Banks as Secret Keepers *

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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 – loans – not be revealed, so that bank money does not fluctuate in value, reducing the efficiency of trade. This need for opacity conflicts with the production of information about investment projects, needed for allocative efficiency. Intermediaries exist to hide such information, which requires banks to select portfolios of information-insensitive assets. For the economy as a whole, firms endogenously separate into bank finance and capital market/stock market finance depending on the cost of producing information about their projects.

1 Introduction

The output of banks is short-term debt used for transactions and storing value. In this paper we show that for this debt to be efficient banks need to be opaque. They are opaque because the assets they select, such as loans to consumers and small businesses, are hard to value; and the information banks produce about borrowers is not revealed. Because of this opacity banks are regulated and examined. Secrecy surrounds banking. Bank regulators' examinations are kept confidential and discount window borrowing from the central bank is (supposed to be) secret. Bank opacity can lead to bank runs, which occur when depositors question the value of the banks assets. Deposit insurance is intended to mitigate this. We argue that opacity is inherent in banking. Opacity can also explain the type of loans that banks hold and how borrowers self-select between banks and capital markets.

A defining characteristic of privately-produced, money-like securities is that agents accept them at par when transacting, because the agents expect to be able to redeem them at par. The value of the money is not in doubt when transacting and the value does not vary 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, while investment efficiency requires that information be produced to select and monitor these investments?

Our answer to this conundrum is that financial intermediaries produce private money because they can keep the information that they produce about the backing assets secret. In our model the raison d'etre of banking is secret-keeping for the production of private money. Without banks, information about investments would come out and reduce the efficiency of private money. So, banks are optimally opaque. Furthermore, to create information-insensitive debt for trading, the bank will also invest in information-insensitive assets. There is an information complementarity between the production of private money and assets that minimize information leakage.

We study a model where a firm has two sequential investment opportunities but no funds. Two overlapping generations of consumers ("early" and "late" consumers) live for a total of three periods and have deterministic "liquidity" needs at an interim date. The early consumer has a storable endowment that can either cover the investment needs of the firm or its own liquidity needs in the intermediate period, but not both. If the early consumer finances the firm's needs, he must cover his liquidity

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needs by selling the claims on the firm to the late consumer in the intermediate period. The liquidity needs make consumers (effectively) risk averse to changes in the value of the claims they hold. Furthermore, an early consumer does not want the late consumer to produce private information about the assets backing the claim, as in Dang, Gorton, and Holmström (2013).

We assume that information about a project is of value in deciding whether to invest. The problem is that there is a tradeoff between socially valuable information production and its negative externality on liquidity provision. The model thus captures the basic dilemma that information is needed for investment efficiency, but is unwanted for trading efficiency.

We begin by analyzing two polar institutional arrangements for information production and funding: an informationally efficient financial market and a secret keeping bank. In the financial market, the two sequential projects are financed by issuing publicly priced securities (equity) that all agents can observe. A bank finances the project by issuing deposits to the consumers. The bank can find out the same information about the projects as the market, but can hide this information from the consumers.

We show that capital markets are inefficient liquidity providers, because market prices reveal information about the projects. By contrast, banks can implement the first best allocation, because they can prevent information leakage. This comparison is not surprising, but provides a benchmark for our main model in which the late consumer can produce private information about the bank's portfolio at some cost and the bank may have to adjust its financing and investment decisions to prevent this from happening.

In the main model, the bank can avoid private information production by the late consumer in one of two ways (when necessary). It can force the early consumer to bear some risk, or it can invest sub-optimally in the initial project. These distortions make private information acquisition less attractive. But if the (second) project is sufficiently risky or the cost of information production sufficiently low, it will not be worthwhile for the bank (nor socially preferred) to fund the projects. Such projects will be funded by financial markets instead.

The logic above implies that banks will choose to create private money by investing in projects that are less risky and more opaque; opacity makes the cost of information acquisition higher. Note that the implied allocation of projects between banks and

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financial markets does not rely on any comparative advantage that banks have in evaluating and overseeing its assets.

Empirical Evidence: Our prediction regarding the type of assets that banks should invest in match rather well those we observe in reality. Banks have on the asset side of their balance sheet relatively safe debt instruments, such as high-grade corporate bonds and government issued securities, as well as hard-to-evaluate debt instruments, such as mortgages and loans to small businesses.

The recent financial crisis illustrates bank opacity. The money produced by shadow banks, sale and repurchase agreements (repo) and asset-backed commercial paper (ABCP), are short-term stores of value. This money, when not backed by U.S. Treasuries, is backed by asset-backed securities (ABS). ABS's are opaque and have no traded equity making them useful for backing repo and ABCP.

Prior to deposit insurance in the U.S., demand deposits were the dominant form of bank money. There was no information leakage because checks were cleared in clearinghouses and bank stock was very illiquid. Again, banks were opaque (see Gorton (2013)). In the period before the U.S. Civil War the dominant form of money was private bank notes. These circulated at discounts that varied over time and space. These discounts were information revealing and the bank money was inefficient as a medium of exchange (see Gorton (1999)).

Bank opacity has been empirically studied in several different ways. Since the advent of deposit insurance banks are examined by government regulators. These examinations are kept secret, but are still informative. DeYoung et al. (2001) find that government examinations did produce new, value-relevant, information which is eventually revealed in bank subordinated debt prices. Berger and Davies (1998) find that information from unfavorable examinations is eventually revealed in banks' stock prices. Apparently, the examiners uncover secrets.

Other evidence includes Bessler and Nohel (1996), who study dividend cuts and find significantly stronger negative reactions for banks than for nonbanks. 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 nonfinancial 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 (2004) 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. However, Flannery, Kwan, and Nimalendran (2013) find evidence of a significant increase in bank opaqueness during the financial crisis 2007-2009. One interpretation of this shift in bid-ask spreads is that opaque bank assets were not causing significant information asymmetries in stock markets before the crisis, but became information sensitive in the financial crisis, leading to adverse selection fears.[1]

Related Literature: The idea that it may be optimal to keep information secret is not new. It was perhaps first articulated by Hirshleifer (1971), who showed that early release of information can destroy future insurance opportunities. This general idea also underlies Kaplan's (2006) study of a Diamond and Dybvig (1983) type model in which the bank acquires information before depositors do. Kaplan studies when the optimal deposit contract will be non-contingent. Breton (2011) view banks as a solution to information appropriability problems. With diversification banks can garble the information. Our focus is on the issue of preventing information production by outside potential depositors and the possible distortions that this may involve. We also discuss the endogenous separation of firms into those that go to capital markets and those that go to banks.

Dang, Gorton, and Holmström (2013) study the optimal design of securities for trading when public shocks and privately produced information can cause adverse selection problems. Their main result shows that debt is optimal both for bilateral trade and as collateral backing up such trade, because debt is the least information-sensitive contract. Our focus here is not on optimal contracts as such, but rather on optimal institutions. We show that the notion of information-insensitivity has important insti-

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

tutional implications, especially for banking and their unique role in creating private money. Banks are purposefully opaque by being sparse in publishing information and by investing in assets that are information-insensitive. Market funding is more transparent and provides an alternative to banking for projects that are riskier and easier to evaluate; banking and markets co-exist, serving different investment needs.

There is a large accounting literature on disclosure, almost all of it on disclosure in stock markets. One of the most influential papers is by Diamond and Verrecchia (1991) who examine the optimal disclosure policy of a firm. They show that more information revelation reduces the firm's cost of capital, but it can have the opposite effect by reducing liquidity in the stock market.[2] Another context in which limited disclosure may be optimal is discussed in Andolfatto (2010) who shows that transparency can be socially costly in a monetary economy with search frictions.

Finally, our paper offers a new explanation for the existence of financial intermediaries that relies on complementarities between the two sides of a bank's balance sheet. Most explanations look at just one side of the balance sheet. One line focuses on the role of banks in making loans. Banks are viewed as producing information about potential borrowers and/or monitoring borrowers after the loan has been made; see, e.g., Boyd and Prescott (1986).

Another line looks at the liability side of banks. In Diamond and Dybvig (1983) the bank issues demand deposits to insure consumers against liquidity shocks. The asset side is deterministic. We also have insurance in our model, but it comes from agents trading with each other (directly or via the bank) under symmetric information. In Diamond and Dybvig's model trading destroys insurance opportunities, because the insured consumers can cash out after they learn their liquidity shock (privately). (See e.g. Jacklin (1987) and Haubrich and King (1990)). Gorton and Pennacchi (1990) focus on a different mechanism of liquidity production. In their model banks produce riskless debt to shield depositors from having to trade with privately-informed agents.

There are a few papers that, like ours, rely on the complementarity of the two sides of the balance sheet. Diamond (1984) argues that bank liabilities should be debt claims because this can ensure that the bank monitors its borrowers. In Diamond and Rajan (2001) banks monitor borrowers and can do so better than others because the design of their liability side gives them credibility in enforcing repayments more ef-

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[2]See also the more recent contribution of Monnet and Quintin (2013).

fectively. Demand deposits, which can be withdrawn at any moment, create the right incentives for investing in and collecting from loans. In Kashyap, Rajan, and Stein (2002) banks structure their balance sheet to take advantage of the imperfect correlation between deposit withdrawals and loan commitment draw-downs, tying the two banking activities together. In Breton (2007) investors invest in long-term projects which they monitor and therefore have private information about. The private information makes the projects illiquid; if they were sold on the market, they would be subject to adverse selection. Kept on the bank's balance sheet, the information about the projects will not leak out so depositors, now without private information, can be issued claims that are liquid in the market.

Our paper also provides a simultaneous explanation of the structure of a bank's balance sheet, but one that is rather different from those above. It combines Gorton and Pennacchi's (1990) view of banks as issuers of private money with the insight from Dang, Gorton, and Holmström (2013) that debt is optimal collateral, because it is least sensitive to public and private information. To this, it adds the important ingredient that banks are purposefully opaque, because keeping information secret will temper the fluctuation in the value of collateral and the desire to leak secrets to the market.

Our argument says that banks exist to produce money and this dictates the nature of bank assets, not the other way around. In our model there is nothing per se special about the banks' activities on the asset side (though they may be screening and monitoring). However, there is still an important complementarity between bank assets and bank liabilities. In order to produce money, the banks select assets to minimize information leakage, publicly or privately. But, there are also other implications for banks' asset portfolios. For example, we show that banks "diversify," hold safe treasury bonds or maintain bank capital in order to reduce the incentives for information production about their portfolios, and hence maintain their opacity.

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 and discuss the coexistence of banks and capital markets. Section 5 shows an overlapping generations extension that can be applied to a macroeconomic environment. Finally, Section 6 concludes.

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2 Model

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

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:

$$U_F = \sum_{t=0}^{2} C_{Ft} \qquad\qquad \omega_F = (0, 0, 0)$$

$$U_E = \sum_{t=0}^{2} C_{Et} + \alpha \min\{C_{E1}, k\} \qquad\qquad \omega_E = (e, 0, 0)$$

$$U_L = \sum_{t=0}^{2} C_{Lt} + \alpha \min\{C_{L2}, k\} \qquad\qquad \omega_E = (0, e, 0)$$

$$U_B = \sum_{t=0}^{2} C_{Bt} \qquad\qquad \omega_B = (0, 0, 0)$$

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 but, as we will discuss next, it has access to a productive technology; the consumers only differ as to the period they are born – the early consumer is born in period $t = 0$ and the late consumer in $t = 1$. Both consumers have e units of goods as endowment when they are born and nothing at other dates, and they both prefer to consume up to k the period after they are born – in period $t = 1$ for the early consumer and in period $t = 2$ for the late consumer.

The consumers' preferences show that they have some urgency ($\alpha > 1$) to consume as least k at dates 1 and 2, respectively. This can be thought of as a demand for "liquidity" or as a productive investment possibility that costs k and produces $k(1 + \alpha)$. The k's for the early and late consumer could differ, but this is of little consequence because the late consumers' liquidity demand plays no role until Section 6, where an

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overlapping generations model is introduced. Similarly, the endowments for early and late consumers could differ, but this just complicates the algebra. It is clear from the pattern of endowments and preferences that there is a motive for the early and late consumers to trade.

Even though the firm does not have any endowment, it has two investment opportunities. At $t = 0$ the firm can invest, at a cost w, in a *first 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 another investment opportunity, a *second project*, at a cost $\widehat{w}$. Projects are perfectly correlated, an assumption made for simplicity, and discussed later. The second project introduces the possibility of information production at $t = 1$, and it is this information production which creates the potential problem for the early consumer's transaction with the late consumer. Hence it is our focus. Commitment not to reveal information cannot happen in markets, but can happen in banks. That is the definition of a bank.

We assume that the original project has a positive net present value and its operation is ex-ante efficient (i.e., $\lambda x > w$). We also assume that at $t = 1$ the firm observes whether the second project will be a success or a failure at $t = 2$ and can communicate this information to other agents, in particular the bank, at no cost.

We also assume that the endowment of early consumers is 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. *The first project is ex-ante efficient.*
   $\lambda x > w.$

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.*
   $2e > 2k + w + \widehat{w}.$

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Some further assumptions are worth noting. First, endowments are fixed and storable, which implies that banks will not be necessary to move endowments intertemporally so, the early consumer can store 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 way to consume k at $t = 1$ is by trading a fraction of those claims with late consumers that are born at $t = 1$. Late consumers have enough resources to potentially finance a second project and to buy the claims from early consumers to cover their liquidity needs.

The trade between early and late consumers that would implement the first best, however, is potentially hindered by information revelation about the second project at $t = 1$. Information about the type of the second project is important, since it allows the second project to be financed only when it is optimal. The information, however, would have a negative impact on the early consumers' ability to trade its claims on the first project, if the first 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.

Remarks The assumption that α and k are known parameters just simplifies the exposition but is not critical for the results. If these parameters that determine liquidity needs were random, the kinks in the utility function would be random as well. Then pricing would be based on expectations of the risk that early consumers face would not be able to trade with late consumers. If banks reduce this risk of no trading with late consumers, then random liquidity needs do not matter as long as there are some states where trading matters.

We also assume early and late consumers are symmetric in their endowments and liquidity needs (same e, k and α for early and late consumers) and only differ on when they are born. We introduce this extreme assumption for two reasons. First, it highlights that our results do not depend on heterogeneous preferences across depositors. Second it allows us to extend the model to an overlapping generation structure and explore the dynamic implications of potential shocks to the quality of projects in the economy.

Again assuming individuals are heterogeneous in their liquidity needs or endowments do not change the main insights as long as the forces in the model remain, i.e., as long as the combinations of endowments and liquidity needs are such that trade

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across different generations is necessary to cover investments and liquidity needs in the economy. In other words, heterogeneous preferences and endowments do not change the results as long as the main trade-off remains – if there is no trade across generations, a single generation bears all the liquidity risk in the economy.

2.2 Autarky and First Best

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

Clearly it is possible for the economy to do better than autarky. Consider the problem of an unconstrained social planner (who can make transfers across consumers, so he does not have to satisfy participation constraints). At $t = 0$, it is socially efficient for the firm to invest in the project. The planner would then 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 transfer $k - z$ resources from the late consumer to the early consumer. It is also optimal to use $\widehat{w}$ from the late consumer to finance the second project if there is information that it will be successful.

These allocations are feasible because $e > 2k - z + \widehat{w}$, 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 first project or less than $\widehat{w}$ to the second project) or distorting consumption (making consumers consume less than k).

The next question is how to split the surplus. We choose to assign the whole 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 $\mu \equiv x + \widehat{x} - \widehat{w}$ to be the total gains of the firm conditional on the projects succeeding. Then, under this first best allocation the ex-ante expected utilities of the agents are $E(U_B^{FB}) = 0$, $E(U_E^{FB}) = E(U_L^{FB}) = e + \alpha k$ and $E(U_F^{FB}) = \lambda \mu - w$.

The gains from trading are clear in this comparison. First, the first project always gets funds and the second project gets funds only if there is information that it will

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succeed, in which case it generates a positive net gain $(\hat{x} - \hat{w})$. Then total 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 their liquidity needs k of consumption with certainty at $t = 1$, which is also feasible.

By the assumptions, if both consumers were born in period $t = 0$, then it would be optimal and feasible for both to store k to consume in period $t = 1$ and to lend $\frac{w}{2}$ each to the firm. The problem is that they are born in different periods so that only the early consumer can invest w. He then faces the risk of not being able to consume k in period $t = 1$. In summary, it is optimal to finance the project at $t = 0$, and to finance the second project if it is good at $t = 1$. However, if the information about the second project leaks out, it may hinder trade between early and late consumers. This leakage happens in capital markets, but not with "secret keeping" intermediaries.
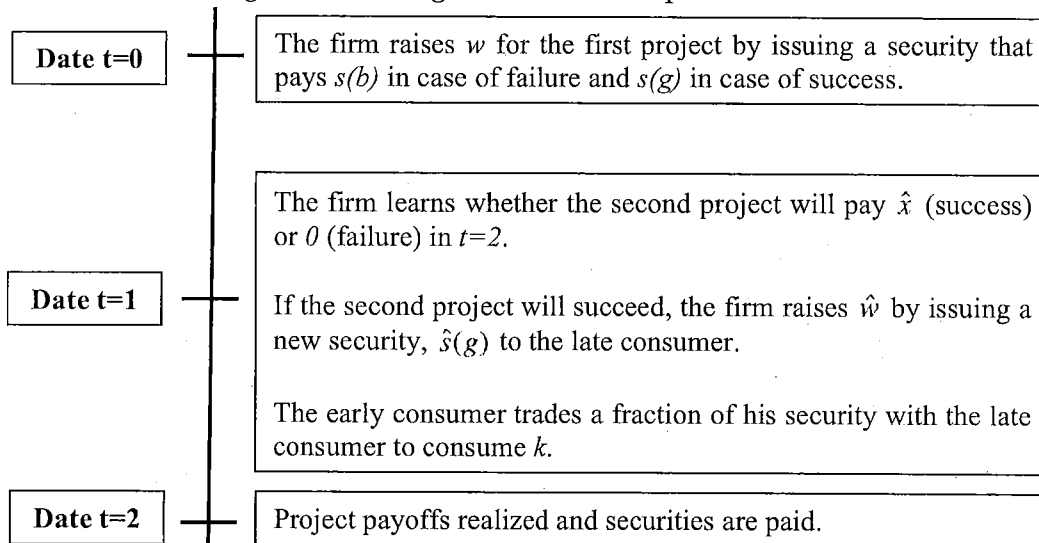
2.3 Capital markets

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 $s(y)$ to be the contingent claim on the project at $t = 2$, where $y \in \{b, g\}$ respectively for the "bad" and "good" project realization, respectively, of the project. Assuming the firm faces limited liability, $s(b) \geq 0$.

At $t = 1$ two transactions may occur. First, the firm may seek financing for a second project if information that the project is successful arrives, by issuing a new security, which we denote as $\hat{s}(y)$, which can be bought by the late consumer. We assume that financing is specific, i.e. each 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 will sell part of his security to the late consumer. Figure 1 shows the sequence of events in the case of a capital market.

An important element of capital markets that we want to capture is that they communicate information about the health of financed projects. Markets are informationally efficient. If firms could commit to raise funds in an uninformative way about the health of its projects, then capital markets would play the role we assign to banks.

Figure 1: Timing Model with Capital Markets

Date t=0	The firm raises w for the first project by issuing a security that pays $s(b)$ in case of failure and $s(g)$ in case of success.
Date t=1	The firm learns whether the second project will pay $\hat{x}$ (success) or 0 (failure) in $t=2$. If the second project will succeed, the firm raises $\hat{w}$ by issuing a new security, $\hat{s}(g)$ to the late consumer. The early consumer trades a fraction of his security with the late consumer to consume k.
Date t=2	Project payoffs realized and securities are paid.

Since information is "hard" (can be credibly transmitted), the firm cannot lie about the project's results. In the capital markets, all agents observe whether a firm is raising funds for a second project or not, so all of them infer whether the first project was successful or not. This leakage of information from the financing of the second project to the information about the first 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, and so the first best allocation cannot be implemented.

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

Proof We proceed by backward induction. If the second project is doomed to fail, the firm does not look for financing (since it cannot prove it has a worthy project), which would reveal that the first project is also doomed to fail. If there is information that the second project will succeed, the firm will seek financing by issuing a security that pays $\hat{s}(g) = \hat{w}$ in $t = 2$. Since the firm has hard information about the project's results, and also has the bargaining power, the firm keeps the surplus $(\hat{x} - \hat{w})$ from the project extension. So, raising money in capital markets is informative about the first project.

The previous stage is critical to define the optimal choices of the late consumer. If the late consumer learns the first project is bad (because the firm never shows up asking

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for a loan to finance a second project), then he is better off just consuming (or storing to consume later) his full endowment e.

If the late consumer learns the first project is successful, then he chooses to finance the second project, buying a fraction θ of the claims on the first 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

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

This implies that

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

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 first 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 first project, then he faces a lottery because the project is risky. 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 in equation (1) and assuming the firm has the bargaining power, the early consumer should be indifferent between financing the project or storing the endowment (i.e., $U_{E|Finance} = U_{E|Store}$), 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 $s(g) \leq x$) is

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

The first component of the first argument corresponds to the certainty equivalent cost of the loan while the second component corresponds to the compensation to the early

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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, x.

Naturally, when $s(g) = x$, and limited commitment binds, then $U_{E|Finance} < U_{E|Store}$ and the first project 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 first project is not financed at all. Still the allocation is better than under autarky since the second project would still be financed if the firm has information that that project will be a success.

By construction (bargaining power to the firm) the expected utility of the two consumers and the bank do not change with respect to the unconstrained first best (FB). However, the expected utility for the firm raising funds in capital markets (CM) 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) that $\lambda s(g) > w$, because the firm has to compensate the early consumer for taking the risk of not consuming as much as desired at $t = 1$. In the extreme, when $s(g) = x$ and there is no financing of the first project, then $U_F^{CM} = \lambda(\widehat{x} - \widehat{w})$.

The cost of capital markets vis-a-vis the first best (FB) outcome is the reduction in the firm's consumption in order 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

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

Q.E.D.

Intuitively, the "money" of the early consumer is subject to information revelation about the project's result, creating the risk of bad news such that he cannot sell those securities, leaving insufficient resources to meet his liquidity needs. Figure 2 illustrates the source of risk aversion given by the limited liquidity needs of the early consumer.

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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 as 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 the case of learning the project is bad. Hence the firm needs to compensate the early consumer to take the risk from financing the project.

Figure 2: Costs of Capital Markets
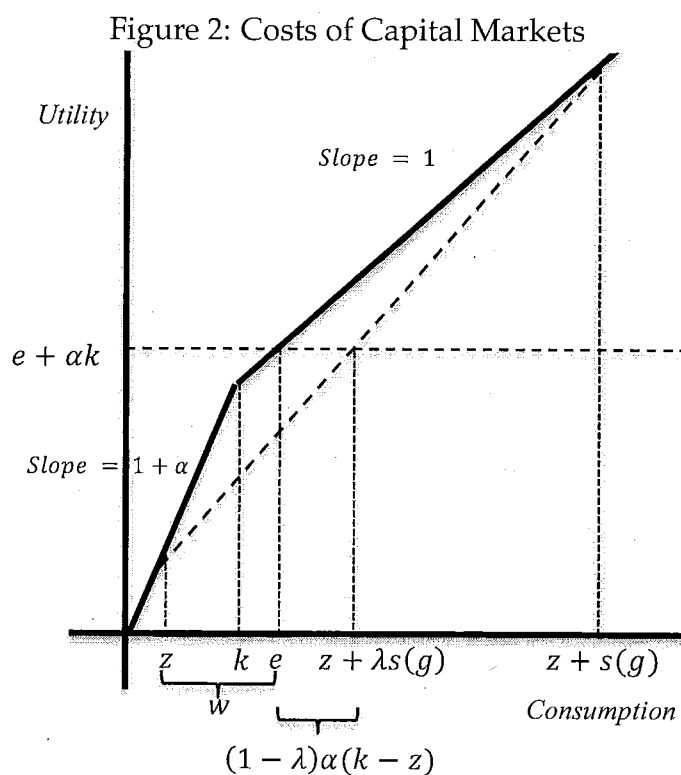
In essence, capital markets reveal *too much* information to people who know how to interpret that information, reducing the expected utility of early consumers since their money cannot buy as much when the bad state is revealed. On the one hand, information about the project is valuable because in its absence some second projects would be financed even though they have a negative net present value or some second projects would not be financed even though they have a positive net present value. However, such information generates an externality by revealing bad news about the original project, hence inefficiently reducing trade at $t = 1$ between early and late consumers. To compensate the early consumer for the risk of not covering

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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-sharing in the economy – all the risk is faced by a single individual rather than being distributed across all individuals.
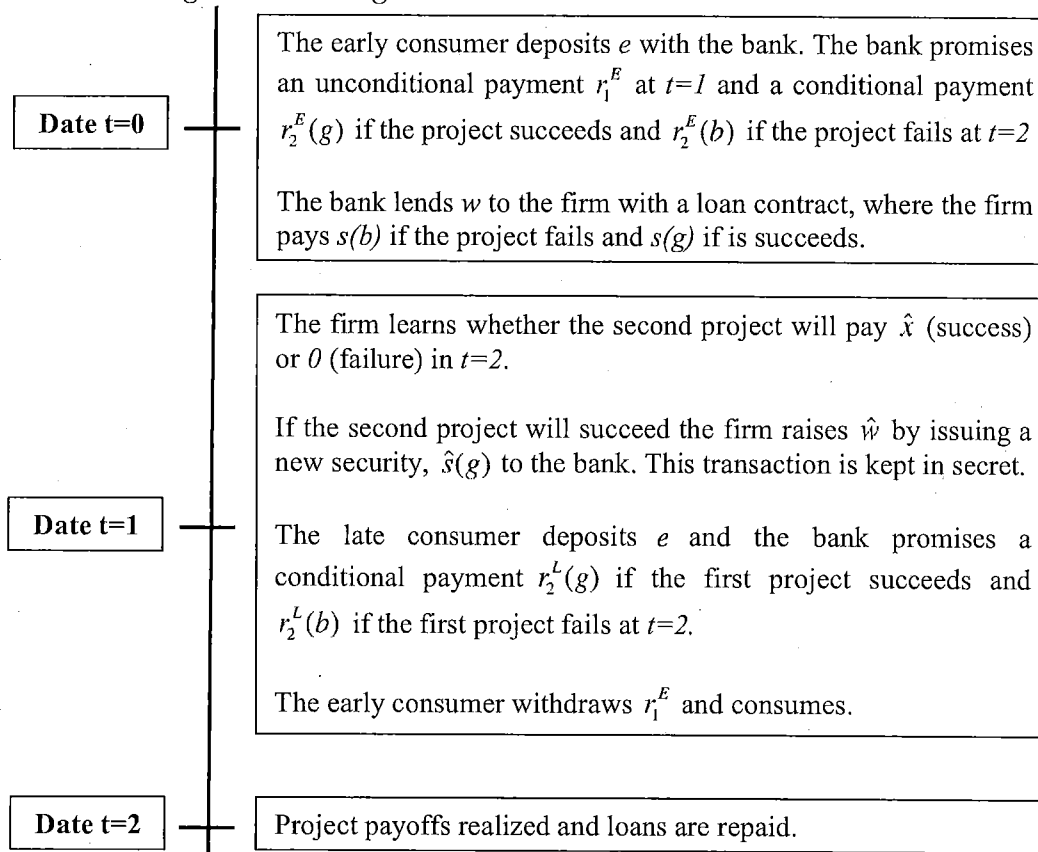
2.4 Financial intermediation

The previous analysis shows that capital markets may not implement the efficient level of investment if the early consumer cares about liquidity and, even in situations where there is efficient investment, there is inefficient risk-sharing in the economy. Now we show that intermediation by a bank dominates capital markets.

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 this 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 subsection we assume consumers cannot privately acquire information about the quality of the project, so there are no limits to the possibilities of financial intermediaries improving welfare. In the next section we relax this restriction.

Figure 3 shows the sequence of events, which we now describe. The setting 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 first project. The loan to the firm is 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 (and contractible) to all agents at $t = 2$.

At $t = 1$, the late consumer deposits e in the bank, which issues a security that promises to pay $r_2^L(b)$ if the state is bad (the first project ends up failing and the bank is liquidated) and $r_2^L(g)$ if the state is good (the first project is successful). If the bank determines that the firm has a good second project, then it lends $\widehat{w}$ to the firm, which issues a security that pays $\widehat{s}(g)$. If the bank determines that the firm has a bad second project, then the bank does not extend any new loan to the firm and $\widehat{w}$ is stored until $t = 2$. Finally, the early consumer withdraws k from the bank.

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Figure 3: Timing Model with Financial Intermediaries

Date t=0	The early consumer deposits e with the bank. The bank promises an unconditional payment r_1^E at $t=1$ and a conditional payment $r_2^E(g)$ if the project succeeds and $r_2^E(b)$ if the project fails at $t=2$. The bank lends w to the firm with a loan contract, where the firm pays $s(b)$ if the project fails and $s(g)$ if is succeeds.
Date t=1	The firm learns whether the second project will pay $\hat{x}$ (success) or 0 (failure) in $t=2$. If the second project will succeed the firm raises $\hat{w}$ by issuing a new security, $\hat{s}(g)$ to the bank. This transaction is kept in secret. The late consumer deposits e and the bank promises a conditional payment $r_2^L(g)$ if the first project succeeds and $r_2^L(b)$ if the first project fails at $t=2$. The early consumer withdraws r_1^E and consumes.
Date t=2	Project payoffs realized and loans are repaid.

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 or not the bank has given the loan to the firm to finance a second project. The intermediary, by hiding this 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 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 there is information that the second project

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will succeed the bank lends $\widehat{w}$ to the firm, which pays $\widehat{s}(g) = \widehat{w}$ in $t = 2$. In contrast, if there is information that the second project will fail, the best alternative for the bank is to not lend to the firm and instead 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 $r_1^E = k$ and $r_2^E(b) = 0$ and in the next section we justify this choice by showing that it minimizes the incentives for late consumers to acquire information, making promises more credible and banks feasible.

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 first project fails or succeeds. When the first project fails bank assets are,

$$A_b \equiv e + z - k \qquad where \quad z = e - w.$$

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

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

and from the indifference condition of the late consumer,

$$(1 + \alpha)k + (1 - \lambda)(A_b - k) + \lambda(r_2^L(g) - k) = e + \alpha k,$$

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

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

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

<div align="right">Q.E.D.</div>

Intuitively, a bank that credibly commits to hide information about the quality of the second project can implement the first best because it allows information to be used at $t = 1$ for investment purposes, but delays the revelation about the realization of the first project until $t = 2$. This prevents the information from affecting efficient trade across consumers at $t = 1$. In this way banks allow risk-sharing between the early and late consumers. 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 whether the firm approached the bank for a second loan or not 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 second project before depositing in the bank, since that provides information about the quality of the first project. 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 cost projects), 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 utility is

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

since, as we showed before, the late consumer does not suffer any liquidity concern given $r_2^L(g) > k$ and $r_2^L(b) > k$. [3]

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 $r_2^L(g) > e$ 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 rather

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[3]Note that when the late consumer does not produce information he may deposit in an insolvent bank. In our setting, the bank would know that it is insolvent, but the bank does not reveal this to the depositor. This, however, would not be the case, for example, if the project returns were not perfectly correlated and the bank did not know the correlation between project returns. In that case the bank could only determine whether a project is "good" or "bad," but not the realized correlation. For simplicity, we have not incorporated this. In a slightly richer setting with a bank manager who is imperfectly controlled, the manager might want to "gamble for resurrection" and so not reveal the bank's insolvency.

than depositing and obtaining $r_2^L(b) < e$ at $t = 2$ (from equation 4). This implies that the expected gains from acquiring information are

$$(1 + \alpha)k + \lambda(r_2^L(g) - k) + (1 - \lambda)(e - k) - \gamma.$$

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

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

At this point, the optimality of our assumption that $r_1^E = k$ and $r_2^E(b) = 0$ is clear. Banks want to maximize the payments to late consumers when the project fails in order to minimize their incentives to acquire information, still providing liquidity to early consumers if possible. 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 allocation only if*

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

The proof just requires replacing $r_2^L(b) = A_b = e + z - k$ 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 is a failure. 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: (i) projects have a low probability of default (high λ), (ii) they are difficult to monitor (high γ), (iii) they are relatively small (low w), (iv) the liquidity needs are relatively small (low k) or (v) the early consumer is relatively rich (high e). That is, relatively safe, small and complex projects are more likely to be observed in the portfolios 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

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best allocation. When condition (6) binds, banks need to either distort risk-sharing or distort 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-sharing in the economy or if they distort investment. Then, we discuss the condition under which banks prefer distorting risk-sharing to distorting investment.

3.1 Distorting risk-sharing

If late consumers have incentives to acquire information about the banks' assets, in particular the quality of the second project, when the bank offers the contract that implements the first best, banks can distort risk-sharing (or the provision of private money) in a way such that intermediation still dominates capital markets.

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

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

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

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

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

in case the project is a failure.

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

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

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The only possibility to satisfy 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 can distort risk-sharing by offering a non-contingent payment less than k to early consumers. Since the bank promises a lower payment at $t = 1$ to early consumers, it has to to offer them a larger payment at $t = 2$ in case the project succeeds, which compensates them for not completely covering their liquidity needs, but making them indifferent between storing or depositing. This condition is

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

Replacing r_1^E (from equation 8) above, we get:

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

From the indifference condition of the late consumer,

$$(1 + \alpha)k + \lambda(r_2^L(g) - k) + (1 - \lambda)(r_2^L(b) - k) = e + \alpha k.$$

Recall, from equation (7), that the promise for the late consumer in the bad state should be larger than without distortions, this is $r_2^L(b) = e - \frac{\gamma}{1 - \lambda} > A_b > k$. Then,

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

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

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

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

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

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

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

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

<div align="right">Q.E.D.</div>

In Figure 4 we show graphically that, if $\lambda(k - z) > \frac{\gamma}{1-\lambda}$ (a violation of the condition in Proposition 4), firms finance the project in capital markets and not through distortionary intermediaries. When intermediaries distort risk-sharing the early consumer's expected utility effectively 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 dots, with a kink located at r_1^E.

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.

<div align="center">24</div>

Figure 4: Case in which Capital Markets Dominate Banks
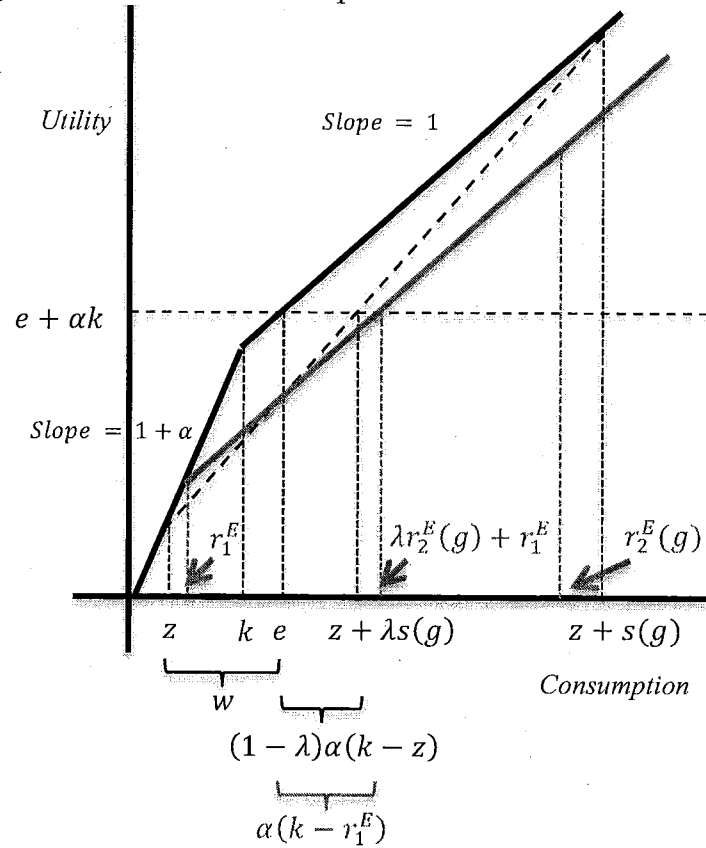
3.2 Distorting investment

Assume now that the firm's project is divisible and it is possible for the bank to invest in just a fraction η of the project and to store the rest of the deposits (for example in Treasury bonds or other safe assets).[4] An alternative view is that a bank finances the project only with probability η, which can be interpreted as credit rationing. We show that 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 $\psi \equiv \left(1 - \frac{\alpha w(1-\lambda)}{\lambda x - w}\right)$, which is implemented by providing funds for only a fraction η of

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

the original project.

Proof How can the bank distort investment in the project to avoid information acquisition? Since the expected benefits for late consumers from acquiring information are given by $(1 - \lambda)[e - r_2^L(b)]$, and their costs are γ, banks can discourage information acquisition by promising late consumers $e - \frac{\gamma}{1-\lambda}$ or more, as in equation (7).

Banks can publicly store a fraction $(1 - \eta)$ of the endowment e of early consumers, or invest in the whole first project just with probability η, even when it is ex-ante efficient to always invest in the project.

Since in this section we allow for efficient risk-sharing, the bank promises to pay k at $t = 1$ to the early consumer, what remains for the late consumer in the case of a bad shock is $r_2^L(b) = \eta(e + z - k) + (1 - \eta)(e + z - k + w) = e + z - k + (1 - \eta)w$ (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

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

and then the investment distortion that allows for optimal risk-sharing when $k - z > \frac{\gamma}{1-\lambda}$. Otherwise the incentives for late consumers to acquire information are:

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

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

$$E(U_F^{Dist}) = E(U_F^{FB}) - (1 - \eta)(\lambda x - w).$$

This implies that the loss from distorting investment is

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

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Banks that distort investment dominate capital markets if

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

Then

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

Q.E.D.

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

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

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

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

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

Q.E.D.

Intuitively, banks distort risk-sharing rather than investment when the welfare costs of risk-sharing (captured by $(1+\alpha)w$) are lower than the welfare costs of not financing the first project (captured by the gains per unit of investment x times the probability of success λ). Then, it is clear that banks are more likely to distort risk-sharing 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 x).

3.3 Coexistence of banks and capital markets

In this section we assume there are many, potentially heterogenous, projects that need financing in the economy. We characterize which projects are financed by banks that replicate first best, and which are financed by banks that have to distort risk-sharing or investment (not implementing the first best because they need to avoid information acquisition) and which are financed by capital markets.

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), i.e., firms differ in their probability of success and in their monitoring costs. [5]

Assume a mass 1 of each agent's type 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; for simplicity each early consumer has endowment e at $t = 0$, and each late consumer has endowment e at $t = 1$. Preferences, technologies, information and the problem for each single individual are exactly the same as specified in the case for a single project. Since we assume the realization of projects are i.i.d., then effectively financing each project has exactly the same characterization as in the previous analysis.

The following proposition shows how projects are sorted by their financing type.

Proposition 7 *Coexistence of Banks and Capital Markets*

First projects are not financed if $\lambda_i < \frac{w}{x}$ (and first projects are ex-ante inefficient).

First 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-sharing if

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

and they are financed by banks that distort investment if

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

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[5]Since there is no agency problems in the banks, banks offer loan and deposit rates consistent with the borrowers characteristics, λ_i and γ_i. Otherwise consumers would need to know which types of borrowers match with which firms. In other words, banks would have to specialize in certain types of loans, based on (λ_i, γ_i), and this would have to be common knowledge.
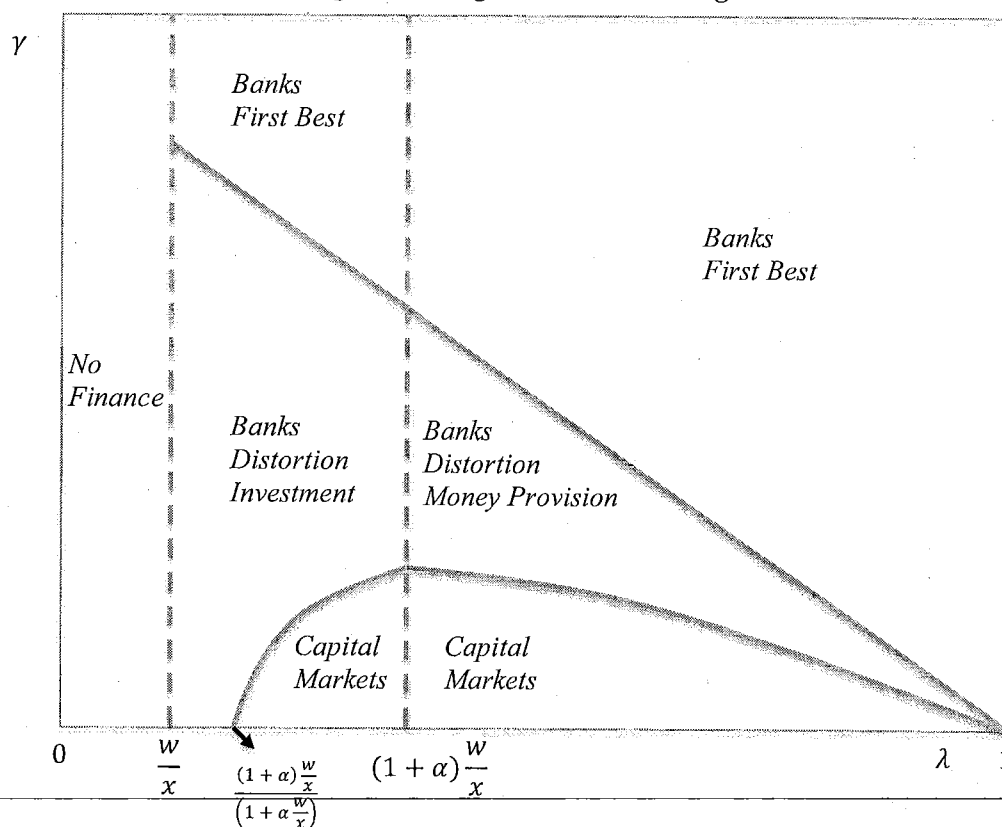
Finally, first projects are financed in capital markets if

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

or

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

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

Figure 5: Regions of Financing

The assumptions of i.i.d. projects and that all project types require the same investments, w and $\widehat{w}$, are critical to sort projects as described above. 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 first project in capital markets does not try to finance a second project also in capital markets, then no late consumer would be willing to deposit in the

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bank because they can infer that all other first projects in the economy have failed. In this extreme case, then, correlation destroys the possibility of using banks at all to improve welfare.

The conditions of Proposition 7 show how firms separate across banks and markets to raise funding. In this model this separation depends only on the banks' desire to have information-insensitive assets; banks charge a very high rate to finance high γ firms for example, and then these firms prefer to raise funds in capital markets. The interpretation of this is that γ corresponds to size, with larger firms having lower γ, hence making them unlikely candidates for bank financing. This result is stark because the model does not include any attractive features of financing in the stock market, such as the ability to trade control rights or rebalance portfolios.

Proposition 7 is broadly consistent with reality, namely, that banks tend to lend to consumers and small businesses, entities which are particularly difficult for outsiders to value. These types of loans are undertaken because of the informational synergy, rather than screening or monitoring, which may also be present (but are not in the model).

4 Optimal portfolio and bank capital

In this section we explore other implications of bank secret keeping for the banks' choice of assets and the effect of bank capital. We assume that a single bank finances two projects using the funds from two identical early consumers and two identical late consumers. This is enough to capture how the bank can exploit a combination of projects to avoid information acquisition. We also assume that each late consumer can choose to privately learn about the quality of one project, and only one, project at a cost γ.[6] 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.

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[6]Restricting consumers to producing information about only one project can be thought of as requiring specialization. This makes sense if "projects" are thought of as asset classes. The bank starts by making loans to home buyers in Florida (the "first project) and then decides to make auto loans in California (the "second project" which is an extension of the banks' expertise.

4.1 Optimal portfolio

We state three propositions, the proofs of which are in the Appendix. First, if the two projects are identical and independent of each other, financing both discourages information acquisition more than financing just one, justifying economies of scale in the banking sector.

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

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

Hence, banks can implement first best outcomes even if $\gamma = 0$ since $e > k + \frac{w}{2}$.

Second, if there is correlation across two identical projects, it is more difficult for banks 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 the previous proposition. This suggests the optimal portfolio of banks should be composed of projects that are uncorrelated.

Proposition 9 *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.

Finally, 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 projects to discourage information acquisition

and implement the first best allocation. So, 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.

Proposition 10 *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 fewer incentives to acquire information. Given the assumption that $e > k + \frac{w}{2}$ it is not necessary to rely on cross subsidization to avoid information acquisition, even for $\gamma = 0$.*

These propositions characterize further the portfolio choices of banks. The motive is not diversification per se, but the desire to make it difficult for outsiders to produce information.

4.2 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 it as "bank capital". Access to this endowment is important in reducing incentives for late consumers to acquire information during the intermediate period. The following Proposition formalizes this result, proved in the Appendix.

Proposition 11 *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 $e > k + w - e_B$.

Intuitively, if the banker can ex-ante commit some of his endowment in the last period to compensate late consumers in case the first project fails, then he can avoid information acquisition and still implement the first best by providing a buffer on the losses of the late consumers that discourage their information acquisition. The bank compensates for providing this buffer by promising lower payments to late consumers in case the project succeeds. Even though we have assumed for simplicity that 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 arrangement and putting its own endowment at stake as bank capital.

Remark The literature has identified diversification and bank capital as two important forces for banks to provide money like services, in particular given their properties on making bank's assets safer. In this paper we show that these two forces also play an additional role in facilitating banks secret keeping, then playing a double role in the provision of money by banks.

5 Overlapping generations

In this section we extend the previous model by developing an overlapping generations structure where the firm has the same investment opportunities as before in periods $t = 0$ and $t = 1$, but the projects mature and pay out at an arbitrary date $T \geq 2$, which is unknown ex-ante. More specifically, conditional on the projects not having paid out in a given period t, the probability the projects pay out during the next period, $t + 1$, is a parameter ν.

This extension just introduces a longer gap between the time projects are financed and the time projects pays out, which is filled by the participation of generations that only live for three periods and overlap over time. The main goal of this extension is to show that the banking contract for all generations, except the two involved with the bank at the time the projects mature, is unconditional on the projects' results, corresponding more closely to standard demand deposits whose payments are independent of the performance of the bank portfolio. Only when projects mature are payments conditional on project results.

The next proposition shows that the contract indeed looks identical to the one we study in our benchmark above, and independent of the probability projects mature. The proof is in the Appendix.

Proposition 12 *When the time T at which projects mature is uncertain, all generations participating during $t < T$ obtain non-contingent payments, while generations participating at $t = T$ receive the same contingent payments as in the benchmark. None of these payments depend on the probability of projects maturing ν.*

Even though the promises that implement first best allocations do not depend on the probability that projects mature during the next period, ν, depositors' incentives to acquire information about the bank's portfolio do depend on that probability. Given the promises obtained above, the expected gains for a consumer to deposit his endowment in the bank at time t without producing information is

$$\nu \left[(1 + \alpha)k + \lambda(r_{t+1}^L(g) - k) + (1 - \lambda)(A_b - k)\right] +$$
$$(1 - \nu) \left[(1 + \alpha)k + \nu\lambda r_{t+2}^E(g) + (1 - \nu)(e - k)\right] = e + \alpha k.$$

In contrast, the net expected gains from producing information about the portfolio of the bank at a cost γ is

$$\nu \left[(1 + \alpha)k + \lambda(r_{t+1}^L(g) - k) + (1 - \lambda)(e - k)\right] +$$
$$(1 - \nu) \left[(1 + \alpha)k + \nu \left(\lambda r_{t+2}^E(g) + (1 - \lambda)(e - k)\right) + (1 - \nu)(e - k)\right] - \gamma.$$

Hence, there are no incentives to acquire information (the first expression is larger than the second) as long as

$$\nu(1 - \lambda) \left[(e - A_b) + (1 - \nu)(e - k)\right] < \gamma.$$

This leads to the next Proposition.

Proposition 13 *When consumers are able to learn privately about the quality of projects at a cost γ, banks can implement the first best allocation only if*

$$\nu \left[(k - z) + (1 - \nu)(e - k)\right] \leq \frac{\gamma}{1 - \lambda}.$$

This condition for information acquisition allows for the possibility of projects not maturing in the future differs from the benchmark in Proposition 3. In the benchmark only late consumers had the potential to acquire information because the information accrues in $t = 1$, while in this extension consumers act potentially both as late consumers (if projects mature the period after depositing, with probability ν) and as early consumers (if projects mature two periods after depositing, with probability ν^2). Both possibilities introduce incentives to learn about the bank's portfolio, depositing when projects are good and not depositing when projects are bad.

The incentives to acquire information increase with the probability the projects mature in the foreseeable future. Proposition 13 shows that if there is a low enough $\bar{\nu} > 0$ such that for all $\nu < \bar{\nu}$ there is no information acquisition and the first best allocation is implementable. Interestingly, since the payments that sustain the first best allocation do not depend on ν, the perceptions about the likelihood that projects mature can vary over time, only affecting the incentives to acquire information over time and then the need for distortions.

This result is consistent with Hanson et al. (2014). They show empirically that banks focus on illiquid, longer-term assets with no terminal risk, but possibly substantial intermediate market risk. By contrast MMMFs and other shadow banking players deal with market risk by assuring speedy exit options (selling). Both low terminal risk and fast exit option map into low ν in our model, then reducing the incentives to acquire information and making both traditional and shadow banks feasible, implementing the optimal allocation.

6 Conclusions

Banks are opaque by design. An efficient transactions medium requires that bank 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.

Furthermore, banks choose portfolios of assets to minimize information leakage. The synergies or complementarities between certain loan types 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 (although banks may also engage in these activities). Bank portfolio choice is determined to minimize information leakage. The optimal assets are precisely loans to small firms and households, but that is because these minimize the information leakage.

Clearly, there are issues we did not address. We assumed that banks can commit not to reveal information, a "bank technology." We defined a "bank" to be a commitment technology, but did not provide any details about how this works. One way to address this would be in a repeated setting where the bank's business would depend

on its history of keeping secrets. We also did not incorporate any agency problems with hired bank managers, which has been the focus of much of the banking literature. See Gorton and Winton (2003). This may be one reason the results are so stark. For example, there is no trade-off between keeping secrets and disclosure of information. While bank examiners also keep the results of their examinations secret, still sometimes limited information, from "stress tests, for example is revealed.

Banks and markets coexist because of the desire on the part of banks to lend to entities that help them minimize information leakage. While in reality there likely are reasons for borrowers to want to fund in capital markets, our point is that there are still reasons for banks to desire hard-to-value loans.

The argument explains why banks are regulated. The role of banks as secret keepers means that they are hard for outsiders to discipline. Although the model did not incorporate moral hazard on the part of the bank or governance issues , these frictions are easy to imagine in the setting here, resulting in a need for the government to examine and regulate banks. However, we also then explain why the results of bank examinations are kept confidential by the regulators. Deposit insurance ensures that demand deposits never risk becoming inefficient due to information leakage.

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A Appendix

A.1 Proof Proposition 8.

If the bank finances two original projects, with funds from two early consumers, there are three possible states:

- With probability λ^2 both original 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 original 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 original 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

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

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.

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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 utility from depositing in a bank should be exactly $e + \alpha k$:

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

or alternatively, simply

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

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

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

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

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

If $e < k + \frac{w}{2}$, then $E(r^L|b) < e$ and $E(r^L|g) > e$. 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,

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

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 $e > k + \frac{w}{2}$, $E(r^L|b) > e$ and $E(r^L|g) < e$, 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 $E(r^L|g) = E(r^L|b) = e$, 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 $E(r^L|b) = e$, then

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

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 $e + \alpha k$.

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

A.2 Proof Proposition 9.

If the bank finances two correlated original 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 $2A_b + s(g)$.

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- 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:

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

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,

$$r_2^L(gb) = r_2^L(bg) = A_b + \frac{s(g)}{2}. \tag{18}$$

From the break even condition of the early consumer

$$r_2^E(gg) = \frac{e - k}{\rho + (1 - \rho)\chi^2}. \tag{19}$$

From the resource constraint when both projects succeed

$$r_2^L(gg) = A_b + s(g) - \frac{e - k}{\rho + (1 - \rho)\chi^2}. \tag{20}$$

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

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

If $e < k + \frac{w}{2}\left[2 - \frac{\chi}{\lambda}\right]$, then $E(r^L|b) < e$ and $E(r^L|g) > e$. 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,

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

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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 $E(r^L|b) > e$ and $E(r^L|g) < e$. In this case, there are enough resources to make promises such that $E(r^L|g) = E(r^L|b) = e$, 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 $E(r^L|b) = e$,

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

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 $e + \alpha k$.

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 $\gamma \geq 0$.

A.3 Proof Proposition 10.

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

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- 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:

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

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:

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

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

$$r_2^E(gg) = \frac{e-k}{\lambda_1\lambda_2}.$$ (21)

From the resource constraint when both projects succeed

$$r_2^L(gg) = A_b + \frac{s_1(g)}{2} + \frac{s_2(g)}{2} - \frac{e-k}{\lambda_1\lambda_2}.$$ (22)

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 $e + \alpha k$ if

$$\lambda_1\frac{s_1(g)}{2} + \lambda_2\frac{s_2(g)}{2} = w.$$ (23)

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:

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

and

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

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

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

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

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necessary that $E(r^L|b_1) = 2e - k - \lambda_2 \frac{s_2(g)}{2}$, or

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

which implies

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

from equation (23).

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

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

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 (23),

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

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

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

Given our assumption that $e > k + \frac{w}{2}$, then $E(r^L|b_i) > e$ and $E(r^L|g_i) < e$ then cross subsidization is not even needed to avoid information acquisitions as shown in the previous proposition.

A.4 Proof Proposition 11.

Assume the bank has an observable endowment e_B at $t = 2$, and it is able to commit to use it as capital when 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

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

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:

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

which implies

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

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

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the case the project is successful,

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

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.

A.5 Proof Proposition 12.

We start with consumers born at $t = 0$. This initial generation faces the possibility (with probability ν) that the projects mature in $T = 2$, in which case the problem is identical to the one in the benchmark. The first consumers receive k in $t = 1$ (to implement the first best) and $r_2^E(g)$ or $r_2^E(b) = 0$, depending on the result of the project, in $t = 2$.

However, in this setting, with the complementary probability $1 - \nu$, the projects do not mature in period $T = 2$, in which case the payment to these consumers in $t = 2$ is non-contingent on the realization of the project, which is information the bank does not have. Since the consumer obtained k in period $t = 1$, then in this situation when the projects do not mature the bank has to compensate the consumer with $e - k$ in $t = 2$.

Is this feasible? When projects do not mature in period $t = 2$, conditional on consumers born in $t = 2$ depositing e (we next check that this is the case), the bank can always pay $e - k$ to consumers who deposited in $t = 0$ and k to consumers who deposited in $t = 1$. In this sense, when projects do not mature, the bank that keeps secrets allows for overlapping generations to just transfer funds optimally over time.

Now we show that the promise $r_2^E(g)$ that banks have to make to induce consumers born in period $t = 0$ to deposit is identical to the promise to late consumers in the benchmark. Assuming $r_2^E(b) = 0$, which is the payment that minimizes the incentives to acquire information about the bank's secrets, consumers born in period $t = 0$ are indifferent between depositing or not when

$$\nu \left[(1 + \alpha)k + \lambda r_2^E(g) \right] + (1 - \nu) \left[(1 + \alpha)k + e - k \right] = e + \alpha k$$

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or similarly, when

$$\nu\left[(1+\alpha)k + \lambda r_2^E(g)\right] = \nu[e + \alpha k]$$

which is exactly the equation that determines $r_2^E(g) = \frac{e-k}{\lambda}$ in the benchmark model. Recall this result is independent of the probability projects mature in $T = 2$.

Now we can focus on all other consumers, who born at $t > 0$. These consumers face the probability the projects mature in $t + 1$ and, if not, that they mature in $t + 2$. If projects mature in $t + 1$, consumers' problem becomes that of late consumers in the benchmark as they immediate receive either $r_{t+1}^L(g)$ or $r_{t+1}^L(b)$, depending on the realization of the first project. If projects mature in $t + 2$, then the consumers' problem becomes that of early consumers as we described above; they receive k in $t + 1$ and either $r_{t+2}^E(g)$ or $r_{t+2}^E(b) = 0$, depending on the realization of the projects. Finally, if projects do not mature in either $t + 1$ or $t + 2$ consumers receive non contingent payments k in $t + 1$ and $e - k$ in $t + 2$, which is feasible as previously discussed.

At the moment T projects mature there are always two generations participating in the banking contract. Generation $T - 1$ takes the place of "late" consumers, and we denote their payments as $r_t^L(i)$, while generation $T - 2$ takes the place of "early" consumers, and we denote their payments as $r_t^E(i)$, with $i \in \{b, g\}$.

Now we show that the promises that banks have to make to induce consumers who born in period $t > 0$ to deposit are identical to the promises to early and late consumers in the benchmark. Assuming $r_{t+1}^E(b) = 0$, by the resource constraint $r_{t+1}^L(b) = A_b$. Then, consumers that are born in period $t > 0$ are indifferent between depositing or not when

$$\nu\left[(1+\alpha)k + \lambda(r_{t+1}^L(g) - k) + (1 - \lambda)(A_b - k)\right] +$$
$$(1 - \nu)\left[(1+\alpha)k + \left(\nu\lambda r_{t+2}^E(g) + (1 - \nu)(e - k)\right)\right] = e + \alpha k$$

From the previous analysis $r_{t+2}^E(g) = \frac{e-k}{\lambda}$, and then this condition is simply

$$\nu\left[(1+\alpha)k + \lambda(r_{t+1}^L(g) - k) + (1 - \lambda)(A_b - k)\right] = \nu[e + \alpha k]$$

which determines

$$r_{t+1}^L(g) = e + \frac{(1 - \lambda)}{\lambda}[w + k - e] > e, \tag{24}$$

exactly as $r_2^L(g)$ in the benchmark model. Recall this result is also independent of the probability ν projects mature in future periods.