The Role of Demandable Debt in Structuring Optimal Banking Arrangements

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Demandable-debt finance by banks warrants explanation because it entails costs of bank suspension, liquidation, and idle reserve holdings. An explanation is developed in which demandable debt provides incentive-compatible intermediation where the banker has comparative advantage in allocating investment funds but may act against the interests of uninformed depositors. Demandable debt attracts funds by giving depositors an option to force liquidation. Its usefulness in transacting follows from information-sharing between monitors and nonmonitors. (JEL G21)

For centuries, the vast majority of externally financed investments have been funded by banks, for which demandable-debt instruments (bank notes and checking accounts) have been the principal source of funds. The goal of this paper is to explain the emergence of demandable-debt banking historically as the primary means of external finance in the economy.

Demandable debt warrants explanation because, in several respects, it appears more costly than available alternative contracting structures. By issuing demandable debt, banks created a mismatch between the maturity of assets and liabilities. This mismatch left them exposed to the possibility that depositors would attempt to withdraw more

funds than a bank could supply on short notice. When this occurred, the consequences were costly. Individual banks that did not meet their obligations were forced into expensive procedures (liquidation or receivership) that would not have arisen in an equity-based or maturity-matched contracting structure.[1] If depositors en masse attempted to withdraw funds from the entire banking system, banks as a group were forced to suspend convertibility of their liabilities into specie on demand. Such suspension was also disruptive and costly. To defend against either of these undesirable consequences, banks had to hold a proportion of their assets in idle reserves to insulate themselves from excessive withdrawals.

Given these costs, demandable debt seems inferior to both maturity-matched debt and equity contracting. However, in this paper, we show that demandable debt has an important advantage as part of an incentive scheme for disciplining the banker. In effect, demandable debt permits depositors to "vote with their feet"; withdrawal of funds is a vote of no-confidence in the activities of the banker. Without the ability to make early withdrawals, depositors would have little incentive to monitor the bank.

[1] Kenneth R. Cone (1983) shows that, in a world of full information, the risk of depositor liquidation under demandable debt is absent, provided that financial intermediaries are maturity-matched.

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This account gives a natural rationale for two important institutional features of banking. The so-called "sequential service constraint," by which payments were made to demanders on a first-come, first-served basis, becomes intelligible as a way to make monitoring depositors interested in registering their no-confidence votes at the first opportunity. The ease with which banks may be forced into liquidation, far from being an unfortunate consequence of the contracting structure, turns out to be central to the structure: we show that, by submitting to the threat of liquidation under appropriate circumstances, the banker can reduce his cost of capital.

In addition, our account may have wider applicability. Features of modern capital structures of nonfinancial institutions bear important similarities to the historical role of demandable debt. Modern-day firms often have multilayerd debt structures, in which certain debt-holders have priority of claim for repayment. Claimants to short-term senior debt in modern firms may play a similar role to that of the monitoring depositors in our model.

The paper is organized as follows: In Section I, we contrast our explanation of demandable debt with the literature based on desire for flexibility of consumption. The model in Section II demonstrates the value of a demandable-debt contract in the case of a single investor contracting with the banker monopolist. Here, a run corresponds to a demand by the investor for liquidation of the bank. Section III examines the case in which different monitors receive different (independent and identically distributed) signals. In this case, it pays to have more than one depositor monitoring the bank, because the quality of signals in the aggregate improves with the number of monitors. Banks find it advantageous to hold reserves to provide a buffer that reduces the likelihood of unwarranted liquidation. An optimal threshold of withdrawal orders is chosen at which the bank is liquidated, and relative payoffs ensure that the optimal number of monitors invest in receiving signals.

At the end of Section III, we briefly and informally indicate how solving the incentive problem facing the banker will also make the banker's liabilities more transactable. Formal models combining the incentive problem and liquidity are an important field for further research.[2] Section IV summarizes and indicates important limitations of our results.

I. Explanations for Demandable Debt

Recent theoretical work on the role of banks has tended to divide into two categories. Theory in one category emphasizes the role of banks as providing flexibility for depositors in the timing of consumption. Theory in the other category, to which our paper belongs, emphasizes the *incentive* problem inherent in the divergence of interest between a bank's depositors and its managers.[3] For reasons indicated below, we believe that accounts which ignore the incentive problem facing the banker do not adequately explain why banks historically settled on demandable debt.

A. *Consumption Flexibility and Demandable Debt*

In the past several years, the preeminent theoretical analyses of banks, bank runs, and bank regulation have assumed that the economic role of demandable debt is to provide flexibility to risk-averse depositors who are uncertain about the timing of their future consumption demand.[4] In this category of models, bank runs, when they occur, are an unfortunate and undesirable side-

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[2]See Gary Gorton and George Pennacchi (1988), Charles J. Jacklin (1988), and A. P. Villamil (1988) for various approaches to combining the liquidity and incentive arguments.

[3]Jacklin and Sudipto Bhattacharya (1988) give a concise but useful review of these approaches.

[4]Fundamental papers that utilize this approach are by John Bryant (1980), Douglas W. Diamond and Philip Dybvig (1983), and Jacklin (1987). For a model emphasizing the costs to depositors of delay in liquidation, see Merwan Engineer (1987).

effect of a contract whose whole purpose is to provide consumption flexibility.

Although these models provide both a concise formalization of the fact that banks provide consumption flexibility and a coherent account of bank runs, they are unable to account for several important institutional features of demandable debt. First, in the absence of incentive constraints on the part of the banker, the optimal arrangement in liquidity-based accounts always involves suspension of convertibility, rather than expensive liquidation. However, suspension was not an option available to individual banks; it was only an alternative for the financial system as a whole, in the face of system-wide panics. Individual banks that could not satisfy creditors' fears about solvency were not permitted to suspend; they were forced to close.[5]

Second, studies of actual bank failures give fraud a prominent place in the list of causes. Studies of 19th- and 20th-century banking indicate that fraud and conflicts of interest characterize the vast majority of bank failures for state and nationally chartered banks.[6]

Third, receivership resulted from a critical mass of depositor withdrawal orders and was invoked because of information about bank asset values, not because of exogenous liquidity needs of individual depositors. In cases of massive exogenous demand for an individual bank's assets by small depositors, banks avoided failure by appealing to other banks for loans of reserves; however, when large informed depositors (including other bankers) concluded that a bank was in trouble, they would precipitate a run, depleting the bank's reserves and forcing it to be placed in receivership.[7]

These considerations make it apparent that the liquidation of banks—which was part and parcel of demandable-debt contracts—was designed to place the assets of banks beyond the reach of the banker. The rationale for prohibiting banks from suspending at their own discretion may have been the discipline that it imposed on the behavior of the banker. Thus, a model of demandable debt with bank liquidation through receivership should account for the desirability of taking control of the bank away from the banker at the option of depositors.

Fourth, the "sequential-service constraint" (first-come, first-served rule) for bank withdrawals, which allowed informed depositors to receive repayment before banks were placed into receivership, also

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[5] See Calomiris and Larry Schweikart (1988) for a discussion of suspension rules during the early U.S. experience. Kevin Dowd (1988) argues that individual-bank suspension of debt redemption would have been beneficial but was prevented by legal prohibitions. We argue that the prohibition-of-suspension option clauses simply reflected the learned desirability of placing the decision regarding whether suspension was "justified" outside the control of the individual banker. The legal prohibition of option clauses on notes may have been perceived as necessary to protect some unsophisticated note-holders, while no such law was deemed necessary for relatively sophisticated depositors.

[6] For example, E. L. Smead (1928) found that three of the nine most common causes of bank failure in the 1920's involved fraudulent or questionable activities by the banker: loans to officers and directors, outright defalcation, and loans to enterprises in which officers and directors were interested. For discussions of the role of fraud in earlier eras, see Carter H. Golembe and Clark Warburton (1958), George J. Bentson and George G. Kaufman (1986), and Calomiris and Schweikart (1988). Data on national bank failures, by cause, can be found in the Annual Report of the Comptroller of the Currency (1920 pp. 56–79). For information on the importance of fraud in more recent bank failures, see Comptroller of the Currency (1988).

[7] Henry C. Nicholas (1907 p. 26) dismissed the importance of withdrawals by uninformed depositors in causing bank liquidation. He wrote, "If a bank is actually in bad shape there is far more likelihood of its initial condition being discovered by other banking institutions than by the individual depositors of the bank .... A run is sometimes started in this manner ... and continues until it has practically wiped out the reserves of the suspected institution, the ordinary depositors receiving their first information regarding the position of the bank when that institution is finally forced to close its doors and formally apply for a receiver." This discussion makes important points about bank runs which appear in our model: some depositors are informed, while others are not. Runs by informed depositors end in liquidation. Informed depositors are able to exercise their withdrawal option before uninformed depositors are able to observe the bank's difficulty (or the run).

warrants explanation. In cases other than banking, payments from bankrupt firms to creditors in anticipation of bankruptcy are not allowed, and creditors may be forced to relinquish such payments during the bankruptcy proceeding. Why in the case of banking should those who run the bank receive preferential treatment in liquidation states?

B. Demandable Debt as an Incentive Scheme

Models in the second category of theory on the role of banks begin with the assumption that bankers have an informational advantage in determining which projects are most worthy of financing. Therefore, the banker has a comparative advantage in allocating funds for investment, but he also may have the ability to act against the interests of uninformed depositors.[8]

We show that demandable debt can provide an incentive-compatible solution to this problem in the presence of costly information. The right to take one's money out of the bank if one becomes suspicious that realized returns are low makes it in the depositor's interest to keep an eye on the bank. If enough depositors agree with this negative assessment of the bank's future, liquidation will be called for, and the bank

[8]This point is emphasized by Diamond (1984) and Ben Bernanke and Mark Gertler (1987). For an overview of the relation between agency costs and the structure of financial contracts, see Eugene F. Fama (1988). Diamond's solution to the delegated-monitoring problem of financial intermediation relies on two assumptions that are absent in our framework: the existence of an *ex post* nonpecuniary penalty that can be imposed on the banker and the ability of the banker to construct a riskless portfolio through diversification. The second assumption permits enforcement of the penalty, even if cheating is costly to observe directly, whenever the banker fails to meet his obligations. Bernanke and Gertler provide a simple macroeconomic model in which bankers are subject to moral hazard and depositors desire liquidity. They explicitly assume that costly monitoring and punishment of defaulting bankers are not possible. For them, demandable debt is desirable solely for its liquidity. In our model, demandable debt is desirable although liquidity demand is absent.

will close. The demandable-debt contract allows the banker to precommit to a set of payoffs he otherwise would not be able to offer depositors.

Not all depositors need monitor the banker. We argue that the first-come, first-served (sequential service) rule of demandable debt provides compensation for those who choose to invest in information and thus avoids free-riding. We view bank intermediation, therefore, as a three-sided relationship. The monitors pay the costs of vigilance but receive the benefit of knowing that they will be "first in line" (and thereby receive a higher payment than other depositors) should it become necessary to withdraw their funds from the bank. The depositors who do not monitor are willing to pay the price of being last in line in "bad" states, because they receive a benefit in return: the active monitors keep the banker in line and thereby provide a benefit to the passive depositors. Depositors need not reveal whether they are active or passive; the same contract works for both types.

The physical structure we assume includes the following important features. 1) The bank is operated by a monopolist with special access to a profitable investment opportunity which yields either a good or a bad realization. 2) There is potential for cheating by the banker which takes the form of his absconding with a proportion of the bank's assets after the investment realization. (One can think of this more generally as costly *ex post* fraudulent behavior which the banker undertakes whenever it is more profitable to do so than to make the promised payments to depositors.) 3) Depositors face different costs of obtaining a signal that allows them to predict profitability. 4) An authority exists who will enforce contracts (some of which may stipulate conditions for bank liquidation) and who can act as receiver for liquidated banks. 5) Depositors have a reservation level of return on their endowments below which they will not invest funds with the banker.

The profit-maximizing banker will act to maximize social gain by selecting a contract that achieves beneficial intermediation (investment in profitable enterprises), while

avoiding as much as possible the costs associated with absconding or liquidating. We find that the demandable-debt contract is optimal for a range of parameter values. The potential for costly liquidation may be more than offset by the social gain that comes from enhanced investment opportunities.[9]

II. The Model with a Single Depositor

A. Physical Structure

A banker has an investment opportunity, but he lacks sufficient capital to take advantage of it. The investment opportunity costs one dollar. Each potential depositor has one dollar to invest. We will let S represent the total expected return available for a dollar's investment elsewhere in the economy. We assume that all agents are risk-neutral; thus, any scheme the banker develops will have to yield a depositor that same expected return.

The investment opportunity yields an uncertain payoff which may take one of two values, T_1 or T_2, with $T_2 > T_1$. The probability of the high outcome is γ. The realization is unknown to all parties at the outset and is observable ex post only by the banker. Thus, there is no way to make a contract tied directly to the value of T_i.[10]

Let period 3 be the date at which the payoff is realized and the loan is to be repaid. We assume that in period 3, immediately before repayment, the banker has the opportunity to abscond with the funds. Absconding is socially wasteful; for concreteness, we will assume that it reduces the realization T_i by the proportion A, where A is between 0 and 1.

Although the act of absconding reduces the size of the pie that is divided between the banker and the depositor, it places the banker beyond the reach of the law. Therefore, he is no longer constrained to repay the loan as initially promised. Thus, any promise to pay the depositor an amount P is actually an option of the banker either to pay P or to leave town with his assets diminished by the proportion A.

The losses from absconding may be interpreted in a variety of ways. They may represent the cost of engaging in fraud (payments to coconspirators) or the costs (forgone earnings) of placing the bank's resources in a form that allows theft. The latter interpretation requires a richer, multiperiod model than the one we provide, in which bankers' allocation decisions depend on last-period earnings.[11]

It should be readily apparent that the temptation to abscond will be greater with lower realizations of T_i. In deciding whether

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[9] V. Chari and Ravi Jagannathan (1988) provide an example of an information-based run for a model that has many features in common with ours. A key difference is that they assume an (exogeneously imposed) negative externality from liquidation of the bank's assets. In their model, the creation of a liquidation technology is not efficient. In our model, there is a *positive* externality from running the bank: when the depositor observes a bad signal, he calls for liquidation, thereby salvaging some of the bank's value. The bank's structure is designed to internalize this positive externality and allows nonmonitoring depositors to compensate monitors for the benefits they provide.

Our model can also be interpreted as allowing depositors to exercise a put option based on the information they receive. However, unlike the usual "inside-trading" scenario, the uninformed depositors also benefit at the expense of the bank. While the uninformed depositors receive a lower payoff than the informed depositors, they benefit because the bank is prevented from cheating. In the usual scenario (e.g., Albert S. Kyle, 1981), the uninformed either lose or the informed cannot successfully earn a return on their information-production because of free-riding, as in Sanford J. Grossman and Joseph E. Stiglitz (1980). We thank an anonymous referee for suggesting this comparison to us.

[10] We assume that the banker is not able to trade in equity shares. This conforms with the relative illiquidity of equity trade in the period under examination. It could also be generated as a conclusion in a model in which bankers possess specialized information about investment projects of borrowers. Robert M. Townsend (1979) notes that in circumstances when only one party has access to information, debt contracts (i.e., contracts not contingent on the private information) will often be the only feasible alternative.

[11] The plausibility of our "leaky bucket" assumption and possible multiperiod reinterpretations are discussed further in the final section of the paper. For an initial generalization of the absconding assumption see Calomiris et al. (1990).

to abscond, the banker compares the "tax" on absconding, AT_l, with the promised funds due the depositor. If the absconding tax is less, then absconding is more profitable than paying up. Historical evidence confirms the greater prevalence of fraud in times of low returns to bank investments.[12]

Because of the threat that the banker will abscond—a threat against which he cannot commit himself—it will generally be necessary for the banker to increase the payment offered to a depositor by a "default premium" as protection against those states in which the depositor will, in fact, receive nothing.

Note that the addition of a default premium can, in turn, increase the probability of default, by making it desirable for the banker to abscond in good states as well. For example, suppose

$$S > AT_1$$

so that any payment promised to the depositor must be sufficiently large to incur absconding in the low realization; that is, a promise to pay P will only be honored a fraction γ of the time. Suppose also that

$$\gamma T_2 + (1 - \gamma)(1 - A)T_1 > S$$

so that the investment would be socially desirable (even taking into account the loss from absconding in the low realization). Then, if

$$S > \gamma AT_2$$

there is no way to promise the depositor enough expected payment to make him willing to invest, despite the social desirability of the project; the promised payment would have to exceed AT_2, making it desirable for the banker to abscond all the time.

Because of the loss of socially desirable opportunities, it is useful to have a method of thwarting absconding. One such method is the liquidation of the bank in period 2. Liquidation means that the bank's assets are taken over by a receiver, controlled by a court. This is an expensive process, not the least because the court-appointed and court-controlled receiver is likely to be less able to realize the full potential of the assets. On the other hand, the fact that the assets are no longer in the banker's control preempts any decision by him to abscond with the funds.

We assume that liquidation reduces the value of the assets by the proportion L, so that L can be regarded as the tax due to liquidation. For a complete characterization of the process of liquidation, it is necessary to take some stand as to the maximum that can be feasibly paid to the depositor in the case of liquidation. We call this value M, and we assume that[13]

$$(1) \qquad AT_2 > M > AT_1$$

so that the amount that can be guaranteed to the depositor in a liquidating contract is greater than the maximum amount that can be guaranteed in a nonliquidating contract. We also assume that

$$(2) \qquad L > A$$

so that liquidation is less wasteful socially than is absconding.[14]

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[12] The concentration of bank fraud during times of regional or national economic decline is pronounced in national bank-failure data. See the Annual Report of the U.S. Comptroller of the Currency (1920 pp. 56–79).

[13] There are several ways we can approach the question of the maximum to be paid once the court has control. For simplicity, we assume that M does not vary with the realization of T_l. One argument is that the value of the firm might be determined by the court, but at a very high cost.

[14] Actual liquidation costs in the United States varied historically, depending on time, location, and bank size but seem to have been small relative to potential social losses from absconding, as our model assumes. Bankruptcy expenses averaged between three percent and six percent of total collections for national banks between 1872 and 1904 (Brian C. Gendreau and Scott S. Prince, 1986).

In some cases, it may be desirable *always* to put the assets of the bank into liquidation rather than risk the banker's absconding. We call such an agreement a "simple liquidation contract," as opposed to a "simple nonliquidation contract," which states a promised repayment and leaves it to the banker whether to abscond or not.

The more interesting case, however, is one in which the depositor, based on his own information, is given the option of demanding liquidation or not. Specifically, suppose that by paying a cost I the depositor is able to receive a signal σ in period 1 as to the likelihood of a high (T_2) or low (T_1) realization. The action of investing in the signal and the result of this action are private. The signal σ works as follows. It takes on one of two values $\{g, b\}$ (for "good" and "bad").[15] The probability of a high realization, contingent on the signal, is ρ_σ:

$$(3) \qquad \rho_g > \gamma > \rho_b.$$

We will use the indicator variable $e \in \{0, 1\}$ to represent the depositor's choice: $e = 1$ if there was an investment in the signal, 0 otherwise.

In summary, the physical structure of our model is as follows. There are three periods. In period 1, the depositor may invest in receiving a signal. In period 2, the bank may be liquidated. In period 3, the loan is repaid to the depositor, unless the banker decides to abscond (which he can only do if the bank has not been liquidated).

B. *The Contracting Structure*

Contracts are arranged in period 0. The monopolist banker offers the profit-maximizing contract among those which yield the depositor at least S in expected returns. (If no such contract exists or the best such contract yields negative profits, then none is offered.)

The universe of contracts in this structure is as follows. A contract is a function from a space of announcements Σ into *outcomes*. An outcome is a pair (P, Λ), where $\Lambda \in \{0, 1\}$ is an indicator variable equaling 1 if liquidation is mandated and 0 otherwise. P is the mandated repayment. (Of course P will only be received if the banker does not abscond.)[16]

If the contract only specifies one outcome, we call it a "simple contract"; otherwise we call it a "compound contract." We have already described the two kinds of simple contracts: the simple liquidating contract and the simple nonliquidating contract. A straightforward application of the revelation principle demonstrates that, for the single depositor case, contracts need never contain more than two outcomes, because the signal the depositor may observe has only two values. We can identify the announcements in a compound contract with assertions by the depositor that he has observed one or the other signal. Thus, a compound contract consists of a quartet $(P_b, \Lambda_b, P_g, \Lambda_g)$.

Each contract generates a sequential game in which the depositor chooses the level of investment in information-gathering (e) and the announcement he makes as a function of the signal he receives. The banker chooses whether to abscond as a function of the announcement made by the depositor and the realization on the investment. An *optimal* contract is one for which there is a sequential equilibrium that generates maximum profits consistent with the depositor's receiving expected returns equal to the amount S.

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[15]In the single-depositor case, the assumption that the signal takes only two values is not restrictive. In fact, the multidepositor model of the subsequent section can be reinterpreted as a single-depositor model with multivalued signals.

[16]As it stands, the specification of the contract is incomplete in two technical respects. First, the specification of the outcome should include a specification of the banker's response (i.e., whether he chooses to abscond) as a function of the announcement $\hat{\sigma}$ and of the realization T_i. However, in almost all contracts, the banker's response is easily discerned: he absconds if $P_{\hat{\sigma}} > g\,AT_i$ and does not abscond if $P_{\hat{\sigma}} < AT_i$. Only in the case of indifference would it be necessary to specify his response in detail. Second, the contract does not include the possibility of randomized outcomes. These can be shown never to dominate deterministic outcomes.

THEOREM 1:[17] *The optimal contract in the problem takes one of the following four forms*:
a) *a simple nonliquidating contract*
b) *a simple liquidating contract*; *in this case,*

$$AT_1 < P \le M$$

c) *a compound contract composed of two simple nonliquidating contracts* $(\Lambda_b = \Lambda_g = 0)$; *in this case,*

$$P_b \le AT_1 \text{ and } AT_1 < P_g \le AT_2$$

d) *a compound contract composed of one simple liquidating contract and one simple nonliquidating contract* $(\Lambda_b = 1, \Lambda_g = 0)$; *in this case,*

$$AT_1 < P_b < P_g \le AT_2.$$

If the optimal contract is a compound contract, then the depositor invests in the signal; if it is a simple contract, he does not. In the case of compound contracts, absconding occurs if and only if the signal was g but the low-value outcome T_1 was realized.

We call contract d "demandable debt." It works as follows: after making the deposit, the depositor invests in learning what the likely outcome will be. If he receives the bad signal, he opts for liquidating the bank. This delivers a payment with certainty. If he receives the good signal, he opts for not liquidating the bank. This promises a higher payment but runs the risk of the banker's absconding.

Contract c works in virtually the same way. The only difference is that the guaranteed payment in the case of a bad signal is sufficiently low that the banker will never wish to abscond and so it is not necessary to use liquidation to hold him in place. Since liquidation always involves social costs, it is not difficult to demonstrate that in any case where contract c is feasible, it dominates contract d. We will (with prejudice) describe contract c as a "nuisance contract."

Next, we provide a characterization of when the various contracts will be observed.

We do so under the assumption that the signal is "accurate" (i.e., ρ_g is high and ρ_b is low, so that the signal is a good predictor of the state) and the signal is "cheap" (so that I is small). It is easily demonstrated that, if the signal is sufficiently inaccurate or sufficiently expensive, a compound contract is not useful.

THEOREM 2: *If the signal is sufficiently cheap and accurate, then there exist values* S^* *and* $\hat{S}$, *such that the optimal contract depends on the required returns S in the following way: for* $S \le AT_1$ *the simple, nonliquidating contract is optimal; for* $S \in (AT_1, S^*]$, *the nuisance contract is optimal; for* $S \in (S^*, \hat{S}]$, *demandable debt is optimal; and for* $S > \hat{S}$, *no contract is feasible.*

In other words, demandable debt will be observed when the returns that depositors can receive in alternate investments are relatively high.

III. Multiple Depositors with Independent Signals

In this section, we develop a model for the case in which a number of depositors enter into contracts with the banker. As before, each depositor has one dollar to invest, and the banker has one "project" he can pursue. The project costs Y and yields a total return of YT_i, which takes one of two values. Any deposits the banker receives in excess of Y can be used to yield the same competitive return S that depositors have available to them on their own. Deposits in excess of Y will be identified with "reserves."

We make the following natural assumptions about the difference between the two forms of bank assets, "project" and "reserves." If the bank is liquidated, the value of the project decreases by $1 - L$; the value of the reserves is unchanged.[18] If the banker

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[17]Proofs of theorems are outlined in the Appendix.

[18]This assumption is natural, given that we regard the project as requiring the banker's expertise and regard the reserves as invested in publicly available technologies.

TABLE 1—PAYOFFS ON EACH OF THE THREE NODES
OF THE GAME TREE

Contract	Banker receives	Depositors receive
Liquidation	$(1-L)T_iY+(Z-Y)S-P$	P
No liquidation		
Banker absconds	$(1-A)T_iY$	$(Z-Y)S$
Banker does not abscond	$T_iY+(Z-Y)S-P$	P

absconds, then he takes the projects with him and receives $(1-A)YT_i$. The depositors retain the entirety of the reserves.[19] We strengthen assumption (2) as follows:

$$(4) \qquad L < A(T_1/T_2).$$

There are Z individuals available to enter into a contract with the bank. Of these individuals, K can receive signals by investing at a cost I; for the remainder, the cost of receiving a signal is prohibitive.[20] Signals are independent and identically distributed (i.i.d.) conditional on T_i. For any individual, a "bad" signal is associated with reduced likelihood of the high-productivity state T_2, so $\rho_b < \rho_g$, as before.

Supposing that all K individuals have invested in the signal, let N be the number who receive the "bad" realization. Given the i.i.d. structure, N is a sufficient statistic for T_i, and the probability that the realization is T_2 decreases with N.

A. The Contract from the Banker's Viewpoint

We start by examining only the incentive problem for the banker, taking the behavior of all depositors as given. We will return to

the individual depositors' incentives in the succeeding subsection. For now, we assume that all K individuals who can invest in obtaining the information do so and report it truthfully.[21] A *contract* specifies an aggregate payment P and a liquidation decision Λ as functions of the number of depositors who announce observations of the bad signal. (In the succeeding subsection, we will investigate a scheme for dividing aggregate payments among the depositors.) Note therefore that the contract is the direct generalization of the contract in the previous section to a case of multiple signals.

After the announcement of the signals, the game tree is as before: if a liquidation is not mandated, the banker makes a decision whether to abscond. Table 1 describes the payoffs on each of the three nodes of the game tree.

The *optimal contract* maximizes the banker's expected profits subject to three restrictions.

1) The expected payments to the depositors equal their aggregate reservation level:

$$SZ + KI.$$

That is, all depositors must be compensated for the opportunity cost of their funds; in addition, any monitors must be compensated for the cost of monitoring.

2) In the case of liquidation, actual payment cannot exceed what is assumed feasible; as before, we suppose that a liquidated investment Y pays off at most MY to the depositors. Thus, the total pay-

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[19]An alternative assumption is that, if the banker absconds, he takes the entirety of the reserves as well. The assumption in the text is natural if we regard absconding as occurring by siphoning a project into a less desirable project whose returns accrue directly to the banker. The assumption in this footnote is natural if we regard absconding as occurring when the banker piles the loot into the stagecoach and heads out of town.

[20]This is the simplest structure of supply of signals; it can be generalized. Alternatively, the cost of investing in a signal could be determined in a general equilibrium model.

[21]It will be clear that, as long as the cost of investing in the signal is sufficiently low, it is optimal to have all individuals with cost I make the investment.

ment to depositors out of the project and the reserves is

$$P \leq MY + (Z - Y)S \qquad \text{if } \Lambda = 1.$$

3) Finally we must consider the banker's incentive to abscond. If liquidation does not occur, then the banker will prefer to abscond whenever

$$AT_i Y < P - (Z - Y)S.$$

If the inequality is reversed the banker prefers not to abscond.

As before, we define $\hat{S}$ to be the least upper bound of feasible expected returns to depositors from the project; if the required rate of return exceeds $\hat{S}$, no contract is feasible. $\hat{S}$ can be calculated explicitly.

Our first result is that, for required returns which are sufficiently high (but less than $\hat{S}$), the optimal contract calls for liquidation when the number of bad signals is high, and not when the number of bad signals is low. When the number of bad signals is low, there is a positive (but small) probability that the banker will abscond.

THEOREM 3: *For an interval of values of S, $(\underline{S}, \hat{S}]$, the optimal contract has the following form: there exists $\underline{N}$ such that:*

If $N > \underline{N}$, $\Lambda(N) = 1$ and

$$P(N) = MY + (Z - Y)S;$$

If $N < \underline{N}$, $\Lambda(N) = 0$ and

$$P(N) = AT_2 Y + (Z - Y)S.$$

In other words, the contract has informed agents announce whether their signal was bad. If more than a critical number $\underline{N}$ announce bad signals, the bank is liquidated. If fewer than $\underline{N}$ announce bad signals, the bank is not liquidated, and the banker chooses to abscond if the productivity draw was low.[22]

[22] If exactly $\underline{N}$ announce bad signals, the optimal contract has a randomization between liquidation and nonliquidation. We omit the details.

Note that Z is arbitrary in this contract. As Z increases, the optimal P increases one-for-one: additional deposits beyond those invested in the project are held in reserves and returned to the depositors with certainty.[23]

B. Depositor Incentives

It remains to be shown that the total aggregate payment to depositors specified in the previous section can be divided among depositors in such a way as to maintain the incentives for low-cost-information depositors to invest in the signal and to report it truthfully. In this section, we derive a demandable-debt contract that achieves this goal.

We make the following assumptions about the population of monitors and the signals:

ASSUMPTIONS: *There are large numbers of potential depositors (Z) and potential monitors (K). The cost of monitoring (I) is small. The probability of any one monitor receiving a bad signal is small. The probability of a bad realization of T is small (although the losses can be large).*

In modeling a bank, each of these assumptions seems natural to us. The assumptions allow us to model the distribution of the number of bad signals as a Poisson distribution. More precise criteria for "small enough" or "large enough" are indicated in the complete appendix (available upon request). Note that as long as I is sufficiently

It can be shown that, for values of S below this range, it will be useful to have two thresholds rather than one. For a range of values of bad signals received, it will be optimal to reduce the promised payment, rather than liquidate the bank. This is analogous to the nuisance contract discussed previously, and as before, it can be precluded by sufficiently high reservation levels of return.

[23] Here, reserves are used solely for redistributing payouts between monitors and nonmonitors in an incentive-compatible way. In a richer model, banks would choose between holding reserves and investing more in higher-earning projects.

TABLE 2—PAYOFF TO DEPOSITOR WHO ANNOUNCES g

Project realization	Payoff to depositor announcing g	
	Number of depositors announcing $b < \underline{N}$	Number of depositors announcing $b > \underline{N}$
T_1	$\dfrac{AT_2 + (Z-Y)S - RN}{Z-N}$	$\dfrac{MY + (Z-Y)S - RN}{Z-N}$
T_2	$\dfrac{(Z-Y)S - RN}{Z-N}$	$\dfrac{MY + (Z-Y)S - RN}{Z-N}$

small, it is always optimal to have all the potential monitors engage in investment.

The contract for all depositors is identical. *Ex post* depositors will pick one of two announcements within the contract. Since there are three information possibilities (observing g, observing b, or not making an investment), there will have to be some pooling in the outcomes. We will build a contract in which it is incentive-compatible for the depositors who have made no investment to pool with those who have observed the good draw.

Each depositor's payoff depends on his announcement and the signal (if any) he observes. We let the symbol $EU(\hat{\sigma}, \sigma)$ denote the expected return for a depositor who observes signal σ and announces signal $\hat{\sigma}$.

Individual depositors are subject to two sorts of constraints: participation constraints (i.e., the contract must give expected returns that are sufficient for depositors to participate) and incentive constraints. From the point of view of the individual depositors, the contract must satisfy the following requirements.

1) Always announcing g gives an expected return of S, which exceeds the expected return from always announcing b. This means that depositors with high costs of gathering information will be willing to participate in the contract in the manner specified.

2) Announcing the observation truthfully gives a return of $S + I$, which exceeds the return from lying. If conditions in requirement 1 are satisfied as well, then individuals with a cost of I for investing

are willing to make the investment in monitoring and report truthfully.

These constraints for individual depositors can be written as follows:

$$\lambda EU(\hat{g}, g) + (1 - \lambda) EU(\hat{g}, b)$$
$$= S \geq \lambda EU(\hat{b}, g) + (1 - \lambda) EU(\hat{b}, b)$$

$$\lambda EU(\hat{g}, g) + (1 - \lambda) EU(\hat{b}, b)$$
$$= S + I \geq \lambda EU(\hat{b}, g) + (1 - \lambda) EU(\hat{g}, b)$$

where λ is the prior probability of signal g.

The scheme we consider has payments of a particularly simple form: any depositor announcing b receives the payment R with certainty. We can call an announcement b a "withdrawal of funds." If more than $\underline{N}$ depositors announce b, the bank is liquidated; otherwise, it is not, and the banker has the option of absconding. In any event, those depositors who do not announce b evenly split the aggregate payment to depositors described in the previous section, less the funds withdrawn. We call this scheme a "standard demandable-debt contract."

Under a standard demandable-debt contract, of course,

$$EU(\hat{b}, b) = EU(\hat{b}, g) = R.$$

However, for depositors who do not withdraw their funds, the payment depends on the number of depositors N who do withdraw, and on whether the banker absconds. Table 2 describes the payments for a depositor who announces g.

For example, if more than $\underline{N}$ depositors withdraw funds, then the bank is liquidated,

and according to the contract, the total payment to depositors P is $MY + (Z - Y)S$; that quantity, less the withdrawn deposits RN is split among the remaining depositors $Z - N$, yielding the quantity in the rightmost column of the table. The remaining numbers are calculated in a similar fashion.

Given the probabilities of the realizations of T_i and the probability of each signal contingent on T_i, it is a straightforward matter to calculate $EU(\hat{g}, b)$ and $EU(\hat{g}, g)$. For this scheme, the incentive and participation constraints reduce to the following:[24]

$$EU(\hat{g}, b) = R - I/(1 - \lambda)$$
$$S > R.$$

When an aggregate contract of the sort described in the previous section is optimal, it can always be implemented with a demandable-debt scheme, as stated in the following theorem.

THEOREM 4: *Under the distributional assumptions and the conditions of the previous theorem, the optimal outcome can be achieved with a simple demandable-debt contract.*

The role of reserves in our model warrants discussion. By holding reserves, the bank is able to guarantee early payment to a small number of monitors (those who receive bad signals) without forcing the bank to be placed into receivership. Reserves allow the bank to commit to the sequential-service constraint (early withdrawals by those who run the bank), which supports the implementation of the contract between bankers and depositors. More familiar justifications for bank reserve holding include the usefulness of reserves in meeting stochastic demands for conversion into gold

(say, due to foreign-transactions needs of depositors) or the contribution of reserves to an optimally diversified portfolio of bank assets. Our model adds to these transactions and portfolio motivations for holding reserves an "incentive-compatibility" demand for reserves.

C. *Transactability and Demandable Debt*

Thus far, we have argued that demandable-debt intermediation may arise in order to permit profitable investment opportunities to be realized. In our models, there is no demand for transactability; therefore, assets are valued entirely based on expected return. Historically, however, an important feature of demandable-debt instruments has been their use as a medium of exchange. In this subsection, we briefly consider the implications of our model for the liquidity of demandable debt.

It is important to note from the outset that transactable instruments need not be demandable. Postdated bills of exchange and postdated bank notes were physically transactable instruments that existed in the 19th century in the United States (Davis R. Dewey, 1910). Their primary difference from demandable debt was that they could be redeemed, not on demand, but only on the date of maturity. Since such instruments could be maturity-matched, they would seem to have none of the disadvantages of demandable debt. Nonetheless, demandable debt outcompeted these as a medium of exchange.

In order to explain the relative liquidity of demandable debt, one must explain why the ability to redeem a bank note or deposit on demand makes people more willing to accept it as a means of payment. We argue that, under demandable debt, monitors and nonmonitors alike are better informed of the market value of the debt instrument at all times.[25]

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[24] The constraints initially have two equalities that must be satisfied. However, given the fact that the total expected payments equal $SZ + KI$, as they do by construction of the demandable-debt contract, one of the equations is redundant: if the informed depositors are each receiving $S + I$, then the uninformed depositors are automatically receiving the remainder, or S per depositor.

[25] In a different context, Gorton and Pennacchi (1990) also employ this definition of liquidity. They show that debt instruments may be more liquid than equity because debt instruments reduce the potential

The fact that "the bank is open" (that monitors have not called for a liquidation) is revealing to nonmonitors. In the simplest, one-monitor case, the fact that the bank is open is fully revealing, because the signal that the monitor receives takes one of two values. In the multimonitor case, the fact that the bank is open is not fully revealing; it only indicates that fewer than the threshold number of bad signals have been announced. Even this information, however, places a lower bound on the value of the bank's liability.[26] If the liquidity of an asset depends on the extent to which information about its value is shared, then one would expect demandable debt to have been more liquid than other contracts with which it competed (see George Akerlof, 1970; Benjamin Klein, 1974). Thus, it may be possible to view the liquidity of bank claims as a by-product of the solution to the agency problem.

While we argue that the transactability of demandable debt enhanced its attractiveness, it is interesting to note that demandable-debt banking predates the transactability of demandable debt.[27] Thus, the desirability of demandable-debt contracting does not seem to have depended crucially on the transactability of the instruments.

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gains insiders can receive from trading. Their model does not, however, explain the special liquidity of demandable debt.

[26]Historically, specie prices of bank notes published in bank-note "reporters" confirm the view that nonmonitors faced little price uncertainty for notes of banks that were open. Discounts on antebellum bank notes convertible on demand into specie traded in the home city at par; in distant locations, the discounts for notes mainly reflected the risk due to the time it would take to reach the city of issue. Typically, one could know the value of a bank's notes in New York by knowing the state in which the bank was located. These discounts typically remained small (between $\frac{1}{8}$ percent and 2 percent) and were subject to little variation. Discounts of notes for failed banks were not quoted in bank-note reporters or were subject to extreme variations across banks in the same locale and over time (see Calomiris and Schweikart, 1988).

[27]For example, Roman banks issued demandable claims which were not transactable (A. W. Ferrin, 1908).

The "liquidity premium" that demandable debt enjoys can be included in our framework by reducing the level of the required return S on demandable debt by the amount of the liquidity premium. In other words, demandable debt would face a lower threshold reservation level to satisfy than the nonliquidating compound contract. This implies an expansion of the parameter values for which demandable debt is preferred over the "nuisance" contract.

IV. Summary

We have argued that historical demandable-debt banking can be understood as the optimal means of incentive-compatible intermediation in an environment of asymmetric information with potential for fraudulent behavior on the part of the banker. Monitoring by some depositors and runs by monitors who receive bad signals ensure sufficiently high payoffs to depositors in states of the world that would otherwise lead to malfeasance by the banker.

Agency problems are inherent in banking. Depositors entrust their endowments to bankers, who decide how to invest them and have essentially unfettered immediate control over the depositors' funds. We capture this agency problem in a simple way by allowing the potential for "absconding" by the banker. The banker has the ability to remove funds from the bank. Absconding is socially wasteful; if the banker steals funds from the bank, he uses a "leaky bucket," so that the amount he actually receives is less than the amount stolen.

If the required return for depositors is sufficiently high, then the banker may find it attractive to abscond, rather than make the promised payment to depositors. Anticipating this, depositors will be unwilling to entrust their funds to the banker, and efficient intermediation will not take place. In other words, the possibility for a banker to abscond may make it difficult for him to attract depositors to his bank.

We introduce a liquidation technology that allows depositors, at a cost, to prevent the banker from absconding and makes it

possible for the banker to attract deposi-
tors. We show that, under some circum-
stances, the optimal arrangement has the
depositor choose whether to liquidate the
bank, contingent on a costly signal he re-
ceives. In good states, it will pay for the
banker not to abscond and to pay the de-
positor as promised; in bad states, absent a
liquidation announcement, the banker will
abscond rather than pay as promised. Thus,
when monitors receive bad signals, they call
for liquidation.

If the signal is perfect and costless to the
depositor, liquidation will occur only when
there are bad loan-investment realizations.
If the signal is imperfect and costly, but not
prohibitively so, it still makes sense to use
the contingent liquidation contract, even
though on occasion monitoring depositors
may make errors in judging when to "run
the bank" and force the bank to liquidate
unnecessarily. Banks can fail either because
the banker absconds or because the deposi-
tor initiates a run on the bank. The purpose
of a run is to prevent absconding from tak-
ing place.

In the case of multiple depositors, the
bank uses reserves to offer guaranteed pay-
ments to early withdrawers and to insulate
itself from a few bad idiosyncratic signals.
At the same time, under circumstances that
probably would lead to costly absconding,
depositors as a group are likely to order
liquidation preemptively. The number of
monitors and the threshold at which a bank
liquidation is called for will be chosen opti-
mally to minimize total expected costs of
liquidation, absconding, and monitoring.

Limitations and Suggested Extensions

Our analysis has several important limita-
tions. First, our goal is to explain the *histor-
ical* importance of demandable debt in
banking. In today's more regulated environ-
ment, where for example, regulations on
clearing through the Federal Reserve Sys-
tem have favored demandable-debt instru-
ments and where deposit insurance makes
depositor monitoring less important, de-
mandable debt may persist simply as an
artifact of regulation.

Second, our framework does not consider
the possibility of trade in bank shares. Un-
like the historical context in which demand-
able debt arose, in today's more sophisti-
cated financial markets, shares of financial
intermediaries are actively traded. In this
richer context, equity trading could conceiv-
ably provide a superior disciplinary alterna-
tive to demandable debt and contingent liq-
uidation. For example, leveraged buy-outs
offer a possible alternative means to prevent
managerial misconduct and provide rewards
that make monitoring incentive-compatible.

Third, our account is one of individual
banks and individual bank liquidations, not
of systems of banks or economy-wide bank
panics. We are only attempting to model
the operation of demandable debt in nor-
mal times, when the rules require banks to
pay on demand. In historical practice, the
provisions of demandable debt, including
liquidation, were suspended during crises
(see James G. Cannon, 1910; Calomiris and
Schweikart, 1988). That is to say, demand-
able debt was a contingent rule; it required
banks to meet the threat of runs in response
to idiosyncratic problems, but it allowed
banks to escape convertibility on demand in
the face of systemic disturbances. Only indi-
vidual bank difficulties led to placing a bank
in receivership. Suspension and interbank
relations during panics are important as
well, but doing this topic justice requires a
larger analysis than the one we have under-
taken in this paper (see Calomiris and Kahn,
1989; Gorton, 1989; Calomiris and Gorton,
1990).

Fourth, our model relies on a crude and
extremely stylized incentive problem char-
acterized by the "leaky bucket" with which
the banker can abscond. This leaky-bucket
assumption is useful, because it allows us to
model the problem in an extremely simple
way, but it raises natural questions as to
whether the degree of leakiness necessary
to generate the results is at all realistic.
After all, if the banker's own stake is less
than 1 percent of the value of the assets,
then it would be necessary that more than
99 percent of the value of the assets leak
from the bucket in good times in order to
keep the banker from absconding.

A more reasonable interpretation of our story is as a simplification of a multiperiod account, in which the banker is in fact choosing whether to engage in malfeasance today, when the decision not to engage in malfeasance always leaves the option open for tomorrow. Suppose that the returns to a bank's investments are intertemporally correlated. Then, in a good realization, the banker may be unwilling to engage in malfeasance because it will destroy the prospects for future returns (including the possibility of future malfeasance), even without assuming the bucket implausibly leaky.[28] Thus, is is important to investigate multiperiod versions of our model to determine whether a consistent account can be generated with plausible parameter values.

Finally, our model does not include any demand for liquidity. We have intentionally limited the model in order to emphasize the difference between our account and those accounts that depend on liquidity demand. Nonetheless, this limitation means that the model is not adequate to investigate the relation between demandable debt and transactions demand. Although we have briefly and informally considered the links, formal models combining the consumption-flexibility and monitoring accounts of banking are an important goal for future research.

APPENDIX: SKETCHES OF PROOFS

To conserve space, we briefly describe the proofs for each of the four theorems. The complete Appendix is available from the authors on request.

PROOF OF THEOREM 1:

The claim that an optimal contract must conform to one of the four cases listed in the theorem is equivalent to the following claims.

a) If the promised payment is less than the minimum absconding tax (AT_1), then liq-

uidation is never called for, since absconding is socially wasteful and simple debt repayment is always credibly preferred *ex post* by the banker.

b) If the optimal contract is a compound contract, then it cannot specify liquidation in all states, since in that case there would be no incentive to invest in signals. If liquidation is going to be called for, it must be that it is only called for under the bad signal.

c) If the optimal contract involves monitoring and contingent debt claims (the depositor announces one of two values to be repaid), then the amount announced contingent on the bad signal will be lower than the one announced contingent on the good signal, and the lower amount will be less than the minimum absconding tax.

PROOF OF THEOREM 2:

When $S < AT_1$, it is immediate that a simple debt contract is optimal. When the banker chooses between the demandable-debt and nuisance contracts, the banker will always choose the nuisance contract when it is feasible, because it is less socially wasteful than demandable debt. In the nuisance contract, social waste occurs through absconding when a good signal is received but a bad outcome is realized. In the demandable-debt contract, an additional source of waste is the liquidation cost when the bad signal is received. It can be shown that, as the reservation level of the depositor rises, liquidation will eventually be required to increase the depositor's returns beyond what is feasible in the nuisance contract. The use of either form of compound contract requires that the costs of receiving the signal be sufficiently low and the signal's accuracy be sufficiently high to warrant investment in the signal.

PROOF OF THEOREM 3:

The optimal contract is designed to give the depositors their required expected return while minimizing expected social waste from absconding and liquidation. The optimal contract in general involves dividing the possible values of N into three regions. For

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[28] We are grateful to an anonymous referee for suggesting this interpretation.

high values of N, the contract mandates liquidation. For intermediate values of N (a nuisance region), liquidation is not mandated, but aggregate payment is set sufficiently low that absconding never occurs. For low values of N, liquidation is not mandated, and payment is set sufficiently high that absconding takes place in bad states. It can be shown that, as the reservation level of depositors rises, the middle nuisance region disappears, in order to expand the range of higher depositor returns achieved through liquidation or high but uncertain payments.

PROOF OF THEOREM 4:

Given the payoff structure, one can write monitors' and nonmonitors' individual expected returns as functions of the signals received and announced by each, given the probability of other depositors' signals and actions. Tedious but straightforward calculation demonstrates that, for Z and $\underline{N}$ sufficiently large, the returns so calculated satisfy individual incentive and aggregate feasibility constraints. Finally we show that $\underline{N}$ sufficiently large can always be found, provided the probability of the good outcome exceeds a certain minimum level.

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