistence of Banks and Capital Markets*

Projects are not financed if $\lambda_i < \frac{w}{\mu}$ *(which implies* $U_F^{FB} < 0$*).*

Projects are financed by banks without distortions if

$$\frac{\gamma_i}{(1-\lambda_i)(k-z)} > 1,$$

they are financed by banks that distort risk-bearing if

$$\lambda_i \leq \frac{\gamma_i}{(1-\lambda_i)(k-z)} < 1 \qquad \textit{and} \qquad \lambda_i\mu \geq (1+\alpha)w$$

and they are financed by banks that distort investment if

$$\psi_i \leq \frac{\gamma_i}{(1-\lambda_i)(k-z)} < 1 \qquad \textit{and} \qquad w \leq \lambda_i\mu < (1+\alpha)w.$$

Finally, projects are financed in capital markets if

$$\frac{\gamma_i}{(1-\lambda_i)(k-z)} < \lambda_i \qquad \textit{and} \qquad \lambda_i\mu \geq (1+\alpha)w$$

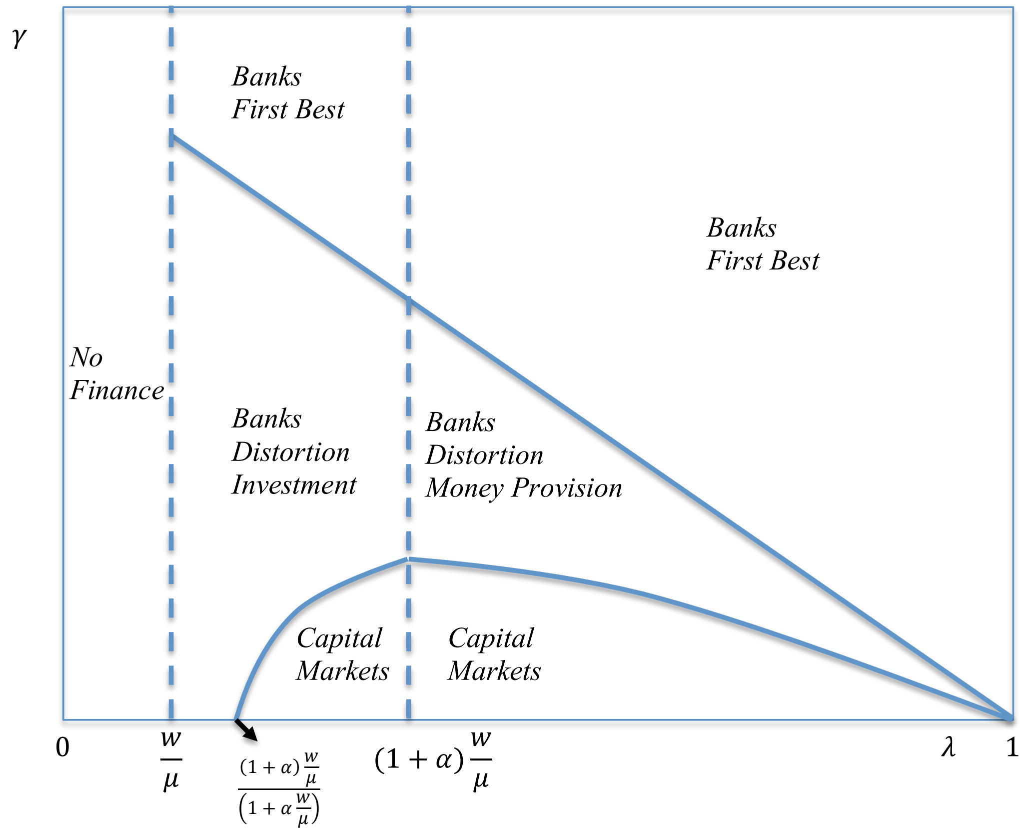
or

$$\frac{\gamma_i}{(1-\lambda_i)(k-z)} < \psi_i \qquad \textit{and} \qquad w \leq \lambda_i\mu < (1+\alpha)w.$$

These regions arise trivially from combining Propositions 4-6 for a single project. The Proposition is displayed in Figure 5.

It is important to highlight at this point that the assumption of i.i.d. projects is critical to sort projects as described. As an illustration, take the extreme opposite case of perfect correlation across projects (if one succeeds, all succeed). In this case, it is easy to see that if a late consumer observes that a firm financing the original project in capital markets does not try to finance an extension also in capital markets, then no late consumer would be willing to deposit in the bank because they can infer that all other projects in the economy have failed. In this extreme case, then, correlation destroys the possibility of using banks to improve welfare.

Figure 5: Regions of Financing



4.2 A Single Bank Finances Two Projects

In this section we assume that a single bank finances two identical projects using the funds from two identical early consumers and two identical late consumers. This is enough to capture how the bank can exploit many projects to avoid information acquisition. We assume each late consumer can choose to privately learn about the quality of one, and only one, project at a cost γ. As will become clear later, introducing more projects just complicates the analysis without adding any new insight to the main conclusions derived with just two projects.

4.2.1 Two Identical Projects

Here we show it is easier for a bank to finance two projects and avoid information acquisition than to finance a single project and avoid information acquisition. First, we assume that the results of the two projects are independent from each other.

Proposition 8 *It is easier for banks to avoid information acquisition if financing two identical projects rather than a single one. Banks can implement the first best outcome if*

$$k - z \leq \frac{\gamma}{1-\lambda} + \frac{w}{2}.$$

Banks can implement first best outcomes even if $\gamma = 0$ *when* $e > k + \frac{w}{2}$.

Proof If the bank finances two projects, there are three possible states:

- With probability λ^2 both projects are successful (gg), and the bank's assets at $t = 2$ are $2[A_b + s(g)]$.
- With probability $2\lambda(1-\lambda)$ only one project is successful (gb or bg), and the bank's assets at $t = 2$ are $2A_b + s(g)$.
- With probability $(1-\lambda)^2$ neither project is successful (bb), and the bank's assets at $t = 2$ are $2A_b$.

In this proof we study the conditions for the bank to implement the first best, hence we require banks to pay each early consumer $r_1^E = k$ at $t = 1$ and to charge firms $s(g) = \frac{w}{\lambda}$, which we know maximizes the utility of firms and both consumers. The question is then, what is the condition for this contract to be feasible and implementable (no incentives for information acquisition).

Since late consumers can only produce information about one project (the condition for information acquisition if the late consumer can produce information about both projects is the same as in the previous analysis of financing a single project), the condition for no information acquisition becomes

$$\lambda \left(\max\{E(r^L|g), e_L\} - E(r^L|g)\right) + (1-\lambda) \left(\max\{E(r^L|b), e_L\} - E(r^L|b)\right) \leq \gamma,$$

where

$$E(r^L|g) = \lambda r_2^L(gg) + (1-\lambda) r_2^L(gb)$$

are the expected payoffs of a late consumer who finds out that the project for which information has been acquired is successful, and

$$E(r^L|b) = \lambda r_2^L(bg) + (1-\lambda) r_2^L(bb)$$

are the expected payoffs of a late consumer who finds out that the project for which information has been acquired is a failure.

As before, banks want to compensate late consumers as much as possible when all projects fail. Then $r_2^E(bb) = 0$ and $r_2^L(bb) = A_b$. Assume this is also the case when one project fails, that is $r_2^E(gb) = r_2^E(bg) = 0$. Then, from the resource constraint when one project fails, $r_2^L(gb) = r_2^L(bg) = A_b + s(g)/2$, since the two late consumers are identical and the proceeds of the single successful project are split in two.

From the break even condition of the early consumer

$$(1+\alpha)k + \lambda^2 r_2^E(gg) = e + \alpha k.$$

Then

$$r_2^E(gg) = \frac{e-k}{\lambda^2}. \tag{12}$$

Using this result in the resource constraint when both projects succeed:

$$r_2^L(gg) = A_b + s(g) - \frac{e-k}{\lambda^2}. \tag{13}$$

Using these results in the break-even condition for the late consumer it is clear that the expected gains from depositing in a bank is exactly e_L:

$$\lambda^2 r_2^L(gg) + 2\lambda(1-\lambda) r_2^L(gb) + (1-\lambda)^2 r_2^L(bb) = e_L.$$

Given the promises that implement first best are feasible, we need to check the incentives for late consumers to acquire information based on those promises. Expected gains for late consumers from depositing when observing a project failing are

$$E(r^L|b) = e_L + e - k - \frac{w}{2},$$

while the expected gains for late consumers from depositing when observing a project succeeding are

$$E(r^L|g) = e_L - \frac{(1-\lambda)}{\lambda}\left[e - k - \frac{w}{2}\right].$$

If $e < k + \frac{w}{2}$, then $E(r^L|b) < e_L$ and $E(r^L|g) > e_L$. This implies that late consumers would deposit in banks when privately observing a project succeeding and store the money if privately observing a project failing. The condition for late consumers not acquiring information is,

$$(1-\lambda)[e_L - E(r^L|b)] \leq \gamma$$

or

$$k - z \leq \frac{\gamma}{1-\lambda} + \frac{w}{2}.$$

If this condition is satisfied, then first best allocations are implementable.

In contrast, if $e > k + \frac{w}{2}$, $E(r^L|b) > e_L$ and $E(r^L|g) < e_L$, then late consumers would deposit in banks when privately observing a project failing and store the money if privately observing a project succeeding. However, there are enough resources for banks to offer a contract to late consumers such that $E(r^L|g) = E(r^L|b) = e_L$, eliminating the incentives to acquire information regardless of information costs. The intuitive way for banks to achieve this result is to still pay $r_2^E(bb) = 0$ but $r_2^E(bg) = r_2^E(gb) > 0$, which reduces expected payoffs to late consumers when a project fails and increases their expected payoffs when a project succeeds.

Following this reasoning, we derive the promises that eliminate the incentives for information acquisition when $e < k + \frac{w}{2}$. Since $r_2^L(bb) = A_b$ and we want to achieve $E(r^L|b) = e_L$, then

$$r_2^L(bg) = r_2^L(gb) = \frac{e_L - (1-\lambda)A_b}{\lambda}. \tag{14}$$

From the resource constraint in the case where only one project succeeds

$$r_2^E(bg) = r_2^E(gb) = \frac{e-k}{\lambda} - \frac{w}{2\lambda} > 0. \tag{15}$$

From early consumers breaking even

$$(1+\alpha)k + 2\lambda(1-\lambda)r_2^E(bg) + \lambda^2 r_2^E(gg) = e + \alpha k,$$

we obtain

$$r_2^E(gg) = \frac{e-k}{\lambda^2} - \frac{2(1-\lambda)}{\lambda^2}\left(e - k - \frac{w}{2}\right). \tag{16}$$

Finally, from the resource constraint when both projects succeed

$$r_2^L(gg) = A_b + \frac{w}{\lambda} - \frac{e-k}{\lambda^2} + \frac{2(1-\lambda)}{\lambda^2}\left(e - k - \frac{w}{2}\right). \tag{17}$$

Finally, substituting these results into the break even condition for each late consumer, the expected gains from depositing in the banks are exactly e_L.

These are the feasible payoffs that implement first best without introducing incentives to acquire information when $e > k + \frac{w}{2}$, for any $\gamma \geq 0$. Q.E.D.

In the Appendix we show that, if there is correlation across the two projects, it is more difficult for banks to use diversification as a way to discourage information acquisition. This suggests the optimal portfolio of banks should be composed by projects that are uncorrelated.

4.2.2 Two Different Projects

Now assume the two projects differ in their probability of success and their costs of monitoring (λ_1, γ_1) and (λ_2, γ_2), but their results are independent of each other. We show that banks can cross-subsidize across projects to discourage information acquisition and implement the first best allocation. In essence, even when there may be incentives to acquire information about a single project, banks can avoid distorting risk-bearing or investment to prevent information acquisition by cross-subsidizing across projects.

Proposition 9 *In the presence of two different projects, banks can discourage information acquisition and implement first best by cross subsidization rather than by distortions, charging relatively more for funds to projects for which there are relatively less incentives to acquire information.*

Proof If the bank finances two different projects, there are four possible states:

- With probability $\lambda_1\lambda_2$ both projects are successful (gg), and the bank's assets at $t = 2$ are $2A_b + s_1(g) + s_2(g)$.
- With probability $\lambda_1(1-\lambda_2)$ only the first project is successful (gb), and the bank's assets at $t = 2$ are $2A_b + s_1(g)$.
- With probability $(1 - \lambda_1)\lambda_2$ only the second project is successful (bg), and the bank's assets at $t = 2$ are $2A_b + s_2(g)$.

- With probability $(1-\lambda_1)(1-\lambda_2)$ no project is successful (bb), and the bank's assets at $t=2$ are $2A_b$.

Again, in this proof we study the conditions for the bank to implement the first best. The condition for no information acquisition on firm 1 is:

$$\lambda_1 \left(\max\{E(r^L|g_1), e_L\} - E(r^L|g_1)\right) + (1-\lambda_1)\left(\max\{E(r^L|b_1), e_L\} - E(r^L|b_1)\right) \leq \gamma_1$$

where

$$E(r^L|g_1) = \lambda_2 r_2^L(gg) + (1-\lambda_2) r_2^L(gb)$$

and

$$E(r^L|b_1) = \lambda_2 r_2^L(bg) + (1-\lambda_2) r_2^L(bb),$$

where g_1 refers to having produced information about firm 1 and discovered that firm 1's project is successful, while b_1 refers to having produced information about firm 1 and discovered firm 1's project is a failure.

Similarly, the condition for no information acquisition of firm 2 is:

$$\lambda_2 \left(\max\{E(r^L|g_2), e_L\} - E(r^L|g_2)\right) + (1-\lambda_2)\left(\max\{E(r^L|b_2), e_L\} - E(r^L|b_2)\right) \leq \gamma_2,$$

where

$$E(r^L|g_2) = \lambda_1 r_2^L(gg) + (1-\lambda_1) r_2^L(bg)$$

and

$$E(r^L|b_2) = \lambda_1 r_2^L(gb) + (1-\lambda_1) r_2^L(bb).$$

Banks want to compensate late consumers as much as possible when all projects fail. Then $r_2^E(bb) = 0$ and $r_2^L(bb) = A_b$. Assume this is also the case when only one project fails, this is $r_2^E(gb) = r^E(bg) = 0$. Then, from the resource constraint in those situations, $r_2^L(gb) = A_b + s_1(g)/2$ and $r_2^L(bg) = A_b + s_2(g)/2$, since the two late consumers are identical and the proceeds of the single successful project are split in two.

From the break-even condition of early consumers

$$(1+\alpha)k + \lambda_1\lambda_2 r_2^E(gg) = e + \alpha k.$$

Then

$$r_2^E(gg) = \frac{e-k}{\lambda_1\lambda_2}. \tag{18}$$

From the resource constraint when both projects succeed

$$r_2^L(gg) = A_b + \frac{s_1(g)}{2} + \frac{s_2(g)}{2} - \frac{e-k}{\lambda_1\lambda_2}. \tag{19}$$

The expected gains for a late consumer from depositing are:

$$\lambda_1\lambda_2 r_2^L(gg) + \lambda_1(1-\lambda_2)r_2^L(gb) + (1-\lambda_1)\lambda_2 r_2^L(bg) + (1-\lambda_1)(1-\lambda_2 r_2^L(bb),$$

and replacing the promises to the late consumer derived above

$$A_b - (e-k) + \lambda_1\frac{s_1(g)}{2} + \lambda_2\frac{s_2(g)}{2}.$$

These expected gains for a late consumer from depositing are equal to e_L if

$$\lambda_1\frac{s_1(g)}{2} + \lambda_2\frac{s_2(g)}{2} = w. \tag{20}$$

In the first best, $s_1(g) = \frac{w}{\lambda_1}$ and $s_2(g) = \frac{w}{\lambda_2}$, which implies that these promises are feasible. The expected gains for a late consumer after privately observing the result of a project $i \in \{1,2\}$ are:

$$E(r^L|b_i) = e_L + e - k - \frac{w}{2}$$

and

$$E(r^L|g_i) = e_L - \frac{(1-\lambda_{-i})}{\lambda_{-i}}\left[e - k - \frac{w}{2}\right].$$

If $e < k + \frac{w}{2}$, then $E(r^L|b_i) < e_L$ and $E(r^L|g_i) > e_L$. This implies that late consumers, regardless of which project they investigate, would deposit in banks when privately observing the project succeed and store the money if privately observing the project fail. The condition for not acquiring information about any of the projects is,

$$(1-\lambda_i)[e_L - E(r^L|b_i)] \leq \gamma$$

or

$$k - z \leq \frac{\gamma_i}{1-\lambda_i} + \frac{w}{2}.$$

If this condition is fulfilled for both projects, then there are no restrictions to implementing the first best, and no distortion is needed.

Without loss of generality, assume now that this condition is not fulfilled for firm 1, i.e., $k - z > \frac{\gamma_1}{1-\lambda} + \frac{w}{2}$. This implies that, in order to avoid information acquisition, it is necessary that $E(r^L|b_1) = e_L + e - k - \lambda_2 \frac{s_2(g)}{2}$, or

$$s_2(g) > \frac{w}{\lambda_2},$$

which implies

$$s_1(g) < \frac{w}{\lambda_1}$$

from equation (20).

More precisely, $s_2(g)$ should be set at a high enough level to avoid information acquisition about firm 1. From the condition for no information acquisition, this implies setting $s_2(g)$ such that

$$(1 - \lambda_1)[e_L - (e_L - k + z + \lambda_2 \frac{s_2(g)}{2})] = \gamma_1$$

or

$$s_2(g) = \frac{2}{\lambda_2} \left[k - z - \frac{\gamma_1}{1 - \lambda_1} \right] > \frac{w}{\lambda_2}$$

and from equation (20),

$$s_1(g) = \frac{2}{\lambda_1} \left[e - k + \frac{\gamma_1}{1 - \lambda_1} \right] < \frac{w}{\lambda_1}.$$

This cross-subsidization to avoid information acquisition is feasible as long as

$$s_2(g) \leq \frac{w + \alpha(1 - \lambda_2)(k - z)}{\lambda_2},$$

otherwise firm 2 would rather raise funds in capital markets than paying a larger rate for funds in banks. This condition can be rewritten as

$$(k - z) \left[1 - \frac{\alpha(1 - \lambda_2)}{2} \right] \leq \frac{\gamma_1}{1 - \lambda_1} + \frac{w}{2}.$$

This implies cross-subsidization is preferred and feasible as long as

$$\left[\frac{\gamma_1}{1-\lambda_1}+\frac{w}{2}\right] < k - z \leq \frac{2\left[\frac{\gamma_1}{1-\lambda_1}+\frac{w}{2}\right]}{1-\alpha(1-\lambda_2)}.$$

Q.E.D.

4.3 Bank Capital

Assume now that agent B, who serves as a banker, receives a deterministic endowment e_B at $t = 2$ and it is able to issue a claim against those cash flows, committing to use them as "bank capital". Access to this endowment is important in reducing incentives for late consumers to acquire information during the intermediate period.

Proposition 10 *It is easier for banks to avoid information acquisition if they have an endowment e_B at $t = 2$ that can be used as "bank capital". Banks can implement the first best outcome if*

$$k - z \leq \frac{\gamma}{1-\lambda} + e_B.$$

Banks can implement first best outcomes even if $\gamma = 0$ when $e > k + w - e_B$.

Proof Assume the bank has access to endowment e_B at $t = 2$, and it is able to commit to use it as capital by issuing claims. We study the conditions for the bank to implement the first best allocation, paying the early consumer $r_1^E = k$ at $t = 1$ and charging the firm $s(g) = \frac{w}{\lambda}$ for the original project, while still breaking-even and generating in expectation $E(U_B) = e_B$. Under what conditions is this contract feasible and implementable (no incentives for information acquisition).

Assume a project that induces late consumers to acquire information, i.e.,

$$k - z > \frac{\gamma}{1-\lambda}.$$

To avoid information acquisition, from equation (6), the bank has to promise late consumers

$$r_2^L(b) = e_L - \frac{\gamma}{1-\lambda} > e_L - k + z$$

in case the project fails.

To cover the difference between the maximum the bank can promise to the late consumer only using firm's funds and paying k to early consumers and the amount that prevents information acquisition, the bank should contribute, as bank capital

$$e_B^k = \min\left\{k - z - \frac{\gamma}{1-\lambda}, e_B\right\}.$$

If

$$k - z - \frac{\gamma}{1-\lambda} < e_B,$$

which is the condition in the proposition, the bank has enough resources to implement the first best allocation. Assume this is the case. Are the promises feasible to make the bank willing to post its own endowment as capital?

When paying late consumers $r_2^L(b)$ as above to avoid information acquisition, they are indifferent between depositing in the bank or not if:

$$\lambda r_2^L(g) + (1-\lambda)\left[e_L - \frac{\gamma}{1-\lambda}\right] = e_L,$$

which implies

$$r_2^L(g) = e_L + \frac{\gamma}{\lambda}.$$

In the first best allocation, $r_1^E = k$ and $r_2^E(g) = \frac{e-k}{\lambda}$. Then, from resource constraints in the case the project is successful,

$$e_L + z + \frac{w}{\lambda} + e_B^k = k + \frac{e-k}{\lambda} + e_L + \frac{\gamma}{\lambda} + r_2^B(g),$$

which implies

$$r_2^B(g) = \frac{e_B^k}{\lambda}.$$

It is clear that there are enough resources to make the banker indifferent between not setting up a bank or setting up a bank and committing capital e_B^k, obtaining $r_2^B(b) = 0$ if the project is a failure and $r_2^B(g)$ if the project is a success.

Bank capital can implement the first best allocation if $e_B^k \leq e_B$. If $e_B^k > e_B$, the first best cannot be implemented, but welfare can still be improved through the distortions analyzed above. Q.E.D.

In essence, if the banker can ex-ante commit some of its own endowment in the last period to compensate late consumers in case the project fails, then he can avoid information acquisition and still implement the first best. Even though we assumed all the surplus goes to the firm, it is natural to think that part of the surplus goes to the bank, having positive incentives to participate in this contract.

It is important to highlight the role of commitment in this situation. Posting its own endowment as capital, introduces less incentives for bankers to reveal that the project is succesful since the promise to late consumers is lower than in the absence of bank capital. In the extreme, when the promise to late consumers is the same whether the project succeeds or fails, there are no incentives for bankers to reveal the truth.

5 Conclusions

Banks are optimally opaque. Banks produce private money that is used as a transaction medium. An efficient transactions medium requires that the money be information-insensitive. But, the production of information is important for investment efficiency. To prevent an information externality from the production of information about investment opportunities, banks act as secret keepers. They are opaque in that the information about the investments is not revealed. Banks choose portfolios of assets to minimize information leakage.

The synergies or complementarities between loans, to small firms and households, and demand deposits (or other forms of bank debt) are not due to the need for monitoring banks, ensuring that the banks screen and monitor borrowers. Our argument is that the output of banks is debt used for trading and that this debt is efficient if it is backed by assets that minimize information leakage. The optimal assets are precisely loans to small firms and households, but that is because these minimize the information leakage.

These results clearly have policy implications. Banks want to create opacity in order for bank money to function effectively. We argue that there is a reason for this opacity. Policies designed to enhance bank transparency reduce the ability of banks to produce (uninsured) bank money.

References

Boyd, John, and Edward Prescott. 1986. "Financial Intermediary-coalitions." *Journal of Economic Theory* 38:211–232.

Dang, Tri Vi, Gary Gorton, and Bengt Holmström. 2013. "Ignorance, Debt and Financial Crises." Working Paper , Yale University.

Diamond, Douglas. 1984. "Financial Intermediation and Delegated Monitoring." *Review of Economic Studies* 51:393–414.

Diamond, Douglas W., and Philip H. Dybvig. 1983. "Bank Runs, Deposit Insurance, and Liquidity." *Journal of Political Economy* 91 (3): 401–19.

Diamond, Douglas W., and Raghuram G. Rajan. 2001. "Liquidity Risk, Liquidity Creation, and Financial Fragility: A Theory of Banking." *Journal of Political Economy* 109 (2): 287–327.

Flannery, Mark. 1999. "Using Market Information in Prudential Bank Supervision: A Review of the U.S. Empirical Evidence." *Journal of Money, Credit, and Banking* 33:273–305.

Flannery, Mark, Simon Kwan, and Mahendrarajah Nimalendran. 2010. "The 2007-2009 Financial Crisis and Bank Opaqueness." Working Paper, Federal Reserve Bank of San Francisco.

Gorton, Gary, and George Pennacchi. 1990. "Financial Intermediaries and Liquidity Creation." *Journal of Finance* 45 (1): 49–72.

Gorton, Gary, and Andrew Winton. 2003. Chapter 8 of *Handbook of the Economics of Finance*, 431–552.

Haggard, Stephen, and John Howe. 2007. "Are Banks Opaque?" Working Paper, University of Missouri.

Haubrich, Joseph, and Robert King. 1990. "Banking and Insurance." *Journal of Monetary Economics* 25:361–386.

Hirtle, Beverly. 2006. "Stock Market Reaction to Financial Statement Certification by Bank Holding Company CEOs." *Journal of Money, Credit and Banking* 38:1263–1291.

Iannota, Giulano. 2006. "Testing for Opaqueness in the European Banking Industry: Evidence from Bond Credit Ratings." *Journal of Financial Services Research* 30:287–309.

Jacklin, Charles. 1987. Pages 26–47 in *Demand Deposits, Trading Restrictions, and Risk Sharing*, edited by Edward Prescott and Neil Wallace. University of Minnesota Press.

Jones, Jeffrey, Wayne Lee, and Timothy Yeager. 2012. "Opaque banks, Price Discovery, and Financial Stability." *Journal of Financial Intermediation* 21:383–408.

Kashyap, Anil, Raghuram Rajan, and Jeremy Stein. 2002. "Banks as Liquidity Providers: An Explnation for the Coexistence of Lending and Deposit-Taking." *Journal of Finance* 57:33–73.

Morgan, Donald. 2002. "Rating Banks: Risk and Uncertainty in an Opaque Industry." *American Economic Review* 92:874–888.

A Appendix

A.1 A Diversified Portfolio Helps Hiding Information.

Here we show that, if there is correlation across two identical projects, it is more difficult for banks to use diversification as a way to discourage information acquisition. We assume that, with a probability ρ there is a good aggregate shock where both projects always succeed and with a probability $1-\rho$ the results of the projects are independent of each other, with a probability of success χ. We redefine the ex-ante probability of success for each project as $\lambda = \rho + (1-\rho)\chi$ to facilitate the comparison with previous propositions.

Proposition 11 *It is more difficult for banks to avoid information acquisition if financing two identical projects that are correlated. Banks can implement the first best outcome if*

$$k - z \leq \frac{\gamma}{1-\lambda} + \frac{\chi}{\lambda}\frac{w}{2}$$

where $\frac{\chi}{\lambda} \leq 1$. *Banks can implement first best outcomes even if* $\gamma = 0$, *when* $e > k + \frac{w}{2}\left[2 - \frac{\chi}{\lambda}\right]$.

As $\rho \to 0$, $\frac{\chi}{\lambda} \to 1$, *converging to the condition in Proposition 8 for two i.i.d. projects.*

As $\chi \to 0$, $\frac{\chi}{\lambda} \to 0$, *converging to the conditions in Proposition 3 for a single project.*

Proof If the bank finances two correlated projects, there are three possible states:

- With probability $\rho + (1-\rho)\chi^2$ both projects are successful (gg), and the bank's assets at $t = 2$ are $2[A_b + s(g)]$.
- With probability $2(1-\rho)\chi(1-\chi)$ only one project is successful (gb or bg), and the bank's assets at $t = 2$ are $2A_b + s(g)$.
- With probability $(1-\rho)(1-\chi)^2$ no project is successful (bb), and the bank's assets at $t = 2$ are $2A_b$.

Again, in this proof we study the conditions for the bank to implement the first best. The condition for no information acquisition becomes:

$$\lambda\left(\max\{E(r^L|g),e_L\}-E(r^L|g)\right)+(1-\lambda)\left(\max\{E(r^L|b),e_L\}-E(r^L|b)\right)\leq\gamma,$$

where

$$E(r^L|b)=\chi r_2^L(bg)+(1-\chi)r_2^L(bb),$$

and

$$E(r^L|g)=Pr(gg|g)r_2^L(gg)+(1-Pr(gg|g))r_2^L(gb),$$

where $Pr(gg|g)=\frac{\rho+(1-\rho)\chi^2}{\lambda}$.

When both projects fail, $r_2^E(bb)=0$ and $r_2^L(bb)=A_b$. Assume that, if only one project fails, $r_2^E(gb)=r_2^E(bg)=0$. From the resource constraint when only one project fails,

$$r_2^L(gb)=r_2^L(bg)=A_b+\frac{s(g)}{2}. \tag{21}$$

From the break even condition of the early consumer

$$r_2^E(gg)=\frac{e-k}{\rho+(1-\rho)\chi^2}. \tag{22}$$

From the resource constraint when both projects succeed

$$r_2^L(gg)=A_b+s(g)-\frac{e-k}{\rho+(1-\rho)\chi^2}. \tag{23}$$

Substituting these results into the break-even condition for the late consumer, the expected gains from depositing in the banks are exactly e_L. This implies that these promises are feasible and late consumers' expected gains from depositing are

$$E(r^L|b)=e_L+e-k-w-\chi\frac{w}{2\lambda}.$$

If $e<k+\frac{w}{2}\left[2-\frac{\chi}{\lambda}\right]$, then $E(r^L|b)<e_L$ and $E(r^L|g)>e_L$. This implies that late consumers would deposit in banks when privately observing the project succeed and store the money if privately observing that the project failed. The condition for no information acquisition is,

$$(1-\lambda)[e_L-E(r^L|b)]\leq\gamma$$

or

$$k-z\leq\frac{\gamma}{1-\lambda}+\frac{\chi}{\lambda}\frac{w}{2}.$$

As $\rho \to 0$, $\frac{\chi}{\lambda} \to 1$, converging to the condition in Proposition 8 for two i.i.d. projects. As $\chi \to 0$, $\frac{\chi}{\lambda} \to 0$, converging to the conditions in Proposition 3 for a single project.

If $e > k + \frac{w}{2}\left[2 - \frac{\chi}{\lambda}\right]$, then $E(r^L|b) > e_L$ and $E(r^L|g) < e_L$. In this case, there are enough resources to make promises such that $E(r^L|g) = E(r^L|b) = e_L$, eliminating incentives to acquire information for all $\gamma \geq 0$. The intuitive way for banks to achieve this result is to promise $r_2^E(bb) = 0$ but $r_2^E(gb) = r_2^E(bg) > 0$, which reduces expected payoffs for late consumers in case they observe a project fail.

Since $r_2^L(bb) = A_b$ and banks want to achieve $E(r^L|b) = e_L$,

$$r_2^L(bg) = \frac{e_L - (1-\chi)A_b}{\chi}.$$

From the resource constraint in the case only one project succeeds,

$$r_2^E(bg) = \frac{e-k}{\chi} - \frac{w}{2\chi}\left[2 - \frac{\chi}{\lambda}\right] > 0.$$

From early consumers breaking-even

$$(1+\alpha)k + 2(1-\rho)\chi(1-\chi)r_2^E(gb) + [\rho + (1-\rho)\chi^2]r_2^E(gg) = e + \alpha k$$

we obtain

$$r_2^E(gg) = \frac{e-k}{\rho+(1-\rho)\chi^2} - \frac{2(1-\rho)(1-\chi)}{\rho+(1-\rho)\chi^2}\left(e - k - \frac{w}{2}\left[2 - \frac{\chi}{\lambda}\right]\right).$$

Finally, from the resource constraint when both projects succeed we obtain

$$r_2^L(gg) = A_b + \frac{w}{\lambda} - \frac{e-k}{\rho+(1-\rho)\chi^2} + \frac{2(1-\rho)(1-\chi)}{\rho+(1-\rho)\chi^2}\left(e - k - \frac{w}{2}\left[2 - \frac{\chi}{\lambda}\right]\right).$$

Finally, substituting these results into the break-even condition for the late consumer, expected gains from depositing in the banks are exactly e_L.

These are the feasible payoffs that implement first best without introducing incentives to acquire information when $e > k + \frac{w}{2}\left[2 - \frac{\chi}{\lambda}\right]$, for all $\gamma \geq 0$. Q.E.D.