NBER WORKING PAPER SERIES

BANK FINANCING AND INVESTMENT DECISIONS WITH ASYMMETRIC INFORMATION

Deborah Lucas

Robert McDonald

Working Paper No. 2422

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
October 1987

We thank Mike Fishman, Stuart Greenbaum, Kathleen Hagerty, George Pennachi, Bill Rogerson, and Anjan Thakor for many useful conversations, and the Banking Research Center at Northwestern University for support for the second author. The research reported here is part of the NBER's research program in Financial Markets and Monetary Economics. Any opinions expressed are those of the authors and not those of the National Bureau of Economic Research.

NBER Working Paper #2422
October 1987

Bank Financing and Investment Decisions with Asymmetric Information

ABSTRACT

Banks know more about the quality of their assets than do outside investors. This informational asymmetry can distort investment decisions if the bank must raise funds from uninformed outsiders, and assets sold will be subject to a lemons discount. Using a three-period equilibrium model we examine the effect of asymmetric information about loan quality on the asset and liability decisions of banks and the market valuation of bank liabilities. The existence of a precautionary demand for T-bills against future liquidity needs depends both on the regulatory environment and the informational structure. If banks are ex ante identical, issuing risky debt to fund a deposit outflow is preferred to holding T-bills ex ante. However, if banks have partial knowledge of loan quality, and if their asset choice is observable, they may hold T-bills to signal their quality, enabling them to issue risky debt at a lower interest rate.

Deborah Lucas
Finance Department
Kellogg School
Northwestern University
Evanston, IL 60201
(312) 491-8333

Robert McDonald
Finance Department
Kellogg School
Northwestern University
Evanston, IL 60201
(312) 491-8344

I. Introduction

Many firms know more about the quality of their assets than do outside investors. This informational asymmetry can distort investment decisions if the firm must raise funds from uninformed outsiders (Myers and Majluf, 1984). Banks appear particularly vulnerable to these information problems; private information about loan quality is usually obtained as part of the lending process.[1] In this paper we consider the effect of asymmetric information about loan quality on the asset and liability decisions of banks, and the market valuation of bank liabilities. Bank incentives differ from those of most other firms for two key reasons in this model:

1. banks receive non-risk-based deposit insurance, and
2. banks provide liquidity services for depositors, resulting in stochastic cash outflows.

It is well known that deposit insurance creates an incentive to increase risk (Merton, 1977). With symmetric information and costless asset sales, a risk-neutral bank would minimize equity holdings and invest in the riskiest available assets, which we call loans, to maximize the option value of the insurance. It is not obvious, however, whether in practice banks actively enhance or decrease risk. The fact that banks keep a significant proportion of their portfolio in low-risk government securities suggests risk avoidance. On the other hand, banks set equity close to the regulatory minimum, and off-balance-sheet activities such as back-up lines of credit may be undertaken to increase risk (Andrews and Sender).[2] Previous studies attribute bank risk aversion to a variety of factors: regulatory incentives (Flannery, 1987), risk averse owners or managers (Hart and Jaffee, 1974; Koehn and Santomero, 1980), protection of charter value (Marcus, 1984; Merton, 1979), and exogenous costs of selling loans (Poole, 1968; Frost, 1971; Baltensperger, 1974).

We suggest that asymmetric information about asset quality coupled with an uncertain need for liquidity may induce a demand for low-risk securities, despite FDIC insurance. Suppose that a bank with good quality loans suffers a large deposit outflow. Banks have several funding alternatives, including sales of loans, and issuing uninsured debt. If the bank sells its good quality loans, it will be able to do so only at a discount, since the presence of asymmetric information gives rise to a lemons market for loans (Akerlof, 1970), in which loans sell at a discount from their average value. For the bank which knows that it has good loans, selling at a discount is a cost of loan sales. By the same token, if the bank issues a risky security such as equity or uninsured debt, there is also a lemons cost, since the security purchaser must contend with the possibility that the security is being issued by a poor quality bank (Myers and Majluf, 1984).

Since lemons pricing is potentially costly, one might expect banks to take precautions against having to sell risky loans or issue debt. This is similar to the idea that corporations with private information about asset quality will hold financial slack to avoid more costly security issues (John and Nachman, 1987). One such precaution is for banks to hold publicly traded securities about which there is symmetric information and hence no discount in the resale market.[3] One cannot conclude, however, that securities or some other form of financial slack will be used to circumvent information problems. In fact we show that in many cases even with private information, it is optimal to hold only risky assets to maximize the value of deposit insurance. The reason is that the lemons cost, while it may be a cost to the relatively good banks ex post, is not necessarily a cost ex ante. In the absence of FDIC insurance, for example, we show that if all banks are ex ante identical, banks will not pay anything to avoid bearing the lemons cost. The reason is simply that if the market sets the lemons discount based on rational expectations about the distribution of loans which will be sold, then banks on average are neither helped nor hurt by selling lemons loans or securities, so ex ante banks will take no steps to reduce the probability of entering a lemons market. The presence of the FDIC changes this conclusion, however, and the lemons discount can then be costly ex ante to banks as a group.

The model answers a number questions about optimal bank behavior in the presence of asymmetric information. Under what circumstances will insured banks hold risk-free securities to avoid liquidity costs? How are bank debt and secondary market loans priced? Is there a limit on the amount of uninsured debt that banks can profitably issue? Does issuing debt dominate loan sales as a means of attaining liquidity? Can banks with good loans credibly signal their asset quality?

We address these issues in a three period equilibrium model. The results depend critically on whether or not banks have ex ante private information about loan quality, so we consider both cases. In each case, a signalling game (Stiglitz and Weiss, 1984) between outside investors and banks determines the price and quantity of uninsured bank debt.

Section II sets up Model I, in which banks are identical at the time that they select their initial portfolio. Subsequently each receives a private signal that reveals loan quality and a deposit realization. If there is a withdrawal and banks have insufficient liquidity to meet it, either debt must be issued or loans sold. In Sections III and IV the solution to a signalling game determines the equilibrium price and quantity of debt in Model I, and the discount on loan sales is derived. We find that if issuing debt is prohibited, banks may have a precautionary demand for securities to avoid costly loan sales. However, when debt issuance in period 1 is a possibility, in equilibrium banks prefer to issue debt when the need for liquidity arises, rather than holding precautionary securities ex ante. Generally there is a partial pooling equilibrium in the debt market, in which banks with poor loans borrow at the expense of banks with good loans and withdrawals. The amount of borrowing in equilibrium is never more than that necessary for banks to avoid liquidating good loans. Banks with good loans always prefer borrowing to selling loans.

An obvious question is whether these results change when banks have private information at the time they make incremental portfolio decisions. Section V studies the case in which banks have old loans of privately known quality at the time they decide whether to invest new funds in loans or in riskless securities. In this case the quantity of securities chosen can signal the quality of existing bank loans, and hence affects the interest rate at which debt may be issued in subsequent periods. Conditions for the existence of a signalling equilibrium are derived, and examples are calculated. Section VI concludes.

II. Model I: Banks Ex Ante Identical

a. Basic Structure

We consider first the case where banks are ex ante identical, but subsequently receive private information about loan quality and liquidity needs. Banks operate for three periods. This provides an initial investment period, a period in which actions are taken based on private information, and a final period in which all information becomes public. This is the minimal number of periods in which to study the role of asymmetric information. To begin we describe the cash flows, decision variables, and constraints in each period.

Period 0:

At time 0 all banks are identical. Each receives an exogenous, insured deposit inflow D_0. The capital requirement is a fraction ε of assets, implying that initial equity must be at least $\varepsilon(S_0+L_0)$. We assume that banks initially set equity to this minimum level. Banks optimally divide the funds raised from equity and deposits between two-period loans, L_0, and two-period securities, S_0. This implies that

$$D_0/(1-\varepsilon) = S_0 + L_0$$

Securities earn the risk-free rate r in both periods 1 and 2, and all principal is repaid in period 2. Loans made in period 0 return $L_0(\psi^0 + \tilde{\alpha}^0)$ in period 1, and return $L_0(1 - \psi^0)(1 + \tilde{\alpha}^0)$ in period 2. ψ^0 is the promised repayment of principal, and $\tilde{\alpha}^0$ is a random interest payment or default amount.[4] For a given loan, α is the same in periods 1 and 2. For tractability, loan returns α are binomial, with probability f of a high return α_H, and probability (1-f) of a low return α_L. The time superscript will be suppressed when there is no ambiguity. Loans are actuarially fair:

$$(1) \qquad (1+r) = f(1+\alpha_H) + (1-f)(1+\alpha_L).$$

Period 1:

Between periods 0 and 1, the bank receives two new pieces of information. First, the bank learns the quality of period 0 loans, so uncertainty is resolved about α^0.[5] Banks also learn whether a deposit or withdrawal will be made in period 1. Deposits are binomially distributed, with probability g of a withdrawal δ_H, and probability (1-g) of a deposit δ_L. By convention a positive δ denotes a withdrawal.

The bank must return any deposits demanded, and pay interest on old deposits. This outflow can be funded by sales of old securities, sales of existing loans, Q_0, or issuing debt, B. Since securities S_0 are risk-free, they can be sold at face value. Two period securities, then, are "informationally matched" with one period deposits. If loans, Q_0, are sold, the bank receives $Q_0(1-c)$, where c is the (endogenously determined) discount due to the information asymmetry.

If the net cash inflow, including funds raised from loan sales and security sales, is positive, then the bank invests the cash in new risky, one-period loans L_1. Because all remaining uncertainty is resolved in period 2, it is optimal because of FDIC insurance for cash which is not used to fund deposit outflows to be invested in these new loans, and for all old securities to be sold.[6] Dividends, which are an alternative use of free cash, are ruled out for tractability.[7]

We assume that the market does not learn the quantity of new L_1 loans until period 2, since this would be sufficient to infer δ.[8] The period 2 return on L_1 is distributed independently and identically to the return on

L_0. Since dividends are zero by assumption, all period 1 cash inflows are invested in new loans:

$$(2) \qquad L_1 = \lambda + Q_0(1-c) + B - \delta$$

where

$$\lambda = (1+r)S_0 + (\alpha^0+\psi^0)L_0 - rD_0$$

All terms except δ and c are non-negative, and $Q_0 \leq L_0(1-\psi^0)$. We define financial slack in period 1, λ, as net funds available from period 0 for investment or to fund deposit outflows. Securities S_0 are included because they can be sold costlessly at time 1. Note that banks with good loans have more slack because α is greater.

Period 2:

In the final period no choices remain. Loans pay off interest and principal, and depositors and debt-holders must be repaid if possible. Equity-holders receive the net cash flow if it is positive, and nothing if liabilities exceed assets. The total value of equity in period 2 is

$$(3) \qquad \max\ [0,\ (L_0(1-\psi^0)-Q_0)(1+\alpha^0) + L_1(1+\alpha^1) - (D_0-\delta)(1+r) - (1+r+s)B]$$

where r+s is the promised rate on bank debt.

III. Equilibrium in the Debt and Used Loan Markets

A. Expected Profit in Period 1

Before determining the period 0 portfolio, it is necessary to derive the equilibrium price and quantity of debt issued and loans sold in period 1, conditional on L_0 and S_0. We solve for the equilibrium price and quantity of subordinated bank debt by setting up a signalling game between banks and investors. For tractability, we consider only subordinated debt. A similar analysis could be applied to straight debt or equity.[9]

Substituting (2) into (3), in period 1 banks choose B and Q_0 to maximize

$$\Pi_{ij} = \beta E_1 \max\{0,\ [L_0(1-\psi^0)-Q_0](1+\alpha_i^0) + [\lambda_i-\delta_j+B+Q_0(1-c)](1+\bar{\alpha}^1) - (1+r)(D_0-\delta_j) - B(1+r+s)\ \} \tag{4}$$

E_1 denotes the expectation operator, conditional on all information available at the beginning of period 1. β is the discount factor, with $\beta=(1+r)^{-1}$.

Because of the distributions of returns and withdrawals, there are four types of banks in period 1: a) "good/good" banks with good loans and deposit inflows, b) "good/bad" banks with good loans and deposit outflows, c) "bad/good" banks with bad loans and deposit inflows, and d) "bad/bad" banks with bad loans and deposit outflows. Expected profit differs for each type, and affects their choices of Q_0 and B.

The pricing of bank securities is complicated by differential default probabilities and payoffs to security holders across the various types of banks. With private information, the different types of banks have different incentives to issue debt and sell loans. Banks with good loans want to avoid discount sales, while banks with bad loans benefit from portfolio churning to increase their portfolio risk. One might expect the debt market to be driven out by the presence of asymmetric information. However, a bank with good loans and deposit outflows (a "good/bad" bank), is willing to pay a premium when issuing securities in order to avoid selling good loans at a discount. This premium creates a potential rent for other market participants. In particular, if risky banks can pool with these good/bad banks, they can issue debt or sell loans at a favorable price. On the other hand, it may be possible for the good/bad banks to distinguish themselves by the amount they choose to borrow, and avoid paying a premium over the fair price. Here we describe more fully the incentives for each type:

Good/bads

The good/bads have less financial slack than deposit outflows, so loans must be sold or debt issued. The amount of loans that must be sold is given by:

$$(5) \quad Q_0 = \max[0, (\delta_H - \lambda_H - B)/(1-c)]$$

It will be shown in Lemma 2 below that in equilibrium subordinated debt issues never exceed that necessary to avoid loan sales, so that $\min[0, \delta_H - \lambda_H - B] = 0$ whenever $B > 0$. This is because for larger amounts of debt the information asymmetry continues to create a lemons problem, but there are no more potential offsetting gains from avoided forced loan sales.

After meeting the deposit outflow the good/bad bank has no uninvested cash, so no new loans are purchased. Thus there is no uncertainty about returns in period 2. Evaluating (4) at $\alpha = \alpha_H$ and $\delta = \delta_L$, the total benefit from borrowing to avoid loan sales is $B(1+\alpha_H)/(1-c) - B(1+r+s)$. This benefit increases with the discount c, and decreases with the premium s on debt.

Good/goods

Good/goods have cash from deposit inflows to invest in new loans. It is clear that they will never choose to sell good loans at a discount in order to buy new risky loans. Whether or not they borrow depends on the premium s, and whether they are risky. Good/goods are risky if in the event that their new loans are bad they go bankrupt. If they have relatively few new loans, the above average returns from the old loans assure solvency. If good/goods are riskfree, the expected return on new loans is 1+r, so borrowing is zero for a premium s>0. If good/goods are risky, the payoff in period 2 from borrowing conditional on solvency, is $(1+\alpha_H)B-(1+r+s)B$.

Bad/goods and Bad/bads

Banks with bad loans always prefer to sell them and use the proceeds to invest in risky new loans. This follows from the fact that the equilibrium secondary market price for loans will be at least as great as the true value of the bad loans, and higher if some good loans are also sold. Even if the price were slightly less than fair, bad banks would prefer to liquidate old loans and buy new loans because this increases risk in the final period. Since we assume that loan sales are unobservable, they have no adverse affect on the ability of bad banks to mimic the good banks in the debt market.

Banks with bad L_0 loans generally need to buy new risky loans in order to have any chance of solvency in period 2. Since the bad/bads can borrow no more than the good/bads, and the good/bads only borrow to avoid loan sales, the bad/bads cannot borrow enough to avoid certain bankruptcy. We assume that when they are bankrupt for certain, the bad/bads sell all their loans in the secondary market in period 1, and wait until period 2 to go bankrupt. This assumption has a negligible affect on the results.

B. Determination of the Lemons Discount for Loan Sales

The informational asymmetry about loan quality implies that old loans sell at a discount c from face value.[10] The value of c depends on investors' beliefs about the quality of loans being sold. Risk-neutral, competitive investors will accept a discount that provides an expected return of r.

Let $E(\alpha_s)$ denote an investor's expectation about the return on a loan purchased in the secondary market. Then to receive an expected return of at least r, c must satisfy:

$$(6) \qquad (1-c)(1+r) \geq (1+E(\alpha_s))$$

If the quantity of loans sold were observable, this expectation would be conditioned on quantity.[11]

Lemma 1: The discount c is positive when the quantity of loans sold is unobservable and loan sales are anonymous.

Proof: Since all banks with bad loans sell them, at least a fraction (1-f) of used loans have a return of α_L. If in addition all banks with good loans were to sell all loans, then from (6) c = 0 and c is at a minimum. But for c=0, good/good banks will not voluntarily sell any loans, so c is positive. //

C. <u>Debt Market Equilibrium</u>

In this section the quantity and promised interest payment on debt is found by solving a signalling game between banks and investors in period 1.

C.1. <u>Structure of the Game</u>

The objective function of all players, distributions of loan quality and deposit flows, and structure of the game is common knowledge. Banks know their own type, but competitive investors observe neither loan quality, quantity of loan sales or new loan purchases, nor deposit realizations. We assume that if a bank is indifferent about borrowing, it won't borrow.

The game proceeds as follows: A bank approaches an investor with an offer (B,s), where B is the desired quantity to be borrowed, and s is the premium over the risk-free rate promised on B. Investors either accept or reject the offer with a response $R \in (\text{yes,no})$. If the bank is solvent in period 2 the investor receives $(1+r+s)B$. Otherwise the investor receives the liquidated value of the bank net of the amount owed to the FDIC. Only pure strategies are considered.

Definition of Equilibrium: [(B^*,s^*), R^*] is an equilibrium offer/response pair if and only if

(a) $\Pi_i(B,s) \leq \Pi_i(B^*,s^*)$

for any other offer (B,s), where Π_i is expected profits for a bank of type i, and

(b) Investors accept any offer yielding non-negative expected profits.

Locating equilibria requires several preliminary steps. Two types of schedules are derived to generate candidate equilibria. The first gives the reservation rate levels above which a bank of a particular type would not borrow. The second provides a rate schedule yielding zero expected profits to the investor for a particular combination of types borrowing. Together, these schedules define a set of interest rates and quantities for which banks willingly lend and investors willingly borrow. This set is the candidate schedule. Theorem 1 establishes that the equilibria are points on this candidate schedule that maximize the profits of a good/bad bank. Thus if there is a unique profit-maximizing offer for the good/bads, there is a unique equilibrium.

C.2. Derivation of Borrowing Reservation Schedules for Banks

Define reservation rates $\Sigma_i(B)$ to be the maximum markup over the risk-free rate at which type i would willingly borrow B rather than borrow nothing. The expected profit function, equation (4), depends on B and s and can be written as $\Pi_i(B,s)$. Solving $\Pi_i(B,s)=\Pi_i(0,0)$ for s as a function of B yields the reservation schedules $\Sigma_i(B)$. As discussed above, the reservation rate for a given level of borrowing depends on whether the bank is risky at that level of borrowing. The appendix gives Σ_{gg} and Σ_{bg} explicitly.[12]

C.3. Derivation of Fair Lending Schedules for Investors

Investors are competitive and risk neutral, so they are willing to lend at any rate that yields non-negative expected profits. The pooling schedules provide the markup over the riskfree rate for which investors will be fairly compensated if those types assumed to borrow B always do so.

The derivation of the pooling schedule is given in detail here only for the case in which good/goods and good/bads borrow, and for which good/bads are riskfree. The other schedules can be found similarly. If only good/goods and good/bads offer (B,s), then the probability of being approached by a good/bad making this offer is $w_1 = fg/(fg+f(1-g)) = g$, and the probability of a good/good is $w_2 = 1-w_1 = 1-g$.

Suppose that banks offer to borrow at a rate r+s*. For the investor to get an expected return of r, s* must solve

$$(7)\quad (1+r)B = w_1(1+r+s^*)B + w_2\ [f(1+r+s^*)B + (1-f)\min\{\ (1+r+s^*)B,\ \max\{\ 0, L_0(1-\psi^0)(1+\alpha_H^0)+(\lambda_H+B-\delta_L)(1+\alpha_L^1)-(1+r)(D_0-\delta_L)\ \}\}\ ]$$

The first term on the right is the sure repayment from the riskless good/bads, while the second term reflects a full repayment from the good/goods if new loans are good and a partial repayment otherwise. Solving for s^*:

$$(8)\quad s^* = \begin{cases} (1-f)w_2[(1+r) - \chi/B]/(w_1+w_2f) & \text{if good/goods risky} \\ 0 & \text{if good/goods riskfree} \end{cases}$$

where $\chi = \max\{\ 0,\ L_0(1-\psi^0)(1+\alpha_H^0)+(\lambda_H+B-\delta_L)(1+\alpha_L^1)-(1+r)(D_0-\delta_L)\ \}$

Lemma 2 establishes that the only relevant pooling schedules include the good/bads, because the other types would never choose to borrow at a fair pooling rate.

Lemma 2: A pool of banks not including the good/bads never would issue subordinated debt at a fair rate to lenders. A good/bad bank never will issue more than enough subordinated debt to avoid loan liquidations. (proof in appendix)

D. Determination of Equilibria

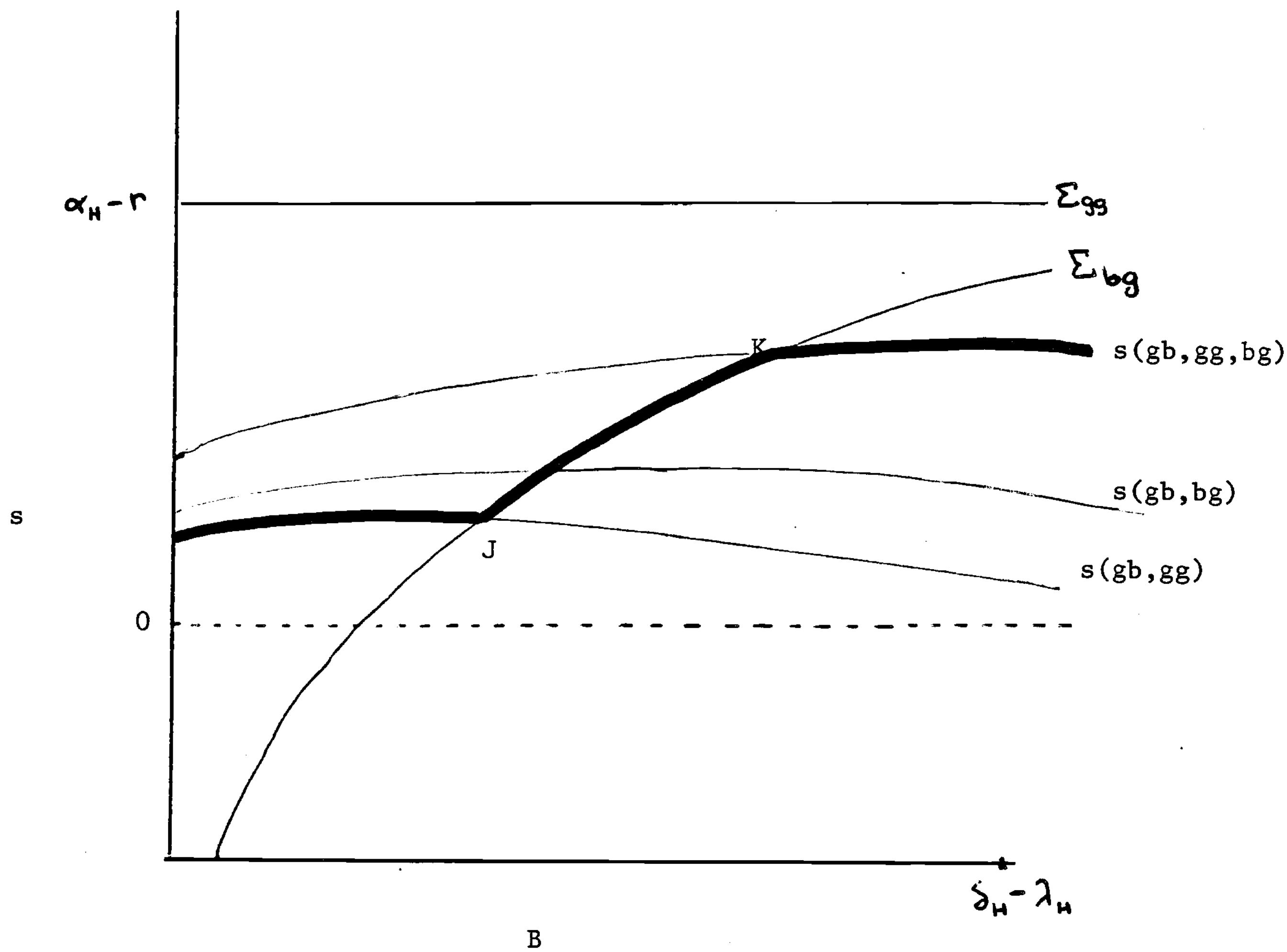
Combining the information in the Σ_i schedules and pooling schedules provides the set of candidate equilibria.

Definition: The set of candidate equilibria are all offer pairs (B,s) with the following properties: (p1) if all banks making positive profits with this offer were to make this offer, investors expectations about expected returns would be satisfied, and (p2) For a given B, s is the minimal premium so that (pl) holds.

The bold line in Figure 1 gives an example of this set for the case when bad/goods are bankrupt without borrowing, and good/goods are risky without borrowing. Recall that the $\Sigma_i(B)$ schedules give the premiums above which type i would not choose to borrow, and the s(.) schedules give rate premiums below which investors would not lend. From Figure 1, it is clear that on [K, $\delta_H - \lambda_H$] all three types borrow along the s(gb,gg,bg) schedule. For B on [J,K], s(gb,gg,bg) lies above the reservation level for bad/goods, so a three-pool is impossible. On this segment any offer on Σ_{bg} just prevents the bad/goods from borrowing, and good/goods and good/bads pool. Note that investors make positive profits in this region, since there is no equilibrium offer that yields zero profits. Below J, only good/goods and good/bads are willing to borrow at the fair pooling price for these two types, so the candidate schedule follows s(gb,gg).

Most of the points on the bold line in Figure 1 are not equilibria, because a good/bad bank would never choose these offers in equilibrium. Theorem 1 characterizes the equilibria.

Theorem 1: An equilibrium of the borrowing game is any point along the candidate schedule that maximizes the expected profits of the good/bads. The equilibrium is unique if there is a unique profit-maximizing point.



$\alpha_H - r$
Σ_{gg}
Σ_{bg}
K
s(gb,gg,bg)
s(gb,bg)
s
J
s(gb,gg)
0
$\delta_H - \lambda_H$
B

Figure 1

Proof: If all banks who borrow make the same offer, these offers must lie on the candidate set. This is because banks know that investors will accept any offer with non-negative profits, and these are the minimum offers consistent with non-negative profits for investors and profit maximizing behavior by banks, by definition of the candidate schedule. The good/bads can borrow at the risk-free rate if they can reveal their type, and would like to do so. Thus they are unconstrained in choosing a profit-maximizing offer. It remains to show that all borrowing banks make the same offer.

Suppose that expected profit-maximizing offers were to differ across types. Then investors could identify at least one type or subpool not including the good/bads. They would only lend to this subgroup at a rate yielding a fair return. By Lemma 2, banks would be unwilling to borrow at this rate. Thus banks either borrow at the profit-maximizing level for good/bads or don't borrow. //

We have not discussed beliefs about out-of-equilibrium offers. Note that if investors believe all out-of-equilibrium offers come from banks with bad loans, then no bank with good loans will have the incentive to make this offer and the belief will be self-fulfilling.

Note that although we do not prove the necessity of a unique equilibrium, all simulations generated a unique equilibrium.

IV. Implications for Period 0 Asset Choice

In the foregoing, we determined equilibrium loan sales and subordinated debt issues taking as given the initial portfolio of loans and securities.

In this section we examine the optimal period 0 division between loans and securities for a wide set of parameters by simulation.

It is a complicated but well-defined problem to consider all possible levels of time 0 security holdings and find ex ante expected profits with borrowing determined as in Theorem 1. Then the optimal division of original deposits between securities and loans is that which maximizes ex ante expected profits.

An algorithm for locating maximum expected profits is the following. Fix a discount c. Divide initial deposits in varying proportions between S_0 and L_0. For a given allocation, find the amount of borrowing and loan sales for each type by solving the borrowing game. Note that lenders in period 1 can observe S_0 and L_0, so borrowing opportunities for banks are conditional on this choice. In particular, lenders will not lend more than the maximum amount that a good/bad could conceivably need to borrow to avoid selling good loans. At the initial allocation that maximizes expected profit, c is recalculated to be fair to purchasers of used loans (eq. (6)). This is repeated until a fixed point in c is located. The treatment of c is consistent with the assumption that banks take c as exogenous.

Numerical implementation of this algorithm established that for a wide set of parameter values:

1) Banks prefer borrowing to holding precautionary securities; when borrowing is possible banks optimally hold no securities.

2) Banks with good loans never sell loans for liquidity purposes when there is the opportunity to borrow.

In order to interpret these results, we look more closely at banks' incentives in several special cases in the next section.

A. Portfolio Choice Without Borrowing, and the Role of the FDIC

To understand the effect on bank asset choice of the ability to issue debt, it is useful to examine the bank's period 0 portfolio choice when debt issues in period 1 are not permitted. Intuition suggests that some precautionary security holdings may be optimal to avoid costly loan sales in period 1. However, depending on parameter values, it is possible that banks will hold no securities or 100% securities. Simulations of the model suggest that for most parameterizations, banks hold only loans, although some precautionary security holdings appear to be optimal when a) the lemons discount is high, and b) there are a relatively large number of good/bad banks.

The result that banks may hold only risk-free securities in period 0 is somewhat surprising, but easily explainable. Suppose banks know that there will be a net inflow of period 1 deposits, so that avoidance of forced loan sales no longer motivates security holdings. Also assume that enough new loans can be purchased in period 1 so that failure in period 2 is determined entirely by the return on loans made in period 1, and is therefore unaffected by L_0 loan quality. The marginal benefit from investing in securities in period 0 is $f(1+\alpha_H)(1+r)$, while that from investing in loans in period 0 is[13]

$$f(1+\alpha_H)[f(1+\alpha_H) + (1-f)(\alpha_L + (1-c))] = f(1+\alpha_H)(1+r-c(1-f))$$

This is less than the return from securities by $cf(1-f)(1+\alpha_H)$. Thus, if solvency depends only on L_1 loan quality and there are no withdrawals, banks invest only in securities. Paradoxically, in this case securities increase risk. Because the returns on period 0 and period 1 loans are independent, by holding loans in period 0 the bank diversifies intertemporally, which lowers the value of FDIC insurance.

Suppose on the other hand that the return on period 0 loans does affect the ultimate probability of bankruptcy, and that it is necessary that the bank have high returns on both period 0 and period 1 loans to be solvent in period 2. Again assume the probability of a deposit outflow is zero. The marginal benefit to investing in securities instead of loans is

$$f^2[(1+\alpha_H)(1+r) - (1+\alpha_H)^2] < 0$$

so it is optimal for the bank to invest solely in loans in period 0.

Thus, if deposit outflows are negligible and current portfolio decisions will not affect the ultimate probability of bankruptcy, a bank will wait and place all its bets in one period. If current portfolio decisions affect the ultimate probability of bankruptcy, it is optimal to invest in risky assets in each period. This suggests that banks which expect to grow rapidly will have less risky asset portfolios, even with FDIC insurance.

The foregoing explains the case of no or few forced sales of loans in the presence of FDIC insurance. We now consider the effect of removing FDIC insurance, and reintroduce the possibility of forced loan sales. Is it possible in this case that banks will have a precautionary motive for holding securities? Lemma 3 establishes that there is no precautionary motive without insurance.

Lemma 3: In the absence of FDIC insurance, if banks have no private information in period 0, and if the lemons price in period 1 is actuarially fair, then banks are indifferent about period 0 asset composition and their debt-equity ratio.
(proof in appendix)

This result implies that the existence of a lemons market for loans in period 1 does not in itself provide a precautionary motive for holding securities. If the price received for liquidated loans is fair conditional on no information, then the prospect of entering a lemons market provides no precautionary motive.

Why can FDIC insurance generate a precautionary demand for securities? In period 2, the FDIC will own the banks with the worst loans, while solvent banks will own more than the ex ante average amount of good loans. To the extent that solvent banks in equilibrium will sell more high quality loans than the bad banks ultimately owned by the FDIC, c is no longer ex ante fair to banks as a group. Thus, banks may hold securities to avoid pooling with the FDIC in the used loan market.

B. <u>Portfolio Choice With Borrowing in Period 1</u>

We have established that with FDIC insurance, there exist cases for which banks in Model I have a precautionary demand for securities. This case is the relevant benchmark for the analysis that follows. The question is whether securities still dominate loans when issuing debt is an alternative to loan sales to raise liquidity.

To answer this question, simulation parameter values were varied over those for which positive security holdings are optimal when borrowing is prohibited. A grid search located this region of parameter space (see Table 1 in the appendix). In this region, optimal security holdings are approximately 15% when borrowing is prohibited.

In all cases the ability to borrow drives out security holdings, although good/bad banks always pay a premium on debt in equilibrium. Furthermore, no good loans are sold. It is not surprising that borrowing dominates loan sales. Selling loans has the worst pooling properties for the good/bad banks, since all bad loans are sold on the secondary market, driving up c. It appears that borrowing crowds out security holdings because to a first approximation borrowing is zero sum across banks, because while the good banks borrow at a premium, the poorer banks borrow at a discount. However security holdings unambiguously reduce the aggregate value of FDIC insurance for these parameters.

V. The Effect of Prior Information About Loan Quality

The foregoing suggests that shielding loans from forced discount sales does not explain bank security holdings when alternative financing is available in this model. However, this result can be reversed with slightly different, and arguably more realistic, informational assumptions. We now ask what happens when banks have information about the quality of existing loans before having to decide whether to hold securities or loans. In this case securities can serve as a signal of bank quality, and will be purchased in equilibrium.

A. A Simple Example

Banks generally have a substantial number of old loans on their books when making a new investment decision. Information about the quality of these loans can affect investment decisions and borrowing costs. In this section Model I is modified to include old loans of known quality, and we demonstrate the existence of signalling equilibria in which the quantity of securities held reveals the quality of old loans.

It is well known that a necessary condition for a signalling equilibrium is that high quality types have a lower cost of taking a costly action than low quality types. When banks have information about the quality of existing loans, it tends to be less costly for banks with good loans to hold securities. This is because bad banks need risky assets to have any chance of solvency, while many good banks may be locally riskfree, and thus indifferent between loans and securities. Good banks also may want to buffer their good loans against discount sales. If by holding securities good banks can distinguish themselves to outside investors, holding securities will lower borrowing costs. Good banks compare the gains from lowering expected borrowing costs against the loss in value of FDIC insurance from holding enough riskless securities to prevent bad banks from mimicking.

A simple algebraic example illustrates this logic. Imagine that in period 0 all banks have old loans, L_{-1} of known quality, which will pay back $(1+\alpha^{-1})^2$ times the principal in period 2, where α^{-1} is α_H or α_L. These loans are backed by deposits D_{-1}. In period 0, new deposits D_0 arrive, and can be used to buy securities or loans. Consider a bank with low quality old loans. If it does nothing or uses the new deposits for securities only, it will have a deficit in period 2 of $D_{0-1}(1+r)^2 - L_{-1}(1+\alpha_L)^2$. However, by investing deposits in risky loans recovery is possible as long as

$$L_{-1}(1+\alpha_L)^2 + D_0(1+\alpha_H)^2 - (D_{-1}+D_0)(1+r)^2 > 0$$

If banks with existing good loans hold securities, then banks with bad loans must also hold securities between periods 0 and 1 if they want to borrow at the pooling rate in period 1. However, doing so means foregoing the possibility of higher interest on loans than on securities for the period, which may outweigh the benefit from borrowing. Let S_g be the quantity of securities held by good banks, and B be the amount that can be borrowed in period 1. Then the payoff to a bad bank that mimics is

$$\max[\ 0,\ L_{-1}(1+\alpha_L)^2 + S_g(1+\alpha_H)(1+r) + (D_0-S_g)(1+\alpha_H)^2 + B(1+\alpha_H) - (D_{-1}+D_0)(1+r)^2 - B(1+r+s)\ ]$$

This expression approaches zero as S_g approaches D_0 or B approaches zero. Thus by choosing a sufficiently high S_g, good banks may distinguish themselves from bad banks. Whether good banks want to do this depends on the difference between the pooling and separating rate premium on borrowing, and the cost of holding loans rather than securities.

B. Solution of Model II

Model II extends Model I by assuming that banks begin period 0 with old loans L_{-1} of known quality, backed by deposits of $D_{-1}/(1-\varepsilon)=L_{-1}$, where ε is the equity requirement. Returns on these loans are distributed independently and identically to L_0, so that high or low interest is paid only in periods 1 and 2. A fraction of principal, ψ^{-1}, is also repaid in period 1 with the balance of principal repaid in period 2. We assume that withdrawals at time 1 are sufficiently large so that old loans must be sold in the absence of borrowing.[14] Effectively there are eight types of banks; the original four types combined with two possibilities for old loan quality. The bank profit function corresponding to (4) is:

$$\Pi_{ijk} = \beta E_1 \max\{0,\ [L_0(1-\psi^0)-Q_0](1+\alpha_i) + L_{-1}(1-\psi^{-1})-Q_{-1}](1+\alpha_j) + [\lambda_{ij}-\delta+B+Q_0(1-c)+Q_{-1}(1-c)](1+\tilde{\alpha}^{-1}) - (1+r)(D_0+D_{-1}-\delta_k) - B(1+r+s)\ \} \tag{9}$$

where

$$\lambda_{ij} = (1+r)S_0 + (\alpha_i+\psi^0)L_0 + (\alpha_j+\psi^{-1})L_{-1} - r(D_0+D_{-1})$$

Despite the increased multiplicity of types, the period 1 borrowing game is almost identical. The exceptions are that (1) the equilibrium markup over the riskfree rate is conditional on security holding, and (2) only "good/good/bads" (good period -1 and period 0 loans, bad deposit realization) will be willing to borrow at a premium to avoid selling loans[15]. To find equilibrium borrowing, we follow the procedure described in Section III. First reservation rate schedules as a function of borrowing are calculated for each type, conditional on their earlier choice of S_0 and L_0 and belief about the discount c. Then fair pooling rate schedules for investors are calculated. Combining the information in these schedules, we find a candidate equilibrium schedule along which banks would be willing to borrow and investors willing to lend. From this schedule, one can prove as in Theorem 1 that the point that maximizes expected profits for the good/good/bads yields the debt market equilibrium.

Once equilibrium borrowing as a function of S_0 and L_0 is determined, the optimal S_0 and L_0 can be found as a function of old loan quality as follows. First compute expected time 0 profit for both types as a function of S_0 when both types hold S_0, so that there is pooling in the debt market. Call these profit schedules $\pi_{g1}(S)$ and $\pi_{b1}(S)$. Then compute expected profits as a function of S_0 for banks with good old loans, assuming those with bad period -1 loans hold no securities. Call these profit schedules $\pi_{g2}(S)$ and π_{b2}.

Theorem 2: A necessary and sufficient condition for the existence of a separating equilibrium is an S*, $0 < S^* < D_0$, such that

a) $\pi_{g2}(S^*) > \max_S \pi_{g1}(S)$ for $\{S: \pi_{b1}(S) > \pi_{b2}\}$

b) $\pi_{b2} \geq \pi_{b1}(S^*)$

Proof: (Necessity) Assume (b) fails. Then if goods choose S* in equilibrium, bads will also since mimicking has a higher expected value than autonomy. Assume (a) fails. Then goods would profit by instead choosing max $\pi_{g1}(S)$ over $S \in \{\pi_{b1}(S) > \pi_{b2}\}$, resulting in pooling.

(Sufficiency) Both goods and bads know these expected profit schedules at time 0. If (a) and (b) hold, a good bank knows that no bad bank would choose to hold S*, so that at time 1 if the good bank borrows it will only be pooled with other ex ante good banks. Thus the expected profit from choosing S* is $\pi_{g2}(S^*)$. By (a), this is preferred to any of the pooling outcomes. Since bads know that goods will choose S*, they choose S=0 for an expected profit of π_{b2}.

A numerical implementation of the above algorithm provides many examples of separating equilibria. A representative example is given in Table 2 in the appendix. However, pooling equilibria can also be found for some parameters. Separation is most likely to occur when a relatively large amount of borrowing is necessary, and when many banks with bad period -1 loans find it advantageous to borrow although their old loans drive them close to bankruptcy.

VI. Conclusion

This paper explores the influence of asymmetric information on banks' portfolio choice and liability decisions. We demonstrate that holding a portion of the bank's portfolio in risk-free securities may be optimal even though banks are risk neutral and receive insurance that induces risk preference. An optimal portfolio can include securities because they signal asset quality, mitigating the cost of asymmetric information. However, securities are not a perfect signal, and outside borrowing still costs a premium over the full-information rate for banks with good assets but a poor liquidity realization. Securities serve as a signal of asset quality because it is more costly for banks with poor assets to lower variance than for banks with good assets. This should be true in the risk-averse case as well. An interesting implication of the model is that banks holding relatively more securities have higher quality assets on average, and hence a lower failure rate.

The model is novel in several respects. First, although the rationale for holding securities is familiar from the transactions cost literature, the cost in this model is endogenously determined and linked directly to the degree of informational asymmetries. Second, the model highlights an unusual kind of maturity mismatch which might be described as "information mismatch". Usually, maturity mismatch refers to interest rate risk arising from unequal payment streams between two securities. In this model, however, the risk arising from mismatched securities arises from asymmetric information that limits the ability to sell assets of longer maturity at a fair price. Thus, one-period demand deposits are informationally matched against two-period riskless securities, but mismatched against two-period loans. A similar analysis might explain firms' tendency to issue securities with maturity equal to the project being financed.

In this model banks can only issue subordinated debt as an alternative to loan sales, but of course banks also can and do issue equity and straight debt. An interesting extension to this model would be to price equity and debt, and determine under what conditions one form of financing dominates another.

Appendix

Reservation borrowing schedules for Model I:

$$(10)\ \Sigma_{gg}(B) = \begin{cases} 0 & \text{riskfree with or without borrowing} \\ \alpha_H - r & \text{risky with or without borrowing} \\ [(L_0(1+\alpha_H)+S_0(1+r)+B-rD_0-\delta_L))(1+\alpha_H)-(D_0+B-\delta_L)(1+r)]/B - \\ [L_0(1-\psi^0)(1+\alpha_H)+(S_0(1+r)+L_0(\psi^0+\alpha_H)-rD_0-\delta_L)(1+r)- \\ (1+r)(D_0-\delta_L)]/(fB) & \text{riskfree without, risky with borrowing} \end{cases}$$

$$(11)\ \Sigma_{bg}(B) = \begin{cases} \alpha_H - r & \text{for } \Pi_{bg} > 0 \text{ without borrowing} \\ [L_0(1-\psi^0)(1-c)+\lambda_L+B-\delta_L)(1+\alpha_H)-(D_0-\delta_L)(1+r)]/B-(1+r) & \text{otherwise} \end{cases}$$

Proof of Lemma 2: First we eliminate the possibility that correctly identified banks ("one-pools") will issue debt. We consider separately the cases where banks are risky at B=0 as opposed to riskless. Imagine that a good/good or bad/good is risky at B=0, borrows B and buys new loans with the money. The expected return on the borrowing is $fB[(1+\alpha_H)-(1+r+s)]$, so borrowing will only be undertaken if $s < \alpha_H - r$. Let P(0) denote profits at zero borrowing. If new loans turn out to be bad, lenders receive

$$P(0) + (1+\alpha_L)B < (1+\alpha_L)B$$

where the inequality follows because by assumption $P(0) < 0$. This occurs with probability (1-f). Thus when the loans are good, a return of greater than $1+\alpha_H$ is required in order for the expected return to equal 1+r. This implies $s > \alpha_H - r$, so there is no borrowing.

If on the other hand good/goods are initially riskfree, then FDIC insurance has no value, and increasing risk through borrowing cannot affect the value of FDIC insurance when the debt is subordinated. Thus, if the debt is fairly priced the bank is indifferent to borrowing, and hence by assumption doesn't.

If good/goods and bad/goods do not borrow by themselves, a two-pool is also impossible. The good/goods are driven out because the borrowing rate for the two-pool must be higher than the rate for a one pool with just good/goods. Finally consider the good/bads. If they borrow slightly more than that necessary to avoid loan sales, they are riskfree and therefore would accept no positive premium. As borrowing increases, risk increases for the bank but not for the FDIC, which is always entirely repaid. As for good/goods who are riskfree at B=0, good/bads are indifferent between borrowing and not borrowing in a one-pool because no risk can be transferred.

Proof of Lemma 3: Let ω_i be the fraction of secondary market loans issued by a bank of type i (where i denotes information learned in period 1 concerning loan returns and deposit flows), with Q_i being the loan liquidations for a type i bank. The condition for secondary market loans to be fairly priced is

$$\text{(A.3.1)} \qquad \beta E_0[Q_i(1+\alpha_i^0)] = (1-c)E_0 Q_i$$

Assume that the bank is all-equity financed at period 0. The value of the bank in period 2 is

(A.3.2) $$V_{2i} = \max[0, (1+\alpha^0)((1-\psi^0)L_0 - Q_i) + (1+\alpha^1)(\lambda_i + Q_i(1-c) + B_i) - (1+r+s)B_i]$$

Q and B are chosen by the bank conditional on time 1 information. Let I be an indicator function such that I = 0 when the bank is bankrupt and I = 1 otherwise. Let F(x) be the joint distribution function for $x=(\delta,\alpha^0,\alpha^1)$. Then actuarial fairness for debt-holders implies that

(A.3.3) $$\int_{I=0}(1+r+\tilde{s})B\, dF(x) + \int_{I=1}(1+r+s)B\, dF(x) = (1+r)B$$

where $\tilde{s}$ is the realized random premium on debt which depends on x. The value of equity in period 0 can be written

$$V_0 = \beta^2[\int_{I=1}(1+\tilde{\alpha}^0)(1-\psi^0)L+(1+\tilde{\alpha}^1)\tilde{\lambda}\, dF(x) + \int_{I=1}(1+\tilde{\alpha}^1)\tilde{Q}(1-c)-\tilde{Q}(1+\tilde{\alpha}^0)\, dF(x)$$

(A.3.4) $$+\int_{I=1}\tilde{B}(1+\tilde{\alpha}^1)-(1+r+s)\tilde{B}\, dF(x)\ ]$$

Using the fact that debtholders own the firm in the event of bankruptcy, (A.3.3) and (A.3.4) together imply

(A.3.5) $$V_0 = \beta^2[\int(1+\tilde{\alpha}^0)(1-\psi^0)L_0+(1+\tilde{\alpha}^1)\lambda\, dF(x) + \int(1+\tilde{\alpha}^1)\tilde{Q}(1-c)-\tilde{Q}(1+\tilde{\alpha}^0)dF(x)]$$

(A.3.1) and equation (1) in the text imply that the term involving Q is zero. Evaluating the first term (recall that λ contains S_0) gives $V_0 = L_0 + S_0 - E_0(\delta)$, which is independent of Q and B, and of the breakdown between L_0 and S_0.

Finally, note that all investors are risk-neutral and symmetrically informed in period 0, so the Modigliani-Miller theorem implies that the value of the bank is not affected by its debt-equity ratio in period 0.

Table 1: Parameter Values Yielding Positive Security Holdings When Borrowing is Prohibited

(Fixed Parameters: $D_0 = 10.$, $r = .03$, $\psi^0 = .1$, $\varepsilon = .05$)

δ_H	1.7 to 3.8
δ_L	-100. to -8.5
α_H	.05 to .13
f	.6 to .9
g	.45 to .75

Note: Not all combinations will yield positive security holdings. α_L and c are determined endogenously given these values.

Table 2. Parameters Generating a Separating Equilibrium

Parameters:

$\varepsilon=.05$, $D_0=10.$, $L_{-1}=12.$, $\delta_H=18.$, $\delta_L=-6.$,

$r=.03$, $\alpha_H=.09$, $\alpha_L=-.08$, $f=.65$, $g=.5$, $\psi^0=.1$, $\psi^{-1}=.1$,

Equilibrium Portfolio and Borrowing:

$S_0=2.6$ $L_0=7.875$ $s=.02$ $B=12.$

Types borrowing in equilibrium: good/good/bad, good/bad/good, and good/bad/bad.

The simulation programs are available from the authors upon request.

REFERENCES

Akerlof, George. "The Market for Lemons: Qualitative Uncertainty and he Market Mechanism", Quarterly Journal of Economics 84 (1970), 488-500.

Andrews, Suzanna and Henry Sender. "Off Balance Sheet Risk: Where is it Leading the Banks?" Institutional Investor, January 1986, pp. 75-84.

Baltensperger, Ernst. "The Precautionary Demand for Reserves", American Economic Review 64 (March, 1974), 205-10.

Flannery, Mark J. "Deposit Insurance, Capital Regulation, and the Choice of Bank Loan Default Rates", unpublished, University of North Carolina at Chapel Hill, 1987.

Frost, Peter A. "Banks' Demand for Excess Reserves", Journal of Political Economy, (July/August, 1971), 805-25.

Hart, Oliver D. and Dwight M. Jaffee. "On the Application of Portfolio Theory to Depository Financial Intermediaries", Review of Economic Studies 41, (January, 1974), 129-47.

John, Kose and Nachman, D., "Multiperiod Financing Strategies and Dividend Management", unpublished, New York University and Georgia Institute of Technology, 1987.

Koehn, Michael and Anthony Santomero. "Regulation of Bank Capital and Portfolio Risk", Journal of Finance 35 (December, 1980), 1235-44.

Lucas, Deborah and Robert L. McDonald. "Bank Portfolio Choice with Private Information About Loan Quality: Theory and Implications for Regulation" Forthcoming, Journal of Banking and Finance, (1987)

Marcus, Alan J. "Deregulation and Bank Financial Policy", Journal of Banking and Finance, (1984) Vol 8, 557-565

Merton, Robert C. "An Analytic Derivation of the Cost of Deposit Insurance and Loan Guarantees: An Application of Modern Option Pricing Theory", Journal of Banking and Finance, 1 (June, 1977), 3-11.

Myers, Stewart C. and Nicolas Majluf. "Corporate Investment and Financing Decisions When Firms Have Information that Investors do Not Have", Journal of Financial Economics 13, (1984), pp. 187-222.

Poole, William. "Commercial Bank Reserve Management in a Stochastic Model: Implications for Monetary Policy", Journal of Finance 23 (December, 1968), 769-91.

Santomero, Anthony M. "Modelling the Banking Firm: A Survey", Journal of Money, Credit, and Banking 16 (November, 1984), 576-602.

Stiglitz, Joseph and Andrew Weiss. "Sorting Out the Differences Between Signalling and Screening Equilibria" working paper

Thakor, Anjan. "Toward a Theory of Bank Loan Commitments", Journal of Banking and Finance 6 (March, 1982), 55-83.

FOOTNOTES

1. Some mechanisms exist to alleviate the problem of informational asymmetry. To take one recent example, REMICs (Real Estate Mortgage Investment Conduits) allow banks to sell mortgages, separated into junior and senior claims. One would expect that by selling the senior claims and retaining the junior claims, banks would face a smaller lemons discount when selling these claims in the secondary market. We have also been told that some resold credit card receivables are selected by an audited randomization procedure. Nevertheless, such mechanisms are unlikely to completely eliminate the lemons problem, since banks with poorer assets are likelier to enter these markets in the first place.

2. Many off balance sheet activities such as swaps, futures, backup lines of credit, and foreign exchange trading have the potential to increase the riskiness of a bank's portfolio.

3. Banks by law cannot hold certain risky assets. For example, the Glass-Steagell act prohibits holdings of corporate equity. Also, regulatory pressure presumably can influence asset choice.

4. The ψ terms provide an extra degree of freedom by allowing the fraction of loans repaid early to vary. Since $\psi + \alpha_L \geq 0$, for $\alpha_L < 0$, we need $\psi > 0$.

5. The assumption that uncertainty is resolved completely is made for simplicity. The same conclusions would follow if the bank still faced some uncertainty about loan quality, but less than the market.

6. Here we use the fact that it is optimal to invest solely in loans the final period. Because the bank is liquidated in period 2, securities merely reduce the value of insurance, without providing liquidity.

7. Allowing the bank to pay dividends complicates the analysis since it is then necessary to model the equity constraint to put a limit on dividends. For a derivation of results in this kind of model, see Lucas and McDonald (1987).

8. If investors knew δ, this would change the interest rate on uninsured bank debt because it would change their inference about who was borrowing.

9. When straight debt is issued, the equity requirement necessitates raising new equity. This complicates the analysis, because the new equity also must be priced. Generally we expect banks to prefer debt to equity for two reasons in this model. Increased equity reduces the value of FDIC insurance, while the affect of non-subordinated debt generally is to increase it. Secondly, poorer banks are more likely to participate in a pooling equilibrium with equity than with debt, so the lemons cost of equity tends to be higher. This is similar to the findings of Myers and Majluf. In particular, it can be shown in our model that good/good banks never would issue equity.

Borrowing at the discount window is another alternative to loan sales. In practice this does not appear to be an unlimited source of funds, so uninsured security issues can still be necessary.

10. If banks with good loans could signal their quality, then c would be a premium rather than a discount for these banks.

11. The equilibrium is sensitive to whether or not loan sales are observable. When loan sales are observable, good banks may be able to signal their quality by their restraint in loan sales, and sell some loans costlessly. Thus a separating equilibrium may obtain in which the informational asymmetry is costless for the good/bad banks. This is a much more complicated problem than the unobservable case.

12. In the simulations the possibility that bad/bads also would choose to borrow is accounted for. However, unless equity is large relative to the variability of loan quality, they can never profitably borrow.

13. This expression assumes that banks with bad loans in period 1 sell them. The comparison with securities is even less favorable if banks do not sell bad loans in period 1. For convenience we also assume ψ is zero, but any $\psi<1$ provides a similar result.

14. Without this restriction there would be no need to buffer old loans from sales.

15. It is possible that good/bad/bads or bad/good/bads also would be willing to pay a premium to protect good loans. In fact they could potentially borrow a small amount at the riskfree rate to avoid selling good loans if the bad loans did not push them into insolvency. However, for the parameter values yielding separating equilibria, both of these groups are bankrupt unless they mimic the good/good/bads.