The Nature of Deposits*

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July 1, 2025

Abstract

I unveil a novel role for demand deposits. In a dynamic model where banks are better informed about the quality of their loans and investors receive noisy signals about loan performance with a delay, demand deposits can be structured to correlate investors' withdrawal decisions with asset quality while maintaining the banks solvent. This explains why small and low-credit rating banks rely heavily on certificates of deposit as their main source of funding, while larger and safer banks on traditional savings deposits. The model also predicts that even though banks' liabilities are often homogeneous, the duration of their liability structure can be very heterogeneous and, in particular, that it is U-shaped in their credit rating. Finally, I also show that when the economy is populated by a large fraction of sleepy depositors, staggered intermediation or an FDIC insurance policy arise as natural candidates to solve the inefficiencies caused by their lack of information.

Keywords: Banks, Deposits, Maturity transformation, Asymmetric information, Allocative efficiency

JEL classification: D61, D82, D86, G21, G32

*First draft: May 2025. I am deeply indebted to Giulio Trigilia for invaluable discussions, comments and suggestions. I want to thank Giovanni de Paola for numerous discussions and support. I also want to thank Alan Moreira, Alex Kopytov, Alex Priest, Christian Opp, Narayana Kocherlakota, Pavel Zryumov, Ron Kaniel, Zijie Liu and other participants at the Simon Brownbag Series for their comments and suggestions.

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1. Introduction

Although banks' liability structures are often homogeneous, realized maturity transformation can be very heterogeneous, a fact that became evident in the 2023 banking crisis (Cipriani et al. (2024)). In a setting as in Diamond (1991), where banks have market power, superior information on the quality of their loans, and depositors learn with a delay, I predict that the duration of a bank's liability structure is U-shaped in its credit rating. Moreover, I show that when the adverse selection problem is intense, banks optimally issue certificates of deposit (CDs) to prevent inefficient liquidation after negative news. However, when the adverse selection problem is mild, banks will expand their balance sheet by issuing standard savings deposits and selling credit default swaps (CDSs) on their risky loans. Essentially, in addition to making risky loans, banks invest in liquid securities and post them as collateral to capture more deposits, since it is cheap for high-quality banks to sell insurance when they have balance sheet capacity.

Contrary to the empirical literature on banking, which usually sets the duration of savings deposits to zero and of certificates of deposits to their specified maturity (e.g, Drechsler et al. (2021), Fleckenstein and Longstaff (2024)), I define an expected duration measure for banks liability structure, which will depend on the equilibrium withdrawals from depositors. When banks' credit rating f is relatively low, the economy's equilibrium will be separating, that is, high-quality borrowers will make risky loans, while low-quality borrowers will prefer to invest in risk-free bonds. In that case, the expected duration will be high, given that depositors anticipate that only high-quality borrowers invested in the risky asset and, therefore, there is no need to withdraw, absent any liquidity shock. On the other hand, when the credit rating improves, separation becomes too costly. Low- and high-quality banks invest in the risky asset after issuing deposits, which will induce investors to withdraw after a credit downgrade, implying a shorter expected duration. This will cause an immediate drop in the expected duration, which then increases in the credit rating f, as the probability of a credit upgrade is higher for higher values of f. The U-shape follows immediately from the fact that, after a credit upgrade, investors do not withdraw their deposits as they become confident in the banks' repayment capacity.

In line with recent empirical results, banks generally do not size down, but instead react by borrowing more after negative shocks. As predicted, banks facing withdrawals are those with worse fundamentals, such as high uninsured to total deposits and low cash-to-asset ratios, as shown by Cipriani et al. (2024) for the 2023 American banking crisis, or banks with low credit rating as shown by Pérignon et al. (2018) for the European market on CDs, and in general, the outflows that small and medium banks face after negative news become inflows to larger and safer banks (Caglio et al. (2024), Cipriani et al. (2024)). Also in line with the model predictions, Pérignon et al. (2018) shows that credit downgrades are not informative for very low-graded banks, as they do not have statistical power to predict large withdrawals immediately after the downgrade event, a fact that cannot be explained by other supply side theories of deposits such as Calomiris and Kahn (1991). This seems to be true for the recent US crisis as well, given that 40% of the run banks were not in the worst decile in any of the predictive measures of a run, while 25% of non-run banks were in the worst decile of at least one measure (Cipriani et al. (2024)). Furthermore, credit downgrades do not cause, but predict, poorer loan performance, as measured by the return on assets (ROA) and the amount of impaired loans.

The optimality of deposit contracts comes from the fact that, when depositors learn about loan quality, withdrawals will correlate with asset quality, which reduces the amount of liabilities the bank has, therefore, preventing liquidation. Thus, deposit contracts are shown to improve allocative efficiency by allowing banks to capture the pricing benefits of rollover without exposure to the deadweight losses of liquidation, which cannot be achieved with short- or long-term debt alone. The results on the optimal capital structure reconcile several other empirical facts. Smaller banks are those that rely more heavily on CDs and invest more in liquid assets (d'Avernas et al. (2023)). Larger banks have savings deposits as their main source of funding and are the ones that trade CDSs. Furthermore, in contrast to credit risk hedging stories such as Parlour and Winton (2013), banks' short position on CDSs is positively correlated with their loan exposure to a particular firm (e.g., Hasan and Wu (2016), Caglio et al. (2016)).

These are accompanied by three sets of results that challenge the intuition of classic models. First, I show that the expected duration of the banks' liability structure is decreasing in the private benefit of making risky loans, contradicting the prediction in Diamond (1991).[1] Second, the cost of capital of high-quality borrowers is hump-shaped in the intensity of the adverse selection problem θ, which can cause a market breakdown for intermediate values of θ, therefore, contradicting classic intuition on static adverse selection and ex-post moral hazard models (e.g, Akerlof (1970), Calomiris and Kahn (1991)).[2] Third, low-quality borrower profits increase in the intensity of the adverse selection problem for low or high values of θ, but are flat and zero for intermediate values of θ, which goes against the prediction from classic adverse selection models such as Akerlof (1970) and Nachman and Noe (1994).

The results on the cost of capital and market breakdown come from investors' participation constraint under the separating and the pooling equilibrium. A separation menu will be feasible only if θ is small enough $\theta < \underaccent{\bar}{\theta}$, since we need to satisfy the incentive compatibility of the low-quality bank to not invest in the risky asset, which is binding and tightens in θ. On the other hand, given that low-quality banks have negative NPV loans, the pooling equilibrium will be feasible only if θ is large enough $\theta > \bar{\theta}$. Hence, when the return on risky loans x is relatively small, there will be a wedge between $\underaccent{\bar}{\theta}$ and $\bar{\theta}$, so that whenever $\underaccent{\bar}{\theta} < \theta < \bar{\theta}$, raising capital is not feasible, as it would require a return on capital greater than x. This result adds some nonlinearity to market breakdown predictions, contrasting with the usual outcomes from static adverse selection or ex-post moral hazard models, where the market breaks down for low values of θ only.

With regard to low-quality banks' profits, it is expected that they increase in the intensity of the adverse selection problem for low values of θ. As discussed above, in a separating equilibrium, the incentive compatibility of a low-quality bank to not invest in the risky asset tightens in θ. At the other extreme, for high values of θ, low-quality banks are always able to fulfill withdrawal requests. Thus, an increase in θ directly translates into an increase in expected profits. However, for intermediate values of θ, the market does not break down when the return on risky loans is large enough. Banks would be pooling in equilibrium, but low-quality banks will be forced to pledge the entire cash flows of risky loans after withdrawals as the adverse selection problem is pervasive, which pushes their expected profits to zero.

[1] The intuition is similar to the result on the duration relative to the credit rating f.

[2] θ measures the dispersion between high- and low-quality loans cash flows.

In a model extension where a fraction of depositors are unsophisticated and unable to learn the quality of banks' loans, I show that an endogenous staggered intermediation could arise in which the sophisticated investors will act as an intermediary between the unsophisticated depositors and the bank.[3] Interestingly, to avoid any hold-up problems or profit manipulation, the new intermediary will raise money by issuing equity plus deposits, while the original bank will keep optimally issuing demandable debt (deposits). This liability structure guarantees that the sophisticated investor, acting as an intermediary, will have proper incentives to optimally withdraw their deposits. In particular, the deposits issued will prevent the sophisticated from threatening to not withdraw after a credit downgrade, holding up the unsophisticated, while the equity part guarantees that they do not suboptimally liquidate after an upgrade, in order to profit from renegotiated terms with the initial borrower.

Alternatively, if this staggered intermediation is institutionally too costly, I show that the same allocation is achieved through an FDIC insurance policy. In line with recent empirical studies (e.g., see Egan et al. (2017); Iyer et al. (2016); Chen et al. (2022); Chen et al. (2024); Martin et al. (2024); Cipriani et al. (2024)), sophisticated and uninsured depositors will be sensitive to solvency risks, which will prompt them to withdraw after negative news arrives, while insured depositors can be sticky without posing any negative consequences to banks' date-zero cost of capital. In summary, the FDIC acts as an informed agent, charging an insurance premium from downgraded banks in order to mimic the optimal withdrawal decisions of sophisticated investors on behalf of the unsophisticated. Consequently, the FDIC policy, in the absence of any market solution, helps banks achieve the most efficient outcome by preventing inefficient liquidation, a common feature found in the literature on deposit insurance (e.g., see Diamond and Dybvig (1983); Repullo (2000); Martin (2006); Hanson et al. (2015)).

Finally, I study an environment where investment is scalable and its marginal return is decreasing in size. There, I show that deposits have not only redistributive properties, but also real effects. Having deposits in their liability structure will induce banks to increase borrowing, and therefore the size of their investment relative to the case where they were issuing straight debt.

[3] Glode and Opp (2016) also show that intermediation chains can improve efficiency in a trade with asymmetric information environment.

Related Literature

This paper is mostly related to the literature on the role played by demand deposits. Maturity transformation, that is, allowing depositors to invest in risky and illiquid long-term assets while still being able to withdraw their funds before maturity whenever they face a private liquidity shock, has been widely discussed by the banking literature at least since Bryant (1980) and Diamond and Dybvig (1983).[4] In models where this private liquidity motive is absent, some work has been done to uncover the supply side role of deposits. In particular, a role for demandable debt has been discussed in environments plagued by ex-post moral hazard, i.e., when realized cash flows are unverifiable and the borrower can divert part of them (e.g., Diamond (1984); Calomiris and Kahn (1991)), and also in limited commitment environments, as is the case of the hold-up problem present in Diamond and Rajan (2000) and Diamond and Rajan (2001), and the leverage ratchet effect as shown by Koufopoulos et al. (2024). However, in situations where borrowers possess private information on future cash flows, such as in Flannery (1986), Diamond (1991), and Diamond (1993), researchers have often overlooked a potential role for demand deposits.

Similar in spirit, several papers discuss the coexistence of lending and deposit-taking in the presence of information asymmetries. Lucas and McDonald (1992) have a framework in which borrowers learn, over time, the past returns of their portfolio of loans. So, there is no asymmetric information at the funding stage, but only over time. Moreover, they assume that the inflow/outflow of deposits is exogenous and not part of the banks optimal capital structure choice. Therefore, without asymmetric information at the funding stage, the capital structure plays no role in the sense discussed here. Stein (1998) studies a framework in which borrowers have private information regarding their assets in place. New loans are assumed to be riskless; therefore, again there would be no role for the capital structure as discussed in this paper given that one could contingent the provision of new capital to claims of new loans instead of the assets in place.

Chu (1999) has a model in which the bank has private information about the quality of its

[4]See also Jacklin (1987); Chari and Jagannathan (1988); Jacklin and Bhattacharya (1988);Gorton and Pennacchi (1990); Farhi et al. (2009).

loans. However, similar to Lucas and McDonald (1992), the deposit inflow is determined exogenously, while the asset structure is chosen after this exogenous capital inflow. He claims that higher-quality banks will have incentives to hold a higher percentage of their assets in the form of risk-free securities. In contrast, I show that, when the adverse selection problem is severe, higher-quality banks will offer a menu of contracts that induce separation at the investment stage, causing lower-quality borrowers to hold risk-free securities, and thus abstaining from investing in risky loans. Kashyap et al. (2002) attribute the coexistence of lending and deposit taking to the synergies between these two activities in sharing the deadweight losses of holding liquid assets. However, they also assume an exogenous inflow of deposits at the funding stage, and information asymmetries only arise at a later date, when banks have to raise external funding to fulfill withdrawals motivated by private liquidity shocks.

The remainder of the paper is devoted to formalizing the ideas and results discussed in the Introduction. Section 2 presents the model, outlines the constrained pareto-efficient allocation, the allocation obtained in Diamond (1991), and proposes a game to implement the efficient allocation. Sections 3 and 4 present the equilibrium outcomes of agents' interactions, while Section 5 shows some comparative statics. Section 6 extends the baseline model by introducing (i) the presence of unsophisticated investors at $t = 0$; (ii) heterogeneity in the supply of risk-neutral capital; and (iii) scalable investment. Section 7 discusses the policy implications that can be used to alleviate some of the inefficiencies seen throughout the analysis. Section 8 concludes the paper.

2. Baseline Model

The primitives of the baseline model follow Diamond (1991).

Environment. Time is discrete and runs for two periods with three dates: $t = 0, 1, 2$. At $t = 0$, a risk-neutral borrower (bank) has a project to finance that requires raising 1 dollar from external investors. At each date $t \in \{0, 1\}$ there is a unit supply of risk-neutral capital. The project can be either "Good" (G), producing a cash flow $x > 1$ with certainty ($p_G = 1$) at $t = 2$, or "Bad" (B), in which case it yields the same cash flow x with probability $p_B = \theta$ and 0, otherwise. The bank has private information on the quality of the project and enjoys a non-pecuniary rent $c > 0$ if it remains in control of the loan at $t = 2$.[5] At $t = 0$, investors assign probability f (credit rating) that the bank's project is of type G and $1 - f$ to being of type B. At $t = 1$, investors receive additional non-verifiable, therefore non-contractible, information $r \in \{d, u\}$ regarding the project's type, which can be either a credit rating downgrade $r = d$, or upgrade $r = u$. Denote by f^d and f^u, the conditional probability that the project is of type G given a downgrade or an upgrade, respectively. I assume that $1 = f^u > f > f^d = \frac{f}{m}$, where $m > 1$. Therefore, all type B projects receive a downgrade ($e_B = 1$), and type G projects receive a downgrade with probability $e_G = \frac{f^d(1-f)}{f(1-f^d)} = \frac{1-f}{m-f}$. Agents do not discount cash flows; that is, the short-term gross risk-free rate is equal to one, and everyone is protected by limited liability. A type B project has a negative NPV relative to the safe asset's return, i.e. $\theta x < 1 < x$, whereas a type G project has a positive NPV. Finally, let us denote a borrower with a type-G project as a high-quality or high-type borrower, and low-quality or low-type for a borrower with a type-B project.

2.1. Game

As usual in the informed principal literature, I will use a two-stage signaling game. It is well known that this type of game generally admits multiple equilibria (e.g., Bernhardt et al. (2022)). Therefore, motivated by the planner's allocation, which I present subsequently, I will restrict attention to contracts in which investors make zero profits in expectation.[6]

Date-zero contracts. At $t = 0$, the bank raises one dollar by issuing a menu of contracts containing a puttable debt [7] (D, F) and a long-term debt with face value ϕ. Formally, the bank demands a quantity of capital $I = 1$, chooses a $t = 1$ withdrawal payment $D \leqslant qx$, a $t = 2$ non-withdrawal payment F, and sets ϕ. Then, if and only if the menu is accepted, the bank chooses

[5]The positive control rent could also be interpreted as a negative private output in case of disintermediation. This could reflect stigma or a lower present value of future income.

[6]The canonical paper that imposes zero profits for investors in an informed principal framework is Nachman and Noe (1994). Alternatively, Diasakos and Koufopoulos (2018) propose an endogenous commitment game and show that it implements the ex-ante efficient allocation for informed principal problems.

[7]e.g., deposits.

either to invest in the risky asset and issue the puttable debt within the proposed menu, or to invest in the riskless security and issue the long-term debt. On the other hand, if the menu is not accepted, the game ends immediately. In summary, a date-zero menu offered by the bank is a tuple $K_0 = (\{D,F\};\{\phi\})$, upon which investors choose to accept it or not. Hence, denote by $\mathbb{K}_0 = K_0 \cup \{a\}$ the date-zero menu where, upon acceptance ($a = 1$), investors provide the borrower with an amount of capital $I = 1$, and receive the puttable debt (D,F) when the bank invests in the risky asset, or the long-term debt ϕ.

Notice that the face value and withdrawal conditions for the puttable debt cannot be made contingent on the credit rating update realized at $t = 1$. This implies that the withdrawal decision at $t = 1$ has to be ex-post optimal for the investors, which will be achieved by a subgame perfection constraint at the implementation. Hence, the dynamics of the game becomes relevant.

Date-one contracts. At $t = 1$ the bank raises capital by issuing short-term debt when needed. Date-zero investors choose whether to withdraw $W(r) = D$, forcing the bank to raise $W(r)$, or not $W(r) = 0$. Date-one investors then compete for the rate $S(r)$. Thus, a date-one contract is a pair $K_1 = (W,S)$, where W is the amount raised at $t = 1$, and SW is the face value at $t = 2$. If $x < SW$, no cash is raised at $t = 1$ and the bank defaults on the withdrawal choices of date-zero investors, losing control over its assets. Otherwise, the bank raises W in short-term debt and proceeds to the next period.

Payoffs. Fix a feasible date-zero contract $\mathbb{K}_0$ and suppose that the investor's withdrawal decision at $t = 1$ does not force the bank to default ($\delta = 0$). Then, a high-quality bank gets the following payoff,

$$U_G(\mathbb{K}_0, K_1, W, i) \equiv \mathbb{1}_{i=risky}\Big[x + c - e_G\Big(\frac{F}{D}(D - W(d)) + W(d)S(d)\Big) - \\ (1 - e_G)\Big(\frac{F}{D}(D - W(u)) - W(u)S(u)\Big)\Big] + \mathbb{1}_{i=riskless}(1 - \phi)$$

and a low-quality borrower gets

$$U_B(\mathbb{K}_0, K_1, W, i) \equiv \mathbb{1}_{i=risky}\theta\left[x + c - \left(\frac{F}{D}(D - W(d)) + W(d)S(d)\right)\right] + \mathbb{1}_{i=riskless}(1-\phi)$$

Whereas, upon default ($\delta = 1$) at $t = 1$, the bank's expected payoff is zero as it loses control over the assets. The expected profits of the competitive date-zero investors will depend on whether they expect the borrower types to pool and both invest in the risky asset or to separate. Thus, their expected profits at $t = 0$ are

$$\pi_0^{pool} \equiv f(1-e_G)\left(\frac{F}{D}(D-W(u)) + W(u)\right) + [f e_G + (1-f)\theta]\left(\frac{F}{D}(D-W(d)) + W(d)\right) + (1-f)(1-\theta)W(d) - 1$$

and

$$\pi_0^{sep} \equiv f\left[e_G\left(\frac{F}{D}(D-W(d)) + W(d)\right) + (1-e_G)\left(\frac{F}{D}(D-W(u)) + W(u)\right) - 1\right] + (1-f)(\phi - 1)$$

It is implicit that both types of borrowers are pooling in the equilibrium menu they offer. The low-type will always mimic the high-type borrower, otherwise investors would never accept the menu offered by the former given that the low-quality project is negative NPV.[8] At $t = 1$, given that the investment opportunity was taken at $t = 0$, date-zero investors update their beliefs about the project's cash flow depending on the credit rating update. Thus, letting $q \equiv f^d + (1-f^d)\theta$, their $t = 1$ expected profits are defined as

$$\pi_{0,1}^{pool}(d) \equiv W(d) + q\frac{F}{D}(D - W(d))$$
$$\pi_{0,1}^{pool}(u) \equiv W(u) + \frac{F}{D}(D - W(u))$$

[8]It is also implicit in their separating profits definition that, in case of separation at the investment stage, the high-type is investing in the risky asset and the low-type in the riskless security. There cannot be a separating menu in which the low-type invests in the risky asset as it would generate negative profits in expectation for the date-zero investors.

and

$$\pi_{0,1}^{sep}(d) \equiv \frac{F}{D}(D - W(d)) + W(d)$$
$$\pi_{0,1}^{sep}(u) \equiv \frac{F}{D}(D - W(u)) + W(u)$$

For each date-zero contract in which there is a positive withdrawal, date-one investors then compete to buy the short-term debt the bank issues to pay for the withdrawals. Similar to date-zero investors, their expected profits depend on whether they predict that both borrower types had invested in the risky asset or only the high-type. Thus, if they end up buying the short-term debt after a credit rating downgrade, their expected profits are defined as

$$\pi_1^{pool}(\mathbb{K}_0, W, d) \equiv qS(d)W(d) - W(d)$$

and

$$\pi_1^{sep}(\mathbb{K}_0, W, d) \equiv W(d)S(d) - W(d)$$

Thus, whenever both types have invested, with probability $q = \left[f^d + (1 - f^d)\theta\right]$ the downgrade comes from a good project or a bad project that becomes successful in $t = 2$, providing date-one investors with the required return $S(d)W$. On the other hand, if they predict that only high-type borrowers are investing in the risky asset, they will get their required return $WS(d)$ for sure. Finally, conditional on a credit upgrade, their profits are defined as

$$\pi_1(\mathbb{K}_0, W, u) \equiv W(u)S(u) - W(u)$$

Equilibrium. Given the nature of the signaling game, investors observe the borrower's menu offer, which makes them potentially update their beliefs about the bank's (project) quality before accepting or rejecting it. Hence, I will analyze the Perfect Bayesian Equilibrium (PBE) satisfying the Intuitive Criterion. Moreover, given the dynamic setting, equilibrium is defined recursively, starting at $t = 1$.

Definition. For a given contract $\mathbb{K}_0$ that implements the $t = 0$ investment, a **date-one equilibrium** consists of a withdrawal decision $W^*(r)$, a date-one contract $K_1^*(\mathbb{K}_0, W^*)$, and a default outcome $\delta^* \in \{0, 1\}$ satisfying:

1. *Withdrawal optimality*: given the posterior belief α_0, W^* is given by:

$$W^*(d) \in \arg\max \pi_{0,1}(d)$$

and

$$W^*(u) \in \arg\max \pi_{0,1}(u)$$

2. *Short-term debt rate*: due to competition, $S^*(r)$ is such that

$$\pi_1(\mathbb{K}_0, W^*, r) = 0$$

3. *Belief consistency*: Denote by α_1 the date-one investors' posterior belief that both types of borrower pooled in equilibrium,

$$\alpha_1 = P(pool|\mathbb{K}_0, W^*, S^*)$$

4. *Default outcome*: given $W^* > 0$,

$$\delta^* = \begin{cases} 1, \text{ if } W^* S^* > x \\ 0, \text{ otherwise.} \end{cases}$$

A date-one equilibrium then consists of an optimal withdrawal decision by date-zero investors, upon which the bank has to raise capital at $t = 1$ to pay for the withdrawals. The short-term debt issued has a competitive rate S^* which implies an expected profit of 0 to date-one investors. If the required rate is such that the bank has to default on the withdrawals, then date-one investors do not provide funds to the bank at $t = 1$. Now we can characterize the date-zero equilibrium.

Definition. A **date-zero equilibrium** consists of a menu K_0^*, a choice of investment $i^* \in \{risky, riskless\}$, and an acceptance decision $a^* \in \{1, 0\}$ satisfying:

1. *Borrower's optimality*: $i_\gamma^* = risky$ if and only if

$$U_\gamma(\mathbb{K}_0^*, K_1^*, W^*, risky) > U_\gamma(\mathbb{K}_0^*, K_1^*, W^*, riskless)$$

2. *Investors' Participation Constraint*: fix a date-zero menu K_0^*. Investors make zero profits in expectation, i.e.,

$$\pi_0(K_0^*) = 0$$

3. *Belief consistency*: Denote by α_0 the date-zero investors' posterior that both types of borrower will pool in equilibrium,

$$\alpha_0 = P(pool|K_0^*)$$

4. *Intuitive Criterion*: The date-zero offer $\hat{K}_0$, inducing $\hat{\mathbb{K}}_0$ and $(\hat{K}_1, \hat{W}, \hat{\delta})$, is not an equilibrium menu if there exists another offer $\tilde{K}_0$, inducing $\tilde{\mathbb{K}}_0$ and $(\tilde{K}_1, \tilde{W}, \tilde{\delta})$, such that

$$U_G(\tilde{\mathbb{K}}_0, \tilde{K}_1, \tilde{W}) > U_G(\hat{\mathbb{K}}_0, \hat{K}_1, \hat{W})$$

and

$$U_B(\tilde{\mathbb{K}}_0, \tilde{K}_1, \tilde{W}) < U_B(\hat{\mathbb{K}}_0, \hat{K}_1, \hat{W})$$

5. *Feasibility*: $F^* \leqslant x$

A date-one equilibrium then guarantees that the borrower (bank) is maximizing its utility while anticipating the equilibrium outcome at $t = 1$ induced by the contract offered at $t = 0$.

Before going forward with the analysis of the game, I outline two relevant benchmarks, the constrained pareto-efficient allocation and the straight-debt allocation proposed by Diamond (1991).

2.2. Optimal Allocation

Following Myerson (1983), I solve the problem of a "competitive" planner who seeks to maximize the expected profits of a high-quality borrower (bank), subject to incentive compatibility, feasibility, and participation constraints. The planner can issue either a pooling contract or a separating menu. In general, the planner cannot offer contingent contracts as the model assumes that the signal observed by investors at $t = 1$ is not verifiable and therefore not contractible. However, as I show later, contingent outcomes are possible when we have pooling plus puttability of the debt. Notice that any contingent plan is only achieved through the presence of date-one investors bringing "new" money to supply any demand from date-zero investors when they update their information regarding the project quality at $t = 1$. Additionally, as shown by *Lemma* 5, puttability of the debt loses its effect when we have a separating equilibrium. Hence, we are back at solving the non-contingent planner's problem for a separating menu.

Contingent Planner (Pooling). I start by characterizing the pooling planner's allocation. Denote by $q \equiv f^d + (1 - f^d)\theta$, the date-one probability of repayment conditional on $r = d$. Generally, a contract for the contingent planner is a tuple $K_c = (I, l, z_{0,1}, z_{0,2}, z_1)$, of (i) borrowed amount $I = 1$ from date-zero investors; (ii) payment $z_{0,1}$ to date-zero investors at $t = 1$ contingent on $r = d$; (iii) payment $z_{0,2}$ to date-zero investors at time $t = 2$ contingent on $r = u$; and (iv) payment z_1 to date-one investors at time $t = 2$.

Definition. A contingent contract is **feasible** if it satisfies limited liability and the contingency constraint. Limited liability implies that $0 \leqslant z_{0,2} \leqslant x$ and $0 \leqslant z_1 \leqslant x$ when the project is successful. The contingency constraint requires that $z_{0,2} \geqslant z_{0,1}$ and $z_{0,1} \geqslant q z_{0,2}$.[9]

For any feasible contract offered by the planner, the payoff of the high-quality borrower is

$$U_G^c(K_c) \equiv e_G(x + c - z_1) + (1 - e_G)(x + c - z_{0,2})$$

[9]This guarantees that the planner is not offering state contingent contracts, but allowing for state contingent outcomes to rise naturally from the time one interaction between date-zero investors, the bank, and date-one investors. That is, it is simply the Revelation Principle at work.

The planner's profits are then defined as

$$\pi^c \equiv [f e_G + (1-f)] z_{0,1} + f(1-e_G) z_{0,2} - 1$$

where $z_{0,1}$ comes from the zero profit condition of date-one investors. That is,

$$\pi_1^c(d) \equiv \left[f^d + \left(1-f^d\right)\theta\right] z_1 = z_{0,1}$$

I define the contingent planner's problem (c-PP) as follows:

$$\begin{aligned} \max_{K_c} \quad & U_G^c(K_c) && \text{(c-PP)} \\ \text{subject to:} \quad & \\ & \pi^c(K_c) \geqslant 0 && \text{(PC)} \\ & K_c \text{ is feasible} \end{aligned}$$

That is, the planner is maximizing the payoff of a good borrower subject to feasibility and investors' participation constraints, i.e, the planner is not making losses in expectation. The next lemma presents the solution to the contingent planner when we have pooling.

Lemma 1 (Contingent Planner Solution)**.** *The optimal payments, $z_{0,1}^*$ and $z_{0,2}^*$ are the following:*

- $z_{0,1}^* = min\{qx; 1\}$;
- $z_{0,2}^* = \frac{1-[f e_G + (1-f)] z_{0,1}^*}{f(1-e_G)}$

as long as $\theta \geqslant \frac{1-\left[f^d(f e_G + (1-f)) + f(1-e_G)\right]x}{[f e_G + (1-f)](1-f^d)x}$.

Proof.

All proofs are in the appendix. □

By raising money at $t = 1$ from date-one investors when $r = d$, the planner can offer contingent payments to date-zero investors to the extent that they satisfy feasibility. Intuitively, a planner that maximizes the utility of a high-quality borrower wants to reduce the adverse selection problem it faces by forcing low-quality borrowers to pay the most as they possibly can. This is achieved here when borrowers raise capital at $t = 1$ after a downgrade to pay initial investors. When $qx > 1$, they cannot go all the way, otherwise they would be violating the contingency constraint, and thus feasibility.

Non-Contingent Planner (Separation). Given that the low-type has a negative NPV project, we would like to pay a certain amount to him at $t = 0$ to avoid making more losses in expectation. Thus, a non-contingent separating menu is a pair (y, M) of: (i) cash transfer y to the borrower at $t = 0$; or (ii) a 1 dollar transfer to the borrower at $t = 0$, contingent on him taking the investment opportunity, in exchange for a $t = 2$ payment M to the investor.

Definition. A menu (y, M) is **incentive compatible**, i.e., it separates high- from low-quality borrowers, if it satisfies $y \geqslant \theta(x + c - M)$. Moreover, it is **feasible** if $M \leqslant x$.

For any incentive compatible menu offered by the planner, the payoff of the high-type is

$$U_G^{nc}(y, D) \equiv x + c - M$$

while the planner's expected profits are

$$\pi^{nc}(y, M) \equiv f(M - 1) - (1 - f)y$$

Therefore, I define the non-contingent planner's problem (nc-PP) as follows:

$$\begin{aligned} \max_{y,M} \quad & U_G^{nc}(y, M) && \text{(nc-PP)} \\ \text{subject to :} & \\ & y \geqslant \theta(x + c - M) && \text{(IC-B)} \\ & \pi^{nc}(y, M) \geqslant 0 && \text{(PC)} \\ & M \leqslant x && \text{(Feasibility)} \end{aligned}$$

Lemma 2 (Non-Contingent Planner Solution)**.**

The solution to the non-contingent separating planner (y^*, M^*) is characterized by

- $M^* = \frac{f+(1-f)\theta(x+c)}{f+(1-f)\theta}$;
- $y^* = \theta(x + c - M^*)$;

as long as $\theta \leqslant \frac{f(x-1)}{(1-f)c}$

Notice that the separation cost increases in θ. Hence, when the adverse selection problem is severe, i.e., when θ is small, it will always be optimal to separate. Alternatively, the next proposition shows that if high-quality borrowers get downgraded with a relatively small probability, the pooling allocation will dominate the separating one in cases where the adverse selection problem is mild.

Proposition 1.

Let K_c^* be a solution to either (c-PP) or (c-PP'), and let (y^*, M^*) be a solution to (nc-PP). If $m > \underline{m}$, there will be $\theta_{\underline{m}} < \frac{1}{x}$ such that $U_G^c(K_c^*) > U_G^{nc}(y^*, M^*)$ if $\theta \geqslant \theta_{\underline{m}}$.

The optimality of the separating menu will depend on how strong is the adverse selection problem faced by investors at $t = 0$. That is, if θ is small, the low-quality borrower destroys a lot of resources if the risky investment is taken, thus separation will be optimal in such cases. On the other hand, as the low-type project NPV becomes less negative, the cost of separation increases — we need a higher cash transfer to satisfy the low-quality borrower incentive compatibility constraint of not investing — and therefore, pooling both types becomes efficient given that the cross subsidization decreases with θ.

2.3. Straight Debt Allocation

For the same notion of efficiency, Diamond (1991) focus attention on straight short- and long-term debt so that both types of borrowers invest in the risky asset. When investors make zero profits, the debt structure that maximizes the utility of the high-quality borrower is summarized in the following proposition.

Proposition 2 (Diamond 1991)**.** *Suppose that $qx < 1$. Short-term debt maximizes the profits of a high-quality borrower if $c \leqslant \hat{c}$, while long-term debt is optimal when $c > \hat{c}$.*

With straight short- and long-term debt, high-quality borrowers trade off the control rent loss due to liquidation when issuing short-term debt, and the excessive subsidy given to low-quality borrowers when issuing long-term debt. The next result shows that, whenever there is some risk of liquidation, straight debt will never implement the optimal allocation discussed above.

Lemma 3. *If $qx < 1$, straight debt does not implement the planner's solution.*

The difference between the allocation achieved through straight debt and the planner's allocation is twofold. First, conditional on pooling, the planner's allocation minimizes the subsidy from high- to low-quality borrowers while avoiding liquidation by exposing the borrowers to state-contingent outcomes. Second, for a certain parameter region, the planner's solution requires separation at the investment stage so that only the high-type invests in the risky asset, which is not achievable through single contracts.

3. Preliminary Results

In this section, I characterize the date-one equilibrium (W^*, K_1^*), given any date-zero contract $\mathbb{K}_0$ that implements investment. Under pooling at the investment stage, deposit withdrawals will occur depending on the withdrawal payment D relative to the long-term payment F, accounting for the credit rating update at $t = 1$.

Lemma 4 (Date-One Equilibrium under Pooling)**.**

Given a date-zero contract $\mathbb{K}_0$ that implements the $t = 0$ investment and $\alpha_1 = 1$, we have

1. $S^*(u) = 1$ *and* $W^*(u) = 0$;
2. $W^*(d) = 0$ *if:*
   - $\frac{F}{D} > \frac{1}{q}$;

3. $W^*(d) = D$, *otherwise. Hence,* $S^*(d) = \frac{1}{q}$.

Intuitively, given a credit rating upgrade, the short-term debt becomes risk-free as investors know for sure that the project will generate a cash flow of x at $t = 2$. Thus, date-zero investors will have no incentives to withdraw after an upgrade. Withdrawal decisions after a downgrade will depend on how costly it is to withdraw relative to the $t = 2$ rate of return. If the withdrawal payment is low enough, they will not withdraw their deposits, while for larger withdrawal payments relative to F, they will withdraw it fully. The short-term rate after a downgrade $S^*(d)$ will be the reciprocal of the project success probability conditional on pooling at the investment stage. Alternatively, if the date-zero menu implements separation at the investment stage, the date-zero investors' behavior will be very different. As I show next, the short-term rate is always equal to 1 and date-zero investors do not withdraw their deposits in this case, which is unexplored in Diamond (1991).

Lemma 5 (*Date-One Equilibrium under Separation*)**.**

Given a date-zero contract $\mathbb{K}_0$ *that implements the* $t = 0$ *investment and* $\alpha_1 = 0$, $S^*(d) = S^*(u) = 1$ *and date-zero investors do not withdraw at* $t = 1$, *i.e.,* $W^*(u) = W^*(d) = 0$.

If investors anticipate separation, they know that only the high-quality borrower had invested in the risky asset at $t = 0$, which means that, regardless of the credit rating update, the project will certainly yield a cash flow of x at $t = 2$. Thus, any date-one short-term debt will be riskless and consequently, date-zero investors will have no incentives to withdraw their deposits at $t = 1$ as they are, at the very least, not losing anything by waiting to be paid at $t = 2$. Therefore, any attempt to achieve a contingent allocation will not be feasible if the game induces type separation at the investment stage. Even though date-zero investors are still in control of their withdrawal choices, their optimal behavior in such a scenario will be equivalent to the case where borrowers are issuing only long-term debt, upon which investors would have no withdrawal choice. As a corollary of the previous couple of lemmas, we find that default is never an equilibrium outcome.

Corollary 1 (Default Outcome)**.**

Given a date-zero contract $\mathbb{K}_0$, the optimal withdrawal policy W^*, and the short-term debt rate of return S^*, $\delta^*(r) = 0$.

We would only observe a default if we have withdrawals and the early cash-out payment is large enough relative to the adverse selection discount, which never happens as $D \leqslant qx$.

4. Equilibrium and the Nature of Deposits

After characterizing the optimal withdrawal and short-term debt pricing at $t = 1$ for any date-zero contract, we can now turn our attention to the date-zero equilibrium. The next lemma shows important properties of the date-zero equilibrium contract.

Lemma 6. *Any date-zero equilibrium menu K_0, inducing $\mathbb{K}_0$, is pooling and maximizes the utility of a high-quality borrower.*

The pooling menu comes from the fact that a type-B project is negative NPV, while zero profits plus the Intuitive Criterion guarantees that the utility of the high type is maximized. The lemma above then highlights that the equilibrium contract is derived from the following program:

$$\begin{aligned}
&\max_{D,F,\phi} \quad U_G(\mathbb{K}_0, K_1, W) && \text{(GP)}\\
&\text{subject to :} \\
&\qquad \pi_0(K_0) = 0 && \text{(PC)}\\
&\qquad W(r) \in \arg\max \pi_{0,1}(r) && \text{(WC)}\\
&\qquad F \leqslant x
\end{aligned}$$

That is, the equilibrium contract is the one in which a high-quality borrower is getting maximum utility subject to investors' participation constraint, withdrawal constraint, and feasibility. The following two results show the date-zero equilibrium contracts under pooling and separation at the investment stage.

Lemma 7 (Date-zero equilibrium under separation)**.**

A date-zero equilibrium contract $\mathbb{K}_0^*$ *that implements separation at the investment stage is characterized by*

- $D^* \leqslant 1$;
- $\phi^* = 1 - \theta(x + c - F^*)$;
- $F^* = \frac{f+(1-f)\theta(x+c)}{f+(1-f)\theta}$;

as long as $\theta \leqslant \frac{f(x-1)}{(1-f)c}$.

Under a separation menu, *Lemma* 5 shows that we do not observe withdrawals at $t = 1$. Thus, the withdrawal payment has no relevance to achieve separation at the investment stage. We just need to make sure that the low-quality borrower will not have incentives to invest in the risky asset at $t = 0$, which is achieved when the long-term debt in the date-zero menu carries a relatively large subsidy $(1 - \phi)$. F and ϕ are then jointly determined so that date-zero investors are making zero profits in expectation and the low-type is indifferent between investing or not, guaranteeing that, conditional on separation, we are maximizing the high-type's profits. Separation always comes at a cost, thus increasing the face value of the debt issued by high-quality borrowers. Notice that, for c small enough, this would be the unique equilibrium if investors did not update their information on the quality of the project at $t = 1$. The game would be a standard signaling game as in Spence (1973), and as shown in Cho and Kreps (1987), the unique PBE that satisfies the intuitive criterion in such signaling games is the most efficient separating equilibrium.

Here, though, investors learn about the project's quality dynamically. Therefore, the possibility of exploiting their belief updating will possibly allow borrowers to achieve contingent outcomes without issuing contingent contracts. This happens only when both types of borrower are pooling in equilibrium, given that investors will potentially have different behavior, at $t = 1$, depending on the credit rating update they observe, as shown in *Lemma* 4. The next result shows that this is precisely the case. In the pooling equilibrium, the deposit contract issued at $t = 0$ will always induce withdrawals in order to minimize the cross-subsidy between high- and low-quality borrowers.

Proposition 3 (The Nature of Deposits and Straight Long-Term Debt Suboptimality)**.**

Suppose that the date-zero equilibrium contract $\mathbb{K}_0^*$ *pools both types of borrowers at the investment stage. Then, it must be true that* $\mathbb{K}_0^*$ *always induce withdrawals at* $t = 1$*. In other words, any date-zero contract which does not induce withdrawals at* $t = 1$ *(e.g., straight long-term debt) cannot be an equilibrium contract.*

The proposition above allows us to better understand the supply side nature of deposits. By delegating the maturity structure choice to investors, high-quality borrowers will guarantee that, whenever these depositors are actually facing low-quality borrowers, they will be able to extract more of the project's cash flow after a credit downgrade relative to the case where investors are given no choice and the maturity structure is predetermined at $t = 0$. Thus, by allowing investors to get a higher yield after a downgrade, the high-type is able to reduce the yield paid at $t = 2$ after a credit upgrade. That is, by issuing deposits, borrowers can get the benefits of favorable rollover terms after a credit upgrade as if it had issued straight short-term debt, without jeopardizing their solvency after a credit downgrade. This improves efficiency and, consequently, provides high-quality borrowers with extra profits given that they are undervalued at $t = 0$, whereas low-quality borrowers are overvalued.[10]

By restricting the contract space to straight short- and long-term debt, Flannery (1986) and subsequently Diamond (1991) predict that maturity transformation is at risk due to the costs of liquidation. *Proposition* 3 contradicts this prediction by showing that, whenever different borrower types are pooling in equilibrium, maturity transformation will always happen. In a very similar environment, Diamond (1993) argues that callable debt should improve on the allocation achieved through straight debt.[11] Intuitively, we could set the date-one calling price at qx, thus preventing disintermediation after a credit downgrade. Surprisingly, this would not work because, after a credit upgrade, high-quality borrowers would also have incentives to call

[10] I present a numerical example in the appendix.

[11] "Callable debt improves on the straight debt contracts in this model, although puttable debt does not." (Diamond (1993), p. 356).

the debt back, thus breaking down the callable debt equilibrium at $t = 0$. My next result shows that it is exactly the opposite, i.e., callable debt would never improve over straight short- or long-term debt.

Lemma 8.

Callable debt is always dominated by straight short or long term debt.

The reason is straightforward. A borrower will always have strictly more incentives to call the debt back after an upgrade relative to a credit downgrade in order to profit from a more favorable rollover pricing. Therefore, we will never be able to improve efficiency in the sense discussed by *Proposition* 3, as we will not be able to provide enough incentives to a low-quality borrower to call it back after a credit downgrade without inducing high-quality borrowers to also call it back after an upgrade. Next, I present the date-zero equilibrium under pooling at the investment stage and discuss its properties.

Proposition 4 (Date-zero equilibrium under pooling)**.**

In a date-zero equilibrium contract in which both borrower types invest we have $\phi^* = 0$ *and* (D^*, F^*) *is characterized by*

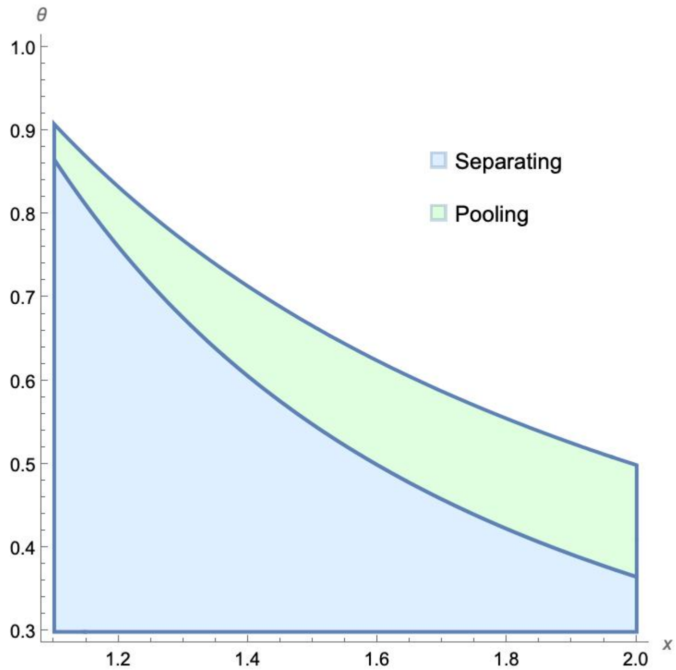
- $D^* = min\{qx; 1\}$;
- $F^* = \frac{1-[fe_G+(1-f)]D^*}{f(1-e_G)}$;

as long as $\theta \geqslant \frac{1-\left[f^d(fe_G+(1-f))+f(1-e_G)\right]x}{[fe_G+(1-f)](1-f^d)x}$.

When the project cash flow is small relative to the risk-free rate ($qx \leqslant 1$), investors will force borrowers to surrender all of it by withdrawing their deposits after a credit downgrade. The long-term yield is then bounded below proportionally by how much they are able to withdraw. *Figure 1* presents the date-zero equilibrium. As the project cash flow increases, it becomes more likely that the high-quality bank will prefer the pooling outcome by issuing deposit contracts. On the other hand, when the project cash flow is larger ($qx > 1$), high-quality borrowers would be willing to increase the short-term yield to reduce even more the long-term one paid out to

Figure 1: Date-zero Equilibrium

$f = 0.5$; $m = 5$; $c = 0$



investors; however, this would violate their incentive compatibility constraint as they cannot commit ex-ante to their actions upon the credit rating update. The next result then shows that there will always exist a parameter region where we have a pooling equilibrium at the investment stage.

Proposition 5 (Optimal Date-Zero Pooling)**.**

There exists $\underline{m} \in [1, \infty)$ *such that the date-zero equilibrium is pooling whenever* $\theta > \hat{\theta}_m$.

The proposition above shows that there will always exist a parameter region in which high-quality borrowers prefer to pool with low-quality ones at the investment stage to profit from the optimal withdrawal decisions of date-zero investors at $t = 1$, after a credit rating downgrade. In particular, this will be true when the probability that the high-type faces a credit downgrade and the adverse selection cost of raising capital are small enough, i.e., $m > \underline{m}$ and $\theta > \hat{\theta}_m$. In other words, the impossibility of issuing state contingent contracts makes the cost of separation increasing as the adverse selection problem decreases. This happens because, in anticipation of separation, investors will always provide the bank with cheap capital at $t = 1$.

The results above show that the solutions proposed by the literature, i.e. a mix of debt maturities or callable debt, does not work for this environment. None of these mechanisms achieve the same allocation as the menu of contracts analyzed here, which implements the ex-ante optimal allocation in Section 2. Next, I present some economic intuition behind the optimal contracts derived in the baseline model.

5. Comparative Statics

It is straightforward to calculate the duration of the liability structure when dealing with straight debt. Here, however, we need an alternative definition, given that it would only be ex-post determined after the demand deposits withdrawal decisions have been made. Hence, I define an expected duration measure, one that takes into account, at $t = 0$, the equilibrium outcomes at $t = 1$ given the menu of contracts offered at $t = 0$. That is, given a date-zero equilibrium menu that implements pooling at the investment stage, we have

$$\mathbb{E}\left[MacD_{pool}\right] \equiv [f e_G + (1-f)]\, D^*_{pool} + 2f(1-e_G)F^*_{pool} < 2$$

while for a date-zero equilibrium menu that implements separation at the investment stage, we have

$$\mathbb{E}\left[MacD_{sep}\right] \equiv 2\left[f F^*_{sep} + (1-f)\phi^*\right] = 2$$

Notice that, when the date-zero equilibrium menu implements separation at the investment stage, investors will not withdraw their deposits even after a credit downgrade, which will allow the high-type borrower to match the duration between its assets and liabilities in expectation. The next result highlights how the expected duration varies with model parameters.[12]

Proposition 6.

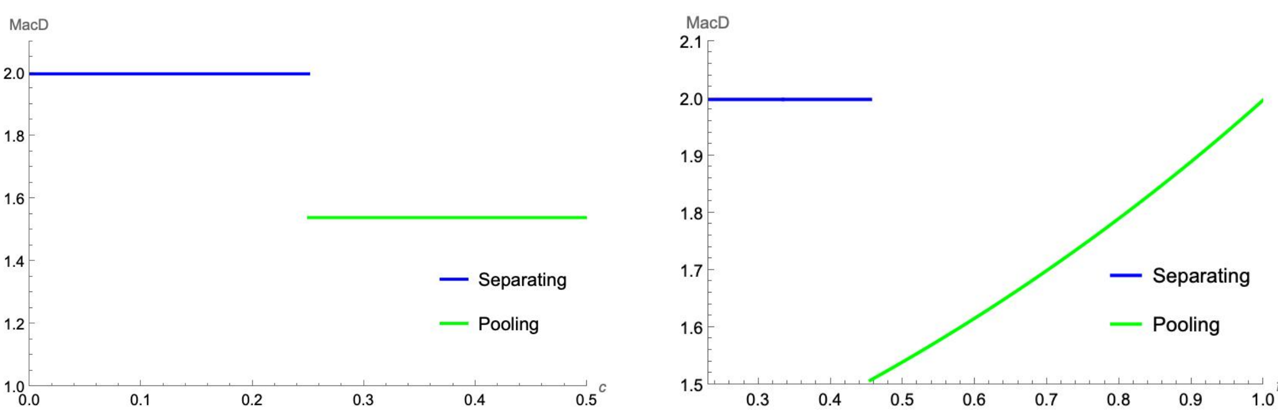
[12] I denote the parameter f as the credit rating of a high quality borrower, and I will refer to θ as the adverse selection problem intensity.

The expected duration defined above is generally

(a) weakly decreasing in the control rent c;

(b) U-shaped in the credit rating f.

Diamond (1991) argues that when the cost of disintermediation is high, i.e., c is large, borrowers would issue straight long-term debt in order to prevent early liquidation, whereas when the liquidation cost is not a concern, i.e., c is small, borrowers would choose a short-term liability structure. In contrast to his results, I show that the duration of the liability structure is non-increasing in c. This happens because, for large values of c, the date-zero equilibrium menu will implement pooling at the investment stage, and, as shown by *Proposition* 4, the equilibrium contractual terms for the deposit contract are independent of c. Moreover, when c is small enough, there will be a parameter region where high-quality borrowers prefer to separate at the investment stage given that the cost of separation decreases in c. As argued above, the separating menu has an expected duration of 2, therefore, the overall expected duration is, in general, weakly decreasing in c (Figure 2, panel (a)).



(a) $m = 5$; $x = 1.5$; $\theta = 0.5$; $f = 0.5$

(b) $m = 5$; $x = 1.5$; $\theta = 0.5$; $c = 0.3$

Figure 2: Expected Duration

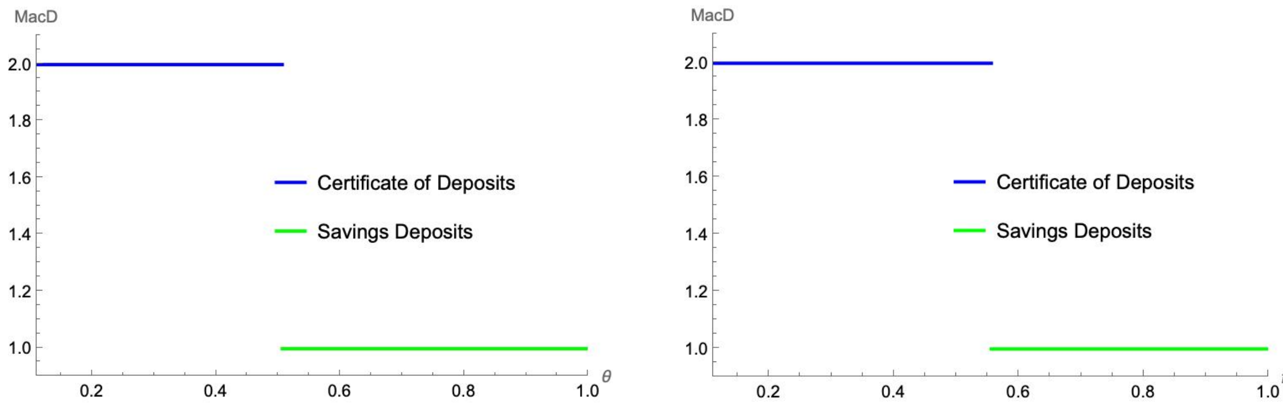
Also in contrast to Diamond (1991), I show that a high duration liability structure is a feature of low- or high-rated borrowers, while intermediate-rated borrowers front load payments because they are the ones most likely to face withdrawals after being downgraded. The U-shaped duration corroborates the prediction in Koufopoulos et al. (2023). The key difference is that, in their model, the rollover benefits increase in the credit rating for low values of f, leading high-type borrowers to underinvest and to have a liability structure duration that decreases in f for low-rated borrowers. On the other hand, as the adverse selection problem fades (f increases), the benefits of investment dominate the rollover benefits of having a shorter-term liability structure, which leads high-type borrowers to issue straight long-term debt. In my model, the main concern is with overinvestment. Therefore, for low-rated borrowers, the adverse selection problem prevents any pooling equilibrium, which then forces low-quality borrowers to not invest in the risky asset, guaranteeing a flat and high expected duration. As the adverse selection problem improves (f increases), pooling becomes the norm, given that investors are able to extract more from borrowers after a credit downgrade. Consequently, the duration increases in f for high-rated borrowers, as the increasing probability of a credit upgrade at $t = 1$ and project success overpower the front-loading terms of the demand deposit contracts ((Figure 2, panel (b)).

The benefit of taking into account the equilibrium outcomes in order to define the expected duration of the liability structure is that it allows us to have a clearer picture with regards to the maturity transformation and, consequently, to the maturity mismatch embedded in banks balance sheets, which can be relevant for assessing systemic risk, for example. If, instead, we were to use the common ex-ante definition of duration for deposit contracts, as in Drechsler et al. (2021) or Fleckenstein and Longstaff (2024), we would have a strikingly different conclusion in terms of maturity mismatch (Figure 3). In particular, the maturity mismatch would be the largest when the intensity of the adverse selection problem is the lowest or the credit rating is the highest.

Lemma 9. *Let certificates of deposits and savings deposits have a Macaulay duration of 2 and 1, respectively. Then, in equilibrium, borrowers' liability structure would have a duration that decreases in the credit rating (f) and in the intensity of the adverse selection problem (θ).*

The next *lemma* highlights why that is the case.

Lemma 10.



(a) $m = 5$; $x = 1.8$; $c = 0.3$; $f = 0.5$

(b) $m = 5$; $x = 1.8$; $c = 0.3$; $\theta = 0.5$

Figure 3: Ex-ante Duration

Conditional on pooling at the investment stage, borrowers issue certificates of deposits for θ small enough and traditional savings deposits when θ is larger.

This is an immediate consequence of *Proposition* 4. When the adverse selection problem is severe, the optimal deposit contract imposes a withdrawal penalty to avoid inefficient liquidation. On the other hand, when the adverse selection problem is mild, lenders can pledge their deposit in full without imposing solvency risks to the bank. This result reconciles the empirical evidence brought by Supera (2021), showing that the issuance of certificate of deposits correlates positively with risky loans in the presence of asymmetric information.

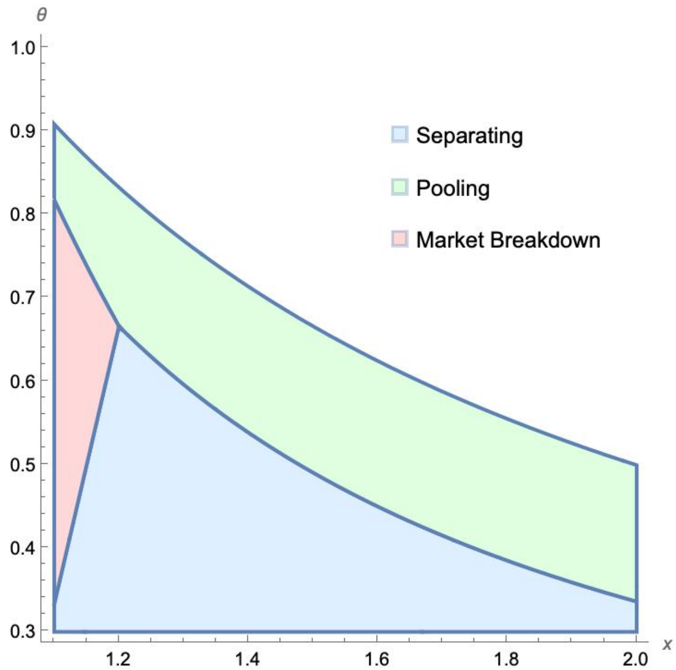
Proposition 7.

The cost of capital is hump-shaped in the intensity of adverse selection problem θ. As a consequence, there exist $\tilde{x} > 1$, $\underline{\theta}$, and $\bar{\theta}$ with $\underline{\theta} < \bar{\theta}$, such that, if $x < \tilde{x}$, the market breaks down and we have underinvestment when $\underline{\theta} < \theta < \bar{\theta}$. Moreover, there exists $\underline{f} < \bar{f}$ such that the cost of capital increases in m if $\underline{f} < f < \bar{f}$, for a certain parameter region.

The first couple of results contradicts classic intuition on static adverse selection and ex-post moral hazard models (e.g., Akerlof (1970); Calomiris and Kahn (1991)). In these models, it is expected that profits increase as we shrink the gap between low- and high-quality goods,

Figure 4: Date-zero Equilibrium

$f = 0.5$; $m = 5$; $c = 0.3$



or low- and high- cash flows.[13] As a consequence, it is expected that market would only break down for low values of θ. The same intuition applies here when we have pooling at the investment stage as the equilibrium outcome. That is, more cash will be pledgeable, conditional on a credit downgrade, the higher the θ, therefore, reducing the overall cost of capital. However, when θ is small enough, we will have separation at the investment stage, and we know that the cost of separation increases in θ, therefore reducing profits. Hence, market will break down for intermediate values of θ when future revenue x is not high enough to cover for the increasing cost of capital (Figure 4).

The last part provides a rationale for opaqueness. In general, it is expected that the signal precision (rating update) about types improves efficiency by reducing the cost of capital.[14] Intuitively, a more precise signal (higher m) reduces the chances that a high-type borrower will

[13]Keeping the high cash flow fixed.

[14]The signal precision in the model is captured by m. If $m \to \infty$, the rating update is fully informative, while when $m = 1$, the update is uninformative.

get downgraded at $t = 1$. Therefore, given a particular credit rating f, the date-zero probability of repayment at $t = 2$ increases in m, which reduces the cost of capital. The problem is that, by increasing the signal precision, we are worsening the adverse selection problem at $t = 1$ conditional on a credit downgrade.[15] As a consequence, lenders will get a lower $t = 1$ withdrawal payment, which increases the cost of capital. This negative effect on the date-one adverse selection problem is more pronounced for higher-rated borrowers (large f), but the probability of a credit downgrade is higher for lower-rated borrowers. Thus, this positive effect of a higher signal precision on the cost of capital will be relevant for intermediate-rated borrowers, whose profits can therefore increase with opaqueness (lower m). Next, I discuss some low-quality borrowers' profits patterns.

Proposition 8. *There exists $\underline{\theta} < \bar{\theta}$ such that the profits of a low-quality borrower increase in θ for $\theta < \underline{\theta}$ and for $\theta > \bar{\theta}$, but it is zero for $\underline{\theta} < \theta < \bar{\theta}$.*

This result contradicts the intuition of classic adverse selection models such as Akerlof (1970) and Nachman and Noe (1994), where the profits of a low-type seller or borrower are generally increasing in θ. Here, it is piecewise increasing. When θ is high enough, borrowers are issuing traditional savings deposits and the expected profits of a low-quality borrower increase as the probability of generating a high cash flow at $t = 2$ increases. For low values of θ, the date-zero equilibrium menu separates borrowers at the investment stage, and we know that the face value of the debt issued by low-quality borrowers ϕ decreases with θ. However, for intermediate values of θ, the optimal menu is pooling and certificates of deposits are issued, forcing low-quality borrowers into zero profits.

To approximate the model to other real-life features of banking, I model three different generalizations. The key of the first two extensions is to introduce depositors' heterogeneity. First, I explore the case in which a fraction of the bank's supply of capital is unsophisticated and, therefore, uninformed regarding any credit rating update. Then, I introduce different levels of risk-aversion for the bank's supply of capital. Finally, I allow for investment scalability by assuming that the risky investment marginal return decreases in size. I show that these extensions have important consequences for banks' capital structure and that they have relevant

[15] Notice that $\frac{\partial q}{\partial m} = -\frac{f(1-\theta)}{m^2}$.

policy implications, especially for deposit insurance.

6. Model Extensions

In this section, I present the three extensions mentioned above and examine potential ex-ante inefficiencies that arise relative to the baseline model. Then, in the next section, I will discuss what government policies can help mitigate these inefficiencies.

6.1. Unsophisticated (Sticky) Depositors

Consider an alternative version of the baseline model in which, out of the date-zero dollar supply of capital the borrower has access to, a fraction $(1-\gamma)$ of it comes from investors who observe the credit rating update at $t=1$, while there is plenty of date-zero supply of capital from investors who do not observe it. Again, for simplicity, I assume that we are always in the pooling region at the investment stage. The next result shows that, when the proportion of capital needed from sticky depositors γ is relatively small, a good borrower can achieve the same level of profits as in the baseline model.

Proposition 9. *Suppose $qx \leqslant 1$. There exists $\gamma^* \in (0, qx)$ such that, if $\gamma \leqslant \gamma^*$, the borrower will optimally issue a quantity γ of traditional savings deposits with a gross interest rate equal to one, and a quantity $(1-\gamma)$ of deposits with a withdrawal payment $D = qx - \gamma$ and a long-term non-withdrawal payment $F = \frac{(1-\gamma)-[fe_G+(1-f)](qx-\gamma)}{f(1-e_G)}$.*

The proposition above highlights the fact that when a small fraction of the capital supply is unsophisticated (sticky), banks can still achieve the same level of ex-ante efficiency as in the baseline model. This happens because they are able to adjust the short- and long-term yields of the (time) deposits issued to sophisticated investors in such a way that the incentive compatibility constraint to withdraw after a credit downgrade is still satisfied. In other words, sophisticated investors absorb the potential inefficiencies caused by the lack of information regarding the borrowers' financial health. On the other hand, in the absence of any market solution, when the presence of unsophisticated investors is more pervasive in the borrowers' capital structure, then the ability to have a state-contingent liability structure is hampered, which would cause an efficiency loss as "Good" borrowers' profit level is diminished. Alternatively, in such a situation, an endogenous staggered intermediation structure could arise. The next result shows that when sophisticated investors act as an intermediary between the bank and the sitcky depositors, the efficiency from the baseline model is restored.

Proposition 10. *Suppose that $\gamma > \gamma^*$. Consider the following intermediation structure. The bank issues the deposit contract from Proposition 4 to a sophisticated investor, who then issues equity plus the same deposit contract to sticky depositors. This guarantees the same profit level as in the baseline model.*

Recall that sticky depositors do not observe the credit update at $t = 1$. Therefore, we need to guarantee that the sophisticated investor, acting as an intermediary, will have proper incentives to optimally withdraw the deposit when needed. Issuing demand deposits will prevent the intermediary from holding up the sticky depositors when $r = d$ against their lack of information. Notice that if straight debt was issued, the intermediary could threaten not to liquidate when $r = d$, and then renegotiate lower payments at $t = 2$. With demand deposits, any threat will be matched by withdrawals, which in turn would force the intermediary to withdraw their deposit from the bank. On the other hand, issuing equity will prevent the intermediary from suboptimally withdrawing at $t = 1$ when $r = u$. If the intermediary retained equity in the venture, she could withdraw when an upgrade is observed and negotiate some profit sharing with the bank, given that, after a credit upgrade, the bank can issue new debt very cheaply.

6.2. Risk-Neutral vs. Risk-Averse Investors

Suppose that at each date $t \in \{0, 1\}$ there exists a λ supply of risk-neutral capital along with an unlimited supply of infinitely risk-averse capital. In addition, risk-neutral investors receive an endowment at $t = 2$, and are not protected by limited liability.[16] The next result shows that, whenever the supply of risk-neutral capital is limited relative to the amount required to invest in risky loans, banks will issue a mix of traditional savings deposits and certificates of deposits.

[16]This endowment could be also thought of as the return of an investment made prior to $t = 0$.

Proposition 11 (Mix of Savings Deposits and CDs.). *Suppose that $\underline{\lambda} < \lambda < 1$. Borrowers will optimally issue a quantity $(1-\lambda)$ of traditional savings deposits with rate of return equal to one, and a quantity λ of certificates of deposits with withdrawal payment $D = 2\lambda - 1$ and long-term non-withdrawal payment $F = \frac{\lambda - [f e_G + (1-f)]D}{f(1-e_G)}$.*

The issuance of CDs is crucial to create balance sheet capacity when the supply of risk-neutral capital is limited. Without CDs, banks would not be able to finance loans subject to information asymmetries when the supply of capital needed exceeds the supply of risk-neutral capital. On the other hand, when there is an abundant supply of risk neutral capital $\lambda > 1$ and the adverse selection problem is mild $qx > 1$, high-quality banks will have incentives to expand the balance sheet, invest in risky loans and risk-free securities, and issue credit default swaps on their risky loans.

Proposition 12 (Balance Sheet Expansion). *Suppose that $\lambda > 1$ and that $qx > 1$. Borrowers will optimally issue a quantity $Q = \min\{\lambda, qx\}$ of traditional savings deposits, invest the excess capital raised $I = Q - 1$ into risk-free securities and issue a CDS to risk-neutral investors which pays I to investors in case of loan default at $t = 2$, and investors are required to pay a premium $P = \frac{(1-q_0)I}{q_0}$ to the bank in case of loan success, where q_0 is the date-zero probability of loan success.*

This result highlights the fact that larger banks are primarily funded with traditional savings deposits. When the supply of risk-neutral capital is abundant and the bank's loans are profitable relative to the adverse selection problem $qx > 1$, the bank has excess capacity in its balance sheet to make risky loans and still be able to sell insurance against them. This happens because it is cheap for high-quality borrowers to sell insurance given that they are certain their loans will not default at $t = 2$, and therefore, they can earn the insurance premium without facing the risk of delivering the insurance payment.

6.3. Variable Investment

Suppose that the payoffs from investing in the risky project are scalable with the size of the investment (I). Hence, let us assume that the risky investment scales in size $x(I)I$, the marginal return is decreasing $x'(I) < 0$ and convex $x''(I) \leqslant 0$, and that the private control rent scales one-to-one cI. The next proposition shows that the capital structure, short-term debt vs. deposits, has real effects on the investment size.

Proposition 13. *The investment size that maximizes the profits of the high-quality borrower under short-term debt (I^*_{st}) is smaller than under deposits (I^*_{dep}).*

When issuing deposits, borrowers increase their marginal utility relative to issuing short-term debt, which usually force them into disintermediation with positive probability. Hence, given that concavity in the risky investment return implies that the marginal cost of capital increases in size, banks will increase borrowing to match the higher marginal utility.

7. Policy Implication

In this section I discuss how a well known FDIC regulatory policy can help mitigate the inefficiency discussed in section 6.1.

7.1. FDIC Insurance

Consider the model extension where a fraction γ of the date-zero capital supply is not informed at $t = 1$. *Proposition* 9 showed that, when γ is large enough, there will be potential efficiency losses incurred by the high-quality borrower if the staggered intermediation solution is institutionally too costly. This happens because the fraction of sophisticated investors is small enough to absorb the lack of information from the unsophisticated ones. The next proposition highlights that, when the government commits to charge an insurance premium from borrowers who get downgraded, then efficiency is restored.

Proposition 14. *Suppose that $qx < 1$. Consider the following policy. At $t = 1$, conditional on observing a credit downgrade, the government commits to charge an insurance premium totaling ρ dollars to the bank. At $t = 2$ if the bank fails, the government pays an insurance ρ to date-zero depositors who still hold deposits at the bank, and if the bank is still solvent it gets the premium back.*

Given this policy, banks can issue the same deposit contract from Proposition 4 so that efficiency is restored if

$$\rho = \gamma F^* + \frac{\rho}{q} - \gamma x \qquad \text{(Optimality Condition)}$$

where $F^* = \frac{1-[f e_G+(1-f)]qx}{f(1-e_G)}$.

The insurance policy guarantees that uninformed investors will get the same expected return that sophisticated investors get conditional on their optimal withdrawal decisions. Lack of information and the presence of insurance creates stickiness that is not harmful to banks profits, as the premium is charged conditional on the credit rating, therefore, providing the same optimality conditions of the baseline model.

8. Conclusion

When there is asymmetric information between banks and depositors, I show that the inefficiencies coming from the inability to issue state contingent claims is partially mitigated by the issuance of deposits as they induce investors to withdraw conditional on their information about banks' asset quality. This is critical when investors learn with a delay, as the correlation between withdrawals and negative signals about banks' loan quality helps reduce the cost of capital of high-quality banks. In addition, I show that the deposit yield structure is tailored so that banks remain solvent even after negative news, thus capturing the benefits offered by both short- and long-term debt.

With that, I reconcile several empirical facts by showing that the duration of banks' liability structure is U-shaped in their credit rating, that smaller banks, due to a more intense adverse selection problem, rely to a large extent on the issuance of certificate of deposits, while larger banks rely heavily on traditional savings deposits. In addition, larger banks use their balance sheet capacity to invest in risk-free securities and issue credit default swaps on their risky loans.

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A. Benchmark Proofs

A.1. Proof of *Lemma* 1

Proof. Suppose (K_c^*) is a solution to (c-PP).

1st observation. Zero profits — (PC) must bind.

Notice that $z_{0,t}^* > 0$ for some $i \in \{1,2\}$. Fix $z_{0,\tau}^* > 0$. Assume $\pi^c(K_c^*) > 0$. Then, because of continuity, one can set $\hat{z}_{0,\tau} = z_{0,\tau}^* - \varepsilon$, for some $\varepsilon > 0$, such that $\hat{K}_c$ — which is equal to K_c^* except for $z_{0,\tau} = \hat{z}_{0,\tau}$ — is feasible, $\pi_c(\hat{K}_c) > 0$, and $U_G(\hat{K}_c) > U_G(K_c^*)$. Therefore, (K_c^*) cannot be a solution to (c-PP), which implies that (PC) must bind.

2nd Observation. $z_{0,1}^* = \min\{qx; 1\}$, where $q = \left[f^d + (1-f^d)\theta\right]$. That is, we want to pay as most as we can to date-zero investors at $t = 1$, i.e., we want to raise whatever the project allows from date-one investors, conditional on the adverse selection discount after a credit rating downgrade.

Notice that, conditional on no liquidation after a credit downgrade,

$$\frac{\partial U_G^c}{\partial z_{0,1}} = -e_G \frac{\partial z_1}{\partial z_{0,1}} - (1-e_G)\frac{\partial z_{0,2}}{\partial z_{0,1}}$$

From the date-one investors zero profit condition we know that

$$\frac{\partial z_1}{\partial z_{0,1}} = \frac{1}{q}$$

and, from the zero profits condition of date-zero investors we get

$$\frac{\partial z_{0,2}}{\partial z_{0,1}} = -\frac{[f e_G + (1-f)]}{f(1-e_G)}$$

Therefore,

$$\frac{\partial U_G^c}{\partial z_{0,1}} = -\frac{e_G}{q} + \frac{[f e_G + (1-f)]}{f}$$

Notice that, $\frac{dU_G^c}{dz_{0,1}} \geqslant 0$ if

$$\theta \geqslant \frac{f e_G}{(1-f^d)[f e_G + (1-f)]} - \frac{f^d}{1-f^d} \equiv \tilde{\theta}$$

Claim. $\tilde{\theta} = 0$

Rearranging $\tilde{\theta}$ we get

$$\tilde{\theta} = \frac{f e_G - f^d [f e_G + (1-f)]}{(1-f^d)[f e_G + (1-f)]} = \frac{f e_G(1-f^d) - f^d(1-f)}{(1-f^d)[f e_G + (1-f)]}$$

Given that $e_G = \frac{1-f}{m-f}$ we get

$$\tilde{\theta} = \frac{f(1-f)(1-f^d) - f^d(1-f)(m-f)}{(1-f^d)[f e_G + (1-f)](m-f)} = \frac{(1-f)\left[f - f f^d - f^d m + f f^d\right]}{(1-f^d)[f e_G + (1-f)](m-f)} = \frac{(1-f)(f - f^d m)}{(1-f^d)[f e_G + (1-f)](m-f)} = 0$$

given that $f^d = \frac{f}{m}$. Therefore, $\frac{dU_G^c}{dz_{0,1}} \geqslant 0$ for any $\theta \geqslant 0$.

Hence, we want to set $z_1^* = x$, so that $z_{0,1}^* = qx$. We just need to check for feasibility, in particular for the contingency constraint. From date-zero investors' (PC) we get

$$z_{0,2} = \frac{1 - [f e_G + (1-f)] z_{0,1}}{f(1-e_G)}$$

Thus, if $qx \geqslant 1$ we must set $z_{0,1} = 1$ in order not to violate the contingency constraint.

Finally, we need to make sure $z_{0,2} \leqslant x$ to satisfy feasibility. If $qx \geqslant 1$ feasibility is satisfied given that $z_{0,1}^* = 1$ and thus $z_{0,2}^* = 1 < x$. However, if $qx < 1$ we need to check if

$$\frac{1 - [f e_G + (1-f)] qx}{f(1-e_G)} \leqslant x$$

That is, $z_{0,2}^*$ will be feasible if and only if

$$\theta \geqslant \frac{1 - \left[f^d (f e_G + (1-f)) + f(1-e_G)\right] x}{[f e_G + (1-f)](1-f^d) x}$$

$\square$

A.2. Proof of *Lemma* 2

Proof.

By similar arguments as in *lemma* 1, both the participation constraint and the incentive compatibility must bind at the optimal solution for the planner's problem. Therefore, from the (IC-B) we have

$$y^* = \theta(x + c - M)$$

and from the (PC) we have

$$f(M-1) = (1-f)\theta(x+c-M)$$

which implies that

$$M^* = \frac{f + (1-f)\theta(x+c)}{f+(1-f)\theta}$$

We just need to guarantee feasibility, i.e., $M^* \leqslant x$, that is

$$\theta \leqslant \frac{f(x-1)}{(1-f)c}.$$

$\square$

A.3. Proof of *Proposition* 1

Proof.

From *Lemma 2* we get that

$$U_G^{nc}(y^*, M^*) = x + c - \frac{f + (1-f)\theta(x+c)}{f+(1-f)\theta}$$

To check when the pooling contingent solution is preferred we need verify in which case the contingent planner's utility is greater than the non-contingent one. That is, if

$$U_G^c(K_c^*) > U_G^{nc}(y^*, M^*)$$

Let $\underline{\mathrm{m}}$ be such that $\frac{\partial U_G^c(K_c^*, \underline{\mathrm{m}})}{\partial m} = 0$. In that case, it must be true that $qx < 1$, for any $m > \underline{\mathrm{m}}$.

From the inequality above we must have

$$(1-e_G)\left[x - \frac{1-[fe_G + (1-f)]qx}{f(1-e_G)}\right] > x - \frac{f + (1-f)\theta(x+c)}{f+(1-f)\theta}$$

Thus, taking $m \to \infty$ and $c \to 0$, the inequality above becomes

$$x - \frac{1-(1-f)\theta x}{f} > x - \frac{f+(1-f)\theta x}{f+(1-f)\theta}$$

which leads us to the following quadratic inequality

$$(1-f)^2 x\theta^2 + (1-f)[2fx-1]\theta - f(1-f) > 0$$

The roots of the "equation" above are then

$$\theta_1 = \frac{-(2fx-1) - \sqrt{(2fx-1)^2 + 4f(1-f)x}}{2(1-f)x} < 0$$

and

$$\theta_2 = \frac{-(2fx-1) + \sqrt{(2fx-1)^2 + 4f(1-f)x}}{2(1-f)x}$$

Claim. $\theta_2 < \frac{1}{x}$

To check it, we verify if

$$\frac{-(2fx-1) + \sqrt{(2fx-1)^2 + 4f(1-f)x}}{2(1-f)x} < \frac{1}{x}$$

which simplifies to

$$x(1-f^2)(x-1) > 0$$

This is always true given that $x > 1$, and $0 < f < 1$.

Therefore, we can conclude that $\exists \underline{\mathrm{m}} \in (1,\infty)$ and $\hat{\theta}_{\underline{\mathrm{m}}}$ solving $U_G^c(K_c^*) = U_G^{nc}(y^*, M^*)$ such that $\hat{\theta}_{\underline{\mathrm{m}}} = \frac{1}{x}$. Hence, $\forall m > \underline{\mathrm{m}}$, $\exists \theta_m < \hat{\theta}_{\underline{\mathrm{m}}}$ solving $U_G^c(K_c^*) = U_G^{nc}(y^*, M^*)$ and such that $U_G^c(K_c^*) > U_G^{nc}(y^*, M^*)$ for $\theta_m < \theta < \frac{1}{x}$.

□

A.4. Proof of *Proposition* 2

Proof. Notice that the face value of a short-term debt F_{st} must be at least 1. Hence, given that $qx < 1$, borrowers would get liquidated after a credit downgrade, since $\frac{F_{st}}{q} > x$. Therefore, the utility of a high-quality borrower issuing a short-term debt is given by

$$U_G^{st} = (1-e_G)(x+c-F_{st})$$

where F_{st} is determined by the date-zero investors participation constraint. That is,

$$[f e_G + (1-f)]qx + f(1-e_G)F_{st} = 1$$

implying that $F_{st} = \frac{1-[f e_G + (1-f)]qx}{f(1-e_G)}$.

On the other hand, the utility of a high-quality borrower after issuing a long-term debt with face value F_{lt} is given by

$$U_G^{lt} = x + c - F_{lt}$$

where $F_{lt} = \frac{1}{f+(1-f)\theta}$, i.e., the reciprocal of the date-zero probability of repayment at $t = 2$.

Hence, issuing short-term debt will be optimal if and only if $U_G^{st} \geqslant U_G^{lt}$, that is

$$F_{lt} + e_G x - (1 - e_G) F_{st} \geqslant e_G c$$

i.e.,

$$c \leqslant \frac{F_{lt} + e_G x - (1 - e_G) F_{st}}{e_G}$$

□

A.5. Proof of *Lemma* 3

Proof. Recall that, in the optimal allocation from *Lemma* 1, the high-quality bank gets

$$U_G^{optimal} = e_G c + (1 - e_G)(x + c - z_{0,2}^*)$$

Notice, however, that $z_{0,2}^* = F_{st}$. Therefore, $U_G^{optimal} > U_G^{st}$. □

B. Baseline Model Proofs

B.1. Proof of *Lemma* 5

Proof.

The short-term debt rate S^* is determined competitively by setting date-one investors profits to zero. Thus, under separation we have

$$\pi_1^{sep}(\mathbb{K}_0, W, d) = W(d)S^*(d) - W(d) = 0$$

and

$$\pi_1^{sep}(\mathbb{K}_0, W, u) = W(u)S^*(u) - W(u) = 0$$

which implies that $S^*(d) = S^*(u) = 1$.

Remember that date-zero investors profits at $t = 1$ are

$$\pi_{0,1}^{sep}(r) = \frac{F}{D}\left(DI - W(s)\right) + W(s)$$

Differentiating it with respect to $W(r)$ we get

$$\frac{\partial \pi_{0,1}^{sep}}{\partial W(r)} = 1 - \frac{F}{D} \leqslant 0$$

since $D \leqslant F$, otherwise the CD would be a straight short-term debt. Thus, we conclude that $W^*(u) = W^*(d) = 0$.

□

B.2. Proof of *Lemma* 4

Proof.

The short-term debt rate S^* is determined competitively by setting date-one investors profits to zero. Thus, under pooling we have

$$\pi_1^{pool}(\mathbb{K}_0, W, u) = W(u)S^*(u) - W(u) = 0$$

which implies that $S^*(u) = 1$. Thus, to determine the optimal withdrawal choice we need to check for the date-zero investors' profits at $t = 1$, that is

$$\pi_{0,1}^{pool}(u) = W(u) + \frac{F}{D}(DI - W(u))$$

Differentiating with respect to $W(u)$ we get

$$\frac{\partial \pi_{0,1}^{pool}(u)}{\partial W(u)} = 1 - \frac{F}{D} \leqslant 0$$

Therefore, $W^*(u) = 0$.

Moving on to the credit downgrade, date-zero investors profits at $t = 1$ are equal to

$$\pi_{0,1}^{pool}(d) = W(d) + q\frac{F}{D}(D - W(d))$$

Differentiating $\pi_{0,1}^{pool}(d)$ with respect to $W(d)$ we get

$$\frac{\partial \pi_{0,1}^{pool}(d, W(d) = 0)}{\partial W(d)} = 1 - q\frac{F}{D}$$

That is, if

$$1 - q\frac{F}{D} < 0$$

We will have $W^*(d) = 0$. Otherwise, $W^*(d) = D$. Additionally, from date-one investors zero-profit condition we have $S^*(d) = \frac{1}{q}$.

□

B.3. Proof of *Corollary* 1

Proof.

Follows immediately from *Lemmas* 5 and 4.

□

B.4. Proof of *Lemma* 6

Proof.

I will show that any date-zero equilibrium contract maximizes the utility of a type-G borrower. Suppose by contradiction that it does not. That is, let $\mathbb{K}_0^*$ be a date-zero equilibrium contract which does not maximize the utility of a type-G borrower.

Let $\mathbb{K}'_0$ be a date-zero contract that solves the type-G borrower problem (GP),

$$\max_{I,D,L} \quad U_G(\mathbb{K}_0, K_1, W) \tag{GP}$$

$$\text{subject to:}$$

$$\pi_0(K_0) = 0 \tag{PC}$$

$$F \leqslant x$$

It must be that $U_G(\mathbb{K}'_0, K'_1, W') > U_G(\mathbb{K}^*_0, K^*_1, W^*)$, where K'_1 and W'_1 are the date-one equilibrium contract and the optimal $t = 1$ withdrawal policy induced by $\mathbb{K}'_0$.

Notice that in any date-zero equilibrium contract, the type−G borrower always invest in the risky asset, and it must be true that $U_B(\mathbb{K}'_0, K'_1, W') < U_B(\mathbb{K}^*_0, K^*_1, W^*)$, otherwise date-zero investors would be making losses in equilibrium, given that both $\mathbb{K}^*_0$ and $\mathbb{K}'_0$ satisfy investors participation constraint. Thus, $\mathbb{K}^*_0$ does not survive the Intuitive Criterion and cannot be a date-zero equilibrium contract.

□

B.5. Proof of *Lemma* 7

Proof.

Follows immediately from *Lemma* 5 and noticing that this is exactly the non-contingent planner's problem solved in *Lemma 2* if we set $\phi = 1 - y$ and $F = M$.

□

B.6. Proof of *Proposition* 3

Proof.

Suppose the pooling equilibrium contract is such that it induces $W^*(d) = 0$ at $t = 1$. Then, from the zero profit condition of date-zero investors at $t = 0$, we have

$$[f + (1 - f)\theta]F = 1$$

Thus,

$$F = \frac{1}{f + (1 - f)\theta}$$

and, therefore, the utility of the type-G borrower will be

$$U_G(W(d) = 0) = x + c - \frac{1}{f + (1 - f)\theta}$$

Now, I move on to the case in which withdrawals are induced in equilibrium. Recall from *Lemma* 4 that withdrawals will happen at $t = 1$ after a credit downgrade only if $\frac{F}{D} \leqslant \frac{1}{q}$. I will show that there always exists a feasible pooling contract where: (i) date-zero investors are withdrawing at $t = 1$ after a credit downgrade; and (ii) it dominates the one in which withdrawals do not happen.

Again, from date-zero investors zero profit condition at $t = 0$ we have

$$(f e_G + (1-f))D + f(1-e_G)F = 1$$

that is,

$$F = \frac{1-[f e_G + (1-f)]D}{f(1-e_G)}$$

The utility of the "Good" borrower will then be

$$U_G(W(d) = D) = x + c - e_G\frac{D}{q} - (1-e_G)\frac{1-[f e_G + (1-f)]D}{f(1-e_G)}$$

Therefore, the question is:

Is there a value of D satisfying:

1. $D > qF$, where $F = \frac{1-[f e_G+(1-f)]D}{f(1-e_G)}$, guaranteeing that (i) date-zero investors are indeed withdrawing at $t = 1$; and (ii) F is such that they are not making losses in expectation;

2. $DS \leqslant x$, where $S = \frac{1}{q}$, guaranteeing that the withdrawal from date-zero investors would not lead to default;

3. $D \leqslant 1$, otherwise this puttable debt would be suboptimal;

4. $e_G\frac{D}{q} + (1-e_G)\frac{1-[f e_G+(1-f)]D}{f(1-e_G)} < \frac{1}{f+(1-f)\theta}$, guaranteeing that indeed a pooling equilibrium inducing withdrawals is dominant, i.e., $U_G(W(d) = D) > U_G(W(d) = 0)$.

Moreover, this comparison between both pooling equilibria, with and without withdrawals, is valid only if the pooling equilibrium without withdrawals is feasible. Meaning that, the long term competitive rate of return has to be less or equal than x. That is, $\frac{1}{f+(1-f)\theta} < x$. Therefore, we assume this condition holds and then I can verify whether or not all conditions $1-4$ above are valid.

Condition (1) implies that

$$D > \frac{q}{f(1-e_G) + q[f e_G + (1-f)]} \equiv D_1$$

whereas, condition (4) requires that

$$D > \frac{q(1-f)\theta}{q[fe_G + (1-f)] - fe_G} \equiv D_4$$

Claim. $D_4 \leqslant D_1$. Thus, if that is true, then condition (4) would be irrelevant. Hence, notice that $D_4 \leqslant D_1$ if

$$(1-f)\theta\{f(1-e_G) + q[fe_G + (1-f)]\} \leqslant q[fe_G + (1-f)] - fe_G$$

that is, if

$$f(1-f)\theta \leqslant \{q[fe_G + (1-f)] - fe_G\}[1-(1-f)\theta]$$

Given that $e_G = \frac{1-f}{m-f}$, the inequality above simplifies to

$$(m-f)f\theta \leqslant (qm-f)[1-(1-f)\theta]$$

Additionally, given that $q = f^d + (1-f^d)\theta$ and that $f^d = \frac{f}{m}$ the inequality above further simplifies to

$$(1-f)\theta[(m-f)\theta - (m+f)] \leqslant 0$$

which is always true. Therefore, condition (4) is irrelevant and we can keep checking the other 3 conditions. Notice that, if $\frac{D_1}{q} \leqslant x$ and $D_1 \leqslant 1$, then by continuity there must exist a feasible D satisfying all conditions $1-4$.

We start by checking whether $\frac{D_1}{q} \leqslant x$. Given that we assumed that $\frac{1}{f+(1-f)\theta} < x$ to satisfy the feasibility constraint of a pooling equilibrium without withdrawals, it is enough to check if $\frac{D_1}{q} \leqslant \frac{1}{f+(1-f)\theta}$. That is, if

$$\frac{1}{f(1-e_G) + q[fe_G + (1-f)]} \leqslant \frac{1}{f + (1-f)\theta}$$

which leads to

$$f e_G(1-q) \leqslant (1-f)(q-\theta)$$

Again, given that $e_G = \frac{1-f}{m-f}$ the inequality above simplifies to

$$f(1-\theta) \leqslant m(q-\theta)$$

Additionally, given that $q = f^d + (1-f^d)\theta$ and that $f^d = \frac{f}{m}$ the inequality above further simplifies to

$$f(1-\theta) \leqslant f(1-\theta)$$

which is obviously always true. We remain to check if $D_1 \leqslant 1$. That is, if

$$\frac{q}{f(1-e_G)+q\left[f e_G+(1-f)\right]} \leqslant 1$$

Notice that the above inequality can be simplified to

$$qf \leqslant f$$

which is always true given that $q \leqslant 1$.

Hence, we can conclude that, given a pooling date-zero contract, there will always exist a feasible pair (D, F) such that date-zero investors are withdrawing at $t = 1$ after a credit downgrade, the level of withdrawals does not lead to default and that this contract dominates any date-zero pooling contract that induces no withdrawal at $t = 1$.

□

B.7. Proposition 3 - Example

The following example highlights the contingent outcomes and its allocative improvement relative to straight debt.

Example 1. *Consider a risk-neutral monopolistic bank at $t = 0$ in need for funds to take a risky investment opportunity (loan) costing \$1. If the investment is of good quality (G), it returns a cash flow of $x = \$1.5$ at $t = 2$ with certainty, whereas if it is of bad quality (B), it will return $x = \$1.5$ at $t = 2$ with probability $\theta = 0.5$ and \$0, otherwise. The banker is assumed to enjoy a private rent of $\alpha = 0.1$ if he retains control of the loan until $t = 2$, and is privately informed about the project's quality, while risk-neutral investors assign a prior probability $f = 0.5$ to the investment being of type G and $1 - f = 0.5$ to type B. An exogenous and non-contractible shock hit investors' priors regarding the project's quality at $t = 1$.[17] In particular, this shock will either be a "credit upgrade" or a "downgrade", that is, denote by $f^u = 1$ and $f^d = 0.25$ the posterior probabilities that the loan quality is of type G conditional on an upgrade or a downgrade, respectively. Notice that, after an upgrade, investors are certain that the loan is of good quality, therefore any security traded on the future cash flow will be risk-less. On the other hand, after a credit downgrade, the posterior probability (q) that the project will in fact payout at $t = 2$ is $q = f^d + (1 - f^d)\theta = 0.25 + 0.75 * 0.5 = 0.625$. Therefore, any dollar claim traded at $t = 1$ after a credit downgrade will be priced at $\frac{1}{q} = 1.6$. The bank would be facing disintermediation and potentially losing any control rents, as in Diamond (1991), if it is funded by short-term debt. To see this, notice that any short-term debt must promise at least the gross risk-free rate to investors, here assumed to be 1. Thus, in case of a credit downgrade, the bank would be forced to raise, at $t = 1$, the dollar promised to initial investors. However, as argued above, the price of this dollar claim would be 1.6, which is greater than what the loan generates at $t = 2$, hence, the bank would be in technical default. This implies that the required short-term rate that guarantees investors participation will be 1.125.[18] We can then conclude that, if funded with short-term debt, a bank holding a good loan would get, in expectation, $U_G^{st} = \frac{f-f^d}{f(1-f^d)} * (1.5 - 1.125 + 0.1) \approx 0.316$.*

[17]This could be interpreted as some soft information regarding the bank's loans. Alternatively, this could be driven by some private liquidity shock faced by investors which correlates to bank's asset quality. Or any economic shock affecting bank's loans in which verification is costly.

[18]Investors would not break-even if they are disintermediating the bank after a credit downgrade and getting only the dollar back after an upgrade. Therefore, the required short-term rate (sr) that guarantees investors partic-

Alternatively, the "good" bank could avoid disintermediation by issuing a long-term debt. Notice that the price of a dollar claim from a long-term debt is exactly the reciprocal of the probability of project success evaluated at $t = 0$. *That is, in order to raise one dollar by issuing a long-term debt, the bank would have to promise* $\frac{1}{f+(1-f)\theta} = \frac{4}{3}$ *at* $t = 2$. *Thus, a "good" bank would get* $U_G^{lt} = 1.5 - \frac{4}{3} + 0.1 \approx 0.266$ *if it issued a long-term debt to finance the loan. Interestingly, even though it would be potentially facing disintermediation, the "good" bank still prefers to issue short-term over the long-term debt, but, can it do better? Even though the bank cannot contract on the signal (upgrade or downgrade), it could still delegate the maturity choice of its liability structure to investors by issuing a (time) deposit contract, and consequently avoiding disintermediation, even after a credit downgrade, by adjusting the short-term yield paid to depositors. Consider a deposit contract which pays* (i) \$0.9375 *at* $t = 1$ *if investors withdraw it;* (ii) \$1.125 *at* $t = 2$ *if they do not withdraw it.*[19] *Therefore, by avoiding disintermediation and guaranteeing investors participation, the "good" bank is getting* $U_G^{dep} = 0.1 + \frac{f-f^d}{f(1-f^d)} * (1.5 - 1.125) = 0.35$, *which is better than issuing either short or long-term debt.*

B.8. Proof of *Lemma* 8

Proof.

Suppose the borrower can call the debt back at $t = 1$ for C, and let the long term payout be denoted by L. Notice that if the borrower calls it back after a downgrade, it would also call it back after an upgrade. The converse is not true. Therefore, if the borrower is calling it back after a credit downgrade then there would be no practical difference between this and a short term debt.

ipation is the one satisfying $\left[f\frac{f^d(1-f)}{f(1-f^d)} + (1-f)\right] * 1.5q + f\frac{f-f^d}{f(1-f^d)}sr = 1$ that is, $sr = 1.125$.. Where $\left[f\frac{f^d(1-f)}{f(1-f^d)} + (1-f)\right]$ is the ex-ante probability of observing a downgrade at $t = 1$ and $f\frac{f-f^d}{f(1-f^d)}$ is the ex-ante probability of observing an upgrade at $t = 1$.

[19]Notice that these deposit terms guarantee that investors are at their participation constraint. If banks are pooling in equilibrium, the probability, at $t = 0$, that investors will observe a credit downgrade at $t = 1$ will be $p_d = f\frac{f^d(1-f)}{f(1-f^d} + (1-f) = 0.666$, whereas the ex-ante probability that they will observe an upgrade at $t = 1$ is $1 - p_d = 0.333$. Hence, $0.666 * 0.9375 + 0.333 * 1.125 = 1$.

Therefore, we remain to check whether, in the case where the borrower is calling it back only after an upgrade, a callable bond can dominate a long term debt. Notice that, in order for the borrower to call it back only after an upgrade, it must be true that $C < L$ and $\frac{C}{q} > L$.

Date-zero investors' zero profit condition is determined by

$$f\left[e_G L + (1-e_G)C\right] + (1-f)\theta L = 1$$

Therefore,

$$L = \frac{1 - f(1-e_G)C}{f e_G + (1-f)\theta}$$

To satisfy the incentive compatibility condition above, $\frac{C}{q} > L$, then it must be true that

$$\frac{C}{q} > \frac{1 - f(1-e_G)C}{f e_G + (1-f)\theta}$$

which implies that

$$C > \frac{q}{f e_G + (1-f)\theta + f(1-e_G)q}$$

Manipulating the expression above and recalling that $q = f^d + (1-f^d)\theta$, $e_G = \frac{1-f}{m-f}$, and that $f^d = \frac{f}{m}$, we can verify that

$$\frac{q}{f e_G + (1-f)\theta + f(1-e_G)q} = 1$$

Therefore, we will satisfy the incentive compatibility constraint whenever $C > 1$.

We then need to check whether or not there exists a pair (C, L) satisfying this incentive compatibility and such that the type-G borrower's utility is greater than when he issues straight long-term debt.

The utility of a "Good" borrower issuing a callable debt satisfying the incentive compatibility is then defined by

$$U_G^{callable} \equiv x + c - e_G L - (1-e_G)C = x + c - e_G \frac{1 - f(1-e_G)C}{f e_G + (1-f)\theta} - (1-e_G)C$$

Recall from *Proposition* 3 that the utility of a "Good" borrower issuing straight long-term debt is

$$U_G^{LT} = x + c - \frac{1}{f + (1-f)\theta}$$

Then, a callable debt satisfying feasibility will dominate the straight long-term debt if $U_G^{callable} > U_G^{LT}$, i.e., if

$$e_G \frac{1 - f(1-e_G)C}{f e_G + (1-f)\theta} + (1-e_G)C < \frac{1}{f + (1-f)\theta}$$

Manipulating this inequality we get that it will be true if

$$C < 1$$

Which violates the incentive compatibility constraint above. Hence, there does not exist a feasible callable debt that dominates a straight short or long term debt.

□

B.9. Proof of *Proposition* 4

Proof.

From *Lemma* 6 we concluded that the date-zero equilibrium of this game must maximize the utility of a type-G borrower. Notice that this maximization program subject to date-zero investors zero-profit condition, feasibility and the anticipation of the equilibrium played at $t = 1$ is identical to the planner's problem if

- $D = z_{0,1} = min\{qx; 1\}$;
- $F = z_{0,2}$;

Hence, the date-zero equilibrium when we have pooling at the investment stage comes directly from *Lemma* 1.

□

B.10. Proof of *Proposition* 5

Proof.

The proof follows the same structure as the proof of *Proposition* 1. □

C. Comparative Statics and Extensions Proofs

C.1. Proof of *Proposition* 6

Proof. (a) Notice that the separating menu dominates the pooling menu if and only if

$$U_G^{sep} > U_G^{pool}$$

That is,

$$x - \frac{f + (1-f)\theta(x+c)}{f + (1-f)\theta} > (1-e_G)\left[x - \frac{1 - [f e_G + (1-f)]qx}{f(1-e_G)}\right]$$

which implies that

$$\frac{(1-f)\theta}{f + (1-f)\theta} c < x - \frac{f + (1-f)\theta x}{f + (1-f)\theta} - (1-e_G)\left[x - \frac{1 - [f e_G + (1-f)]qx}{f(1-e_G)}\right]$$

that is, if $c < \hat{c}$. Given that the expected duration conditional on separation is equal to 2, and the expected duration conditional on pooling is strictly less than 2, we have our result.

(b) Similarly, the separating menu dominates the pooling menu if and only if $f < \hat{f}$. Therefore, we remain to show that the expected duration under the pooling menu is increasing in f.

For simplicity, take the case where $qx \geqslant 1$. Recall from *Proposition* 4 that $D_{pool}^* = 1$ and that $F_{pool}^* = 1$. Plugging it back into the expected duration we get

$$\mathbb{E}\left[MacD_{pool}\right] = [f e_G + (1-f)] + 2f(1-e_G)$$

Note that $\frac{\partial e_G}{\partial f} = -\frac{(m-1)}{(m-f)^2}$. Hence,

$$\frac{\partial \mathbb{E}\left[MacD_{pool}\right]}{\partial f} = e_G - \frac{f(m-1)}{(m-f)^2} - 1 + 2(1-e_G) + \frac{2f(m-1)}{(m-f)^2} = 1 - e_G + \frac{f(m-1)}{(m-f)^2} > 0$$

□

C.2. Proof of *Lemma* 9

Proof. Follows immediately from *Proposition* 6 and *Lemma* 10. □

C.3. Proof of *Lemma* 10

Proof. Follows immediately from *Proposition* 4. □

C.4. Proof of *Propostion* 7

Proof. From *Lemma* 7 we know that the feasibility condition for a separating menu is given by

$$\theta \leqslant \frac{f(x-1)}{(1-f)c} \equiv \underline{\theta}$$

Moreover, the cost of capital for the high-quality borrower in a separating menu F^*_{sep} is given by

$$F^*_{sep} = \frac{f + (1-f)\theta(x+c)}{f + (1-f)\theta}$$

which is increasing in θ. On the other hand, from *Proposition* 4 we know that the feasibility condition for a pooling menu is given by

$$\theta \geqslant \frac{1 - \left[f^d(f e_G + (1-f)) + f(1-e_G)\right]x}{[f e_G + (1-f)](1-f^d)x} \equiv \bar{\theta}$$

Moreover, the cost of capital for the high-quality borrower in a pooling menu F^*_{pool} is given by

$$F^*_{pool} = \frac{1 - [f e_G + (1-f)]D^*}{f(1-e_G)}$$

which is weakly decreasing in θ given that $D^* = min\{qx; 1\}$ and that $q = f^d + (1-f^d)\theta$. Hence, we can conclude that the cost of capital for the high-quality borrower is hump-shaped in θ and that, if $\underline{\theta} < \bar{\theta}$ the market breaks down for intermediate values of θ. We remain to show how the cost of capital varies with m, the signal precision.

Consider the case in which $qx < 1$ and that the pooling menu is the date-zero equilibrium. The cost of capital for the high-quality borrower in a pooling menu F^*_{pool} is given by

$$F^*_{pool} = \frac{1 - [f e_G + (1-f)]qx}{f(1-e_G)}$$

Therefore, differentiating F^*_{pool} with respect to m we get

$$\frac{\partial F^*_{pool}}{\partial m} = f(1-qx)\frac{\partial e_G}{\partial m} - f(1-e_G)[f e_G + (1-f)]x\frac{\partial q}{\partial m}$$

The first term of the RHS captures how an increase in the signal precision (m) reduces the cost of capital by its effect on the probability of a credit downgrade, while the second term captures the effect on the date-one adverse selection problem conditional on a credit downgrade, thus increasing the overall cost of capital. To check which force dominates we can expand even further the expression above and notice that

$$\frac{\partial F^*_{pool}}{\partial m} \propto (1-f)f\frac{x(1-\theta)}{m} - (1-qx)$$

Notice that, the second term $-(1-qx)$ is negative, whereas the first term $f(1-f)\frac{x(1-\theta)}{m}$ is hump-shaped in f and that

$$lim_{f\to 0} f(1-f) = 0$$

and

$$lim_{f\to 1} f(1-f) = 0$$

Therefore, $\frac{\partial F^*_{pool}}{\partial m}$ is positive only for intermediate values of f. $\square$

C.5. Proof of *Proposition* 8

Proof. From *Proposition* 5 we know that for low values of θ the date-zero equilibrium is separating. That is, the low-quality borrower is issuing long-term debt with face value $\phi^{ast} = 1-\theta(x+c-F^*_{sep})$ which is decreasing in θ. This implies that the monetary profit of a low-quality borrower increases in θ for low values of θ.

For higher values of θ, the date-zero equilibrium is pooling at the investment stage. In this case we need to analyze two regions. When θ is at an intermediate value such that $qx \leqslant 1$, then the monetary profit of a low-quality borrower will be zero. This happens because the date-zero equilibrium is pooling and borrowers are issuing certificate of deposits with a withdrawal payment $D^* = qx$. Therefore, since a low-quality borrower is always downgraded at $t = 1$, investors will withdraw, forcing the borrower to raise additional capital at $t = 1$ with a face value equal to $\frac{qx}{q} = x$.

On the other hand, when θ is high enough such that $qx > 1$, then the borrowers are issuing traditional savings deposits. Therefore, a higher θ implies a lower face value of the debt when the low-quality borrower needs to raise capital at $t = 1$ to cover for withdrawals. □

C.6. Proof of *Proposition* 9

Proof. Note that, conditional on withdrawals after a downgrade, the borrower's rollover cost at $t = 1$ when $r = d$ will be $\frac{D+\gamma}{q} = x$. Moreover, after a credit upgrade, the borrower's payment to investors at $t = 2$ will be $F + \gamma = \frac{1-[fe_G+(1-f)]qx}{f(1-e_G)}$. That is, they are identical to the optimality condition of *Proposition* 4.

Hence, we just need to verify for the withdrawal constraint. That is

$$D \geqslant qF$$

or, equivalently

$$qx - \gamma \geqslant q\frac{(1-\gamma) - [f e_G + (1-f)](qx - \gamma)}{f(1-e_G)}$$

that is

$$\gamma \leqslant \frac{q[q(f e_G + (1-f)) + f(1-e_G)x - 1]}{q[f e_G + (1-f)] + f(1-e_G) - q} \equiv \gamma^*$$

□

C.7. Proof of *Proposition* 10

Proof. We just need to guarantee that the sophisticated investor is optimally withdrawing when $r = d$ and not withdrawing when $r = u$.

Suppose $r = d$ at $t = 1$ and the sophisticated investor tries to renegotiate the terms of the contract with the unsophisticated. The attempt to renegotiate would immediately be met by withdrawals, forcing the sophisticated to then withdraw its deposits in its entirety to repay the unsophisticated investors.

Alternatively, suppose that $r = u$. The sophisticated, knowing that any attempt to renegotiate would be met by withdrawals from the unsophisticated, could try to renegotiate with the unsophisticated, and then also renegotiate with the original borrower a profit split, given that, after a credit downgrade the rollover is cheap. This attempt would not render extra profits to the sophisticated investor as he has sold equity to the unsophisticated.

Therefore, given that the sophisticated would never profit from renegotiation attempts, he has proper incentives to optimally withdraw the deposits. □

C.8. Proof of *Proposition* 11

Proof. We need to guarantee that the bank raise enough capital to make the risky loan. When there is only $\lambda < 1$ supply of risk-neutral capital, we will also need to raise capital from the infinitely risk-averse investors, who demand safe deposits. Notice that we cannot raise one dollar from the risk-averse, given that, in the case of a credit downgrade, we would only have a supply of $\lambda < 1$ to pay for withdrawals. Hence, we prefer to raise λ dollars from the risk-neutral and $(1-\lambda)$ from the risk-averse. For the same reasoning, we cannot issue safe traditional savings deposits to the risk-neutral, therefore we issue CDs which pay D in case of withdrawal and F in the long run.

To satisfy the balance sheet capacity at $t = 1$, i.e., the limited supply of risk-neutral capital, we need to set D such that

$$D + (1 - \lambda) = \lambda$$

Hence, $D = 2\lambda - 1$. Risk-neutral investors participation constraint would then require that

$$F = \frac{\lambda - [f e_G + (1 - f)]D}{f(1 - e_G)}$$

Finally, we just need to guarantee that the risk-neutral investors would have incentives to withdraw after a credit downgrade, that is, $D > qF$

$$2\lambda - 1 > q\frac{\lambda - [f e_G + (1 - f)]D}{f(1 - e_G)}$$

or, equivalently

$$\lambda > \frac{qx + q[f e_G + (1 - f)] + f(1 - e_G)}{2[q[f e_G + (1 - f)] + f(1 - e_G)]} =\equiv \underline{\lambda}$$

□

C.9. Proof of *Proposition* 12

Proof. Note that the utility of the high-quality borrower can be written as

$$U_G^{expansion} = e_G\left(x + c - \frac{Q}{q} + (Q-1) + \frac{(1-q_0)(Q-1)}{q_0}\right) + (1-e_G)\left(c + x - Q + (Q-1) + \frac{(1-q_0)(Q-1)}{q_0}\right)$$

Differentiating $U_G^{expansion}$ with respect to Q we get

$$\frac{\partial U_G^{expansion}}{\partial Q} = e_G\left(1 + \frac{(1-q_0)}{q_0} - \frac{1}{q}\right) + (1-e_G)\left(\frac{1-q_0}{q_0}\right) = \frac{1-q_0}{q_0} - e_G\frac{1-q}{q} > 0$$

Hence, we want to maximize Q. Therefore, it must be true that $Q = min\{\lambda, qx\}$ in order to respect the balance sheet capacity λ and the solvency constraint qx. We just need to check that risk-neutral investors buying the credit default swap are breaking even in expectation. That is, let the premium paid to the bank in case of loan success be $P = \frac{(1-q_0)(Q-1)}{q_0}$, then

$$(1-q_0)(Q-1) - q_0\frac{(1-q_0)(Q-1)}{q_0} = 0$$

□

C.10. Proof of *Proposition* 13

Proof. Let's consider the baseline model where banks are pooling in equilibrium and $qx < 1$. We will analyze two cases. First, let's consider the case where banks are issuing short-term debt with face value equal to one. The high-quality bank's utility is given by

$$U_G^{st} = (1-e_G)(x(I)I + cI - 1)$$

The first order condition gives us

$$\frac{\partial U_G^{st}}{\partial I} = x'(I_{st}^*) + x(I_{st}^*) + c = 0$$

Now, consider the case where banks are issuing the deposit from *Proposition* 4. The high-quality bank's utility is given by

$$U_G^{dep} = e_G(cI) + (1-e_G)(x(I)I + cI - 1)$$

The first order condition gives us

$$\frac{\partial U_G^{dep}}{\partial I} = c + (1 - e_G)(x'(I^*_{dep}) + x(I^*_{dep})) = 0$$

This implies that $x'(I^*_{dep}) + x(I^*_{dep}) < 0$ and that $x'(I^*_{dep}) + x(I^*_{dep}) < x'(I^*_{st}) + x(I^*_{st})$. Therefore, given that $x'(I) < 0$ and that $x''(I) \leqslant 0$, it must be true that $I^*_{dep} > I^*_{st}$. □

C.11. Proof of *Proposition* 14

Proof. First, notice that the low-quality borrower utility under the FDIC policy is given by

$$U_B^{FDIC} = \theta\left(x + c - \frac{(1-\gamma)qx + \rho}{q} - \gamma F^* + \rho\right)$$

Therefore, given the *Optimality Condition*, we get that

$$U_B^{FDIC} = \theta c = U_B^{baseline}$$

We remain to check for the high-quality bank's utility. That is,

$$U_G^{FDIC} = e_G\left(x + c - \frac{(1-\gamma)qx + \rho}{q} - \gamma F^* + \sigma\right) + (1 - e_G)(x + c - F^*)$$

that is,

$$U_G^{FDIC} = e_G c + (1 - e_G)(x + c - F^*) = U_G^{baseline}$$

□