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Banking and Deposit Insurance as a Risk Transfer Mechanism

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This paper models an economy in which risk-averse savers and risk-neutral entrepreneurs make investment decisions. Aggregate investment in high-yielding risky projects is maximized when risk-neutral agents bear all nondiversifiable risks. A role of banks is to assume nondiversifiable risks by pledging their capital in addition to diversifying risks. Banks, however, do not completely eliminate risks when monitoring by depositors is imperfect. Government deposit insurance that uses tax revenue to repay depositors transfers remaining risks to entrepreneurs. Deposit insurance can improve welfare because imperfect monitoring by the government largely results in income transfer among risk-neutral agents rather than lower production. *Journal of Economic Literature* Classification Numbers: G21, G28. © 1996 Academic Press, Inc.

1. INTRODUCTION

Traditional banking subsumes risky lending, deposit contracts with insurance (implicit or explicit) provided by the government, and relatively tight government regulation. This paper shows that these banking arrangements increase aggregate investment by transferring nondiversifiable risks from risk-averse savers to risk-neutral (or less risk-averse) entrepreneurs and bankers. A main assumption is that savers are more risk averse than entrepreneurs and bankers.[1] In this case, it is desirable to have entrepreneurs and

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[1] Kindleberger (1984) notes that financial intermediaries stand between risky borrowers and risk-averse lenders.

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bankers bear all nondiversifiable risks. Government insured bank deposits transfer nondiversifiable risks from risk-averse savers to risk-neutral agents.

The principal objective of this paper is to rationalize federal deposit insurance as a risk transfer mechanism that increases aggregate investment. In the model I develop, banks diversify risks and assume nondiversifiable risks by exposing their capital. With complete information, bank capital ensures the transfer of risks from depositors to banks. However, when depositors have incomplete information and limited ability to monitor banks, banks do not eliminate risks completely because of their incentive to increase their risks. The government eliminates remaining risks for depositors by providing deposit insurance and regulating banks. The elimination of risks does not require superior ability of the government to monitor banks. In the event that banks fail due to imperfect monitoring, the government taxes entrepreneurs to repay depositors. Deposit insurance, thus, effectively transfers risks from depositors to entrepreneurs.

The transfer of nondiversifiable risks results in a lower equilibrium interest rate and a higher level of investment. In the model, risk-averse savers and risk-neutral entrepreneurs choose between high-yielding, risky investment projects and risk-free self-storage. Since highly profitable investment opportunities are limited, the rate of return on the marginal project is a decreasing function of aggregate investment. Risk premiums disappear when risk-neutral agents bear all nondiversifiable risks. The elimination of risk premiums increases aggregate investment by lowering the equilibrium interest rate.

The utility gains of savers and entrepreneurs resulting from increased investment depend on assumptions about investment opportunities and market structure. *Ex post* redistribution through taxation, however, unambiguously improves the *ex ante* utility of both savers and entrepreneurs because the expected value of production increases with investment. While the inability of depositors to monitor banks lowers the level of production, ineffective monitoring by the government largely affects income distribution among risk neutral agents. The effect of the expected tax on aggregate investment is small because the tax burden is lighter on marginal entrepreneurs. Thus, deposit insurance can still improve welfare even if the government is less effective than depositors in monitoring banks.

Recent studies emphasize the banks' ability to resolve information problems. Bryant (1980), Diamond and Dybvig (1983), and Jacklin (1987) show that demand deposit contracts enable individuals to share uninsurable liquidity risk. According to them, liquidity needs of individuals are unobservable to the market and hence cannot be insured in a normal manner. Other studies emphasize information about borrowers (Boyd and Prescott, 1986; Chan, 1983; Diamond, 1984; Fama, 1985; Ramakrishnan and Thakor, 1984). They argue that financial intermediation reduces monitoring costs arising from information asymmetry between borrowers and lenders. Information about bankers themselves has also been considered. Calomiris and Kahn (1991) rationalize demandable debt as a means to discipline bankers when information is incomplete. Gorton and Pennacchi (1990) focus on information asymmetry among investors wherein the creation of riskless securities such as bank deposits prevents agents with superior information from taking advantage of uninformed "liquidity traders."

While these papers have taught us much about why banks do what they do, it is not obvious that nonbank financial intermediaries could not do what these papers have ascribed to banks. For example, money market mutual fund shares offer transaction services and liquidity. Stock and bond mutual funds channel savings to investment projects and diversify risks at low costs. Established corporations, which are typically subject to less information asymmetry, often reduce their reliance on bank loans by issuing commercial paper. These developments pose questions about the uniqueness of banks and the need for government intervention, including deposit insurance. For example, if some run-free financial instruments such as money market shares can provide liquidity and payment services as efficiently as banks, deposit insurance as a mechanism to prevent bank runs is unjustified. The purpose of this study is to explain a role of the traditional banking arrangement with federal deposit insurance that has not been replaced by alternative institutional arrangements.

The rest of the paper is organized as follows. The next section analyzes the effects of financial intermediation and moral hazard problems on aggregate investment. Section 3 examines the role of government-backed deposit insurance in transferring risks. In Section 4, I discuss the cost of government intervention and the possibility of private arrangements. The last section summarizes.

2. FINANCIAL INTERMEDIATION

This section models an economy in which individuals with different risk preferences maximize their utility. The analysis focuses on the role of banks in reducing risks for risk-averse savers. Although banks offering deposit contracts can eliminate risks by pledging their capital, moral hazard problems reduce the effectiveness of deposit contracts.

2.1. *Structure of the Economy*

Individuals live two periods. They are of two types: savers and entrepreneurs. Savers are more risk-averse than entrepreneurs. For simplicity, entrepreneurs are assumed to be risk neutral; $U_s'(C) > 0$, $U_s''(C) < 0$, $U_e'(C) >$

0, and $U''_{\mathrm{e}}(C) = 0$, where C denotes consumption, and subscripts s and e stand for savers and entrepreneurs.

All are endowed with one unit of good and concerned only about consumption in the second period. Goods can be either costlessly self-stored or invested in production. In addition to self-storage, entrepreneurs have access to risky, productive investment projects. Production can fail, and the failure probability depends on the state of the economy: good or bad. If the good state occurs, the failure probability is zero. In the bad state, each investment project faces a positive failure probability, P_{f}, which is assumed to be independent and identical across projects. In this situation, investing in a large number of projects will diversify the failure risk of individual projects. The risk of the occurrence of the bad state, however, cannot be diversified or insured at the aggregate level.

The return from failed production is zero, and the return from successful production varies across projects because of differing opportunities of entrepreneurs. The expected return from project j is

$$E(R_j) = P_{\mathrm{B}}\{P_{\mathrm{f}}0 + (1 - P_{\mathrm{f}})R_j\} + (1 - P_{\mathrm{B}})R_j = (1 - P_{\mathrm{B}}P_{\mathrm{f}})R_j,$$

where P_{B} is the probability that the bad state occurs, P_{f} is the probability of failure in the bad state, and R_j is the return from project j when it succeeds. $E(R_j)$ is distributed between $E(R_M)$ and $E(R_1) > 1$. It is assumed that $E(R_j) > E(R_{j+1})$, so that the subscript j serves as an index of profitability.

Any fraction of the good can be stored, but investment is lumpy. Each production project requires $X > 1$ units of investment. Thus, entrepreneurs who fail to attract enough capital cannot undertake their own projects. Since they are risk-neutral, entrepreneurs desire to undertake all sound production projects with expected returns greater than or equal to one. If terms are agreeable, savers lend some or all of their endowments to entrepreneurs.

The numbers of savers (N) and entrepreneurs (M) are large so that the capital market is competitive. In aggregate, there are enough resources to finance all sound projects; $N + M \geq mX$, where m is the number of sound projects. Thus, all entrepreneurs with sound production opportunities can undertake production projects when savers lend all of their goods to entrepreneurs.

2.2. *Utility Maximization of Entrepreneurs and Savers*

Individuals make investment decisions in the first period to maximize the expected utility from second-period consumption. The jth entrepreneur undertakes the production project if his/her expected profit is

$$\begin{aligned} E(\pi_{ej}) &= P_B[P_f 0 + (1 - P_f)\{R_j X - R^E(X-1)\}] \\ &\quad + (1 - P_B)\{R_j X - R^E(X-1)\} \\ &\quad - P_B[P_f 0 + (1 - P_f)R^E] + (1 - P_B)R^E \\ &= (1 - P_B P_f)(R_j X - R^E X) \geq 0, \end{aligned} \tag{1}$$

where R^E is the equilibrium return per unit promised to investors. Since the capital market is competitive, individuals take R^E as given. The expected profit is the expected revenue minus the expected payment to investors and the opportunity cost of entrepreneurs' capital which is $E(R^E)$. The expected profit is zero for the marginal entrepreneur, and the owners of infra-marginal projects capture rents from their superior opportunities. This model does not consider the needs of lenders to monitor borrowers because many previous studies have extensively analyzed the monitoring of borrowers (See Boyd and Prescott, 1986; Chan, 1983; Diamond, 1984; Fama, 1985; Ramakrishnan and Thakor, 1984).

Savers maximize their expected utility by choosing the optimum proportion of their endowments to be invested in the risky asset with two possible outcomes: high or low return. The expected utility of savers is

$$E(U_s) = P_L U\{(1 - \theta) + \theta R^L\} + P_H U\{(1 - \theta) + \theta R^H\}, \tag{2}$$

where θ is the proportion of endowments invested in production, R^L is the low return on the risky asset, R^H is the high return on the risky asset ($R^L \leq 1 \leq R^H$), P_L is the probability of the low return, and P_H is the probabililty of the high return ($P_L R^L + P_H R^H \geq 1$). The equilibrium return and institutional arrangements determine R^L, R^H, P_L, and P_H. A key aspect of this maximization problem is summarized by the following proposition.

PROPOSITION 1. *For risk-averse investors, the marginal gain from shifting endowments from a risk-free asset to a risky asset of a higher expected return decreases as the portfolio share of the risky asset increases.*

A formal proof appears in the Appendix. An intuitive explanation for this proposition is as follows. A shift of endowments from self-storage to the risky asset results in an increase in the amount of consumption when the high portfolio return is realized (C_H) and a decrease in the amount of consumption with the low portfolio return (C_L) at constant rates. Accordingly, the expected return on the portfolio increases at a constant rate, and the gap between C_L and C_H increases with the portfolio share of the risky asset. When the share of the risky asset is high, therefore, additional investment in the risky asset involves a sacrifice of the stored good in a region where marginal utility is high and a gain from the risky asset in a region where marginal utility is low. Thus, the attractiveness of the risky asset decreases with its portfolio share. This result suggests that there may exist an interior solution, i.e., $\partial E(U_s)/\partial\theta$ is zero at θ^*, that is greater than zero but less than one.

2.3. *Banks*

Diversification reduces the variance of the return on production. Since the number of projects is large, lending an equal amount to all entrepreneurs undertaking investment projects completely diversifies away individual project risks in this economy. In diversifying risks, a scale economy arises from contract costs. When they are devoted to production, entrepreneurs can costlessly contract with a finite number of investors. Thus, if savers attempt to diversify independently, the contract cost is positive because financing a project requires a large number of contracts. In this case, entrepreneurs need to share the contract cost with investors. A financial intermediary can eliminate the cost of diversification by pooling resources. This scale economy is assumed to be exhausted at a moderate level so that a competitive financial market is sustainable.

A mutual fund distributing the realized return may eliminate project-specific risks. The uncertainty about the state of the economy remains, however. Entrepreneurs whose projects are unprofitable at the equilibrium borrowing cost have an incentive to assume the aggregate risk by pledging their endowments. Those entrepreneurs pool their endowments to form a financial intermediary that diversifies perfectly and pledges enough capital to guarantee a fixed return to depositors. Assuming that the bank fully lends deposits and capital, its expected profit net of the opportunity cost of capital is

$$E(\pi_b) = E(R)(D + K) - R^D D - E(R)K = (E(R) - R^D)D,$$

where $E(R) = P_L R^L + P_H R^H$, D is the amount of deposits, K is the amount of capital, and R^D is the per-unit return promised to depositors. Since savers are risk averse, $U(E(R)) > P_L U(R^L) + P_H U(R^H)$. Thus, it is possible for a bank offering R^D lower than $E(R)$ to attract deposits and make a positive economic profit. Competition may drive the economic profit of banks to zero. If no entrepreneur offers bank deposits, however, there is a profit opportunity. Thus, in equilibrium, some entrepreneurs elect to be bankers. Other entrepreneurs with unprofitable projects are assumed to invest directly in others' projects.

2.4. *Equilibrium Return*

In equilibrium, the aggregate demand for funds is equal to aggregate supply. The aggregate demand for funds is the required borrowing per project multiplied by the number of production projects entrepreneurs want to undertake,

$$Q^{\mathrm{d}} = j^*(R^{\mathrm{E}})(X - 1),$$

where j^* is the number of profitable projects at R^{E}. From Eq. (1), the profit of entrepreneur j is positive if $R_j \geq R^{\mathrm{E}}$. Thus, Q^{d} is a decreasing function of R^{E}. A smaller number of projects are profitable when R^{E} is higher.

The aggregate supply is the endowments of entrepreneurs with unprofitable projects plus the optimum amount of savers' investment at R^{E},

$$Q^{\mathrm{s}} = \{M - j^*(R^{\mathrm{E}})\} + N\theta^*(R^{\mathrm{E}}).$$

Holding other things constant, a higher return makes the risky asset more attractive. Thus, the optimum proportion, θ^*, increases with R^{E}. Accordingly,

$$\partial Q^{\mathrm{s}}/\partial R^{\mathrm{E}} = -\partial j^*/\partial R^{\mathrm{E}} + \partial\theta^*/\partial R^{\mathrm{E}} \geq 0.$$

As R^{E} increases both entrepreneurs and savers invest more in others' projects.

The equilibrium condition is

$$j^*(R^{\mathrm{E}})(X - 1) = \{M - j^*(R^{\mathrm{E}})\} + N\theta^*(R^{\mathrm{E}}).$$

As usual the demand curve is downward sloping, and the supply curve slopes upward. Thus, there may exist an equilibrium return on the risky asset, R^{E}, that satisfies this condition.

2.5. *Effects of Diversification and Risk Transfer*

Set aside banks for a moment and assume that each individual lends to only one entrepreneur because of high transaction costs (Case 1). In this case, the expected utility of savers is

$$\begin{aligned} E(U_{\mathrm{s1}}) &= P_{\mathrm{B}}[P_{\mathrm{f}}U(1-\theta) + (1-P_{\mathrm{f}})U\{(1-\theta) + \theta R^{\mathrm{E1}}\}] \\ &\quad + (1-P_{\mathrm{B}})U\{(1-\theta) + \theta R^{\mathrm{E1}}\} \\ &= P_{\mathrm{B}}P_{\mathrm{f}}U(1-\theta) + (1-P_{\mathrm{B}}P_{\mathrm{f}})U\{(1-\theta) + \theta R^{\mathrm{E1}}\}, \end{aligned} \tag{3}$$

where 1 in subscripts and superscripts stands for the case of no diversification or risk transfer.

Based on Proposition 1, the following lemma is established.

LEMMA 1. *An interior solution exists if* $\partial E(U_s)/\partial\theta > 0$ *at* $R^E = R_1$ *and* $\theta = 0$.

When θ is one, saving finances all sound projects. Thus, the equilibrium return, which is the expected return on the marginal project, is one per unit. Since an asset with a positive variance and zero rate of return is unacceptable to depositors, the optimum proportion, θ^*, cannot be one in this case. Thus, provided that the return from the most profitable production project is high enough to induce risk-averse savers to lend some of their endowments to the owner of the project, θ^* is between zero and one, and R^E is between one and R_1.

Banks diversify risks and assume nondiversifiable risks with their capital. If savers can observe the behavior of banks perfectly, competition to attract risk-averse savers will force banks to offer risk-free deposits by diversifying to the maximum extent and holding enough capital. The diversification and transfer of risks lower the equilibrium return on saving and increase aggregate investment in production.

The expected utility of savers with complete diversification (Case 2) is

$$E(U_{s2}) = P_B U\{(1-\theta) + (1-P_f)\theta R^{E2}\} + (1-P_B)U\{(1-\theta) + \theta R^{E2}\}. \tag{4}$$

In the bad state, a saver recovers $(1 - P_f)\theta R^{E2}$ from their investment θ because the proportion P_f of production projects fails. The maximization of Eq. (4) with respect to θ produces the following lemma.

LEMMA 2. *When risks are diversified*, θ^* *is higher for all* R^E. *Accordingly*, $\theta^{*2} > \theta^{*1}$, *and* $R^{E2} \leq R^{E1}$.

The Appendix presents a formal proof. Intuitively, a reduction of risks through diversification increases the attractiveness of investment in production. In aggregate, the supply curve becomes flatter. Therefore, diversification leads to a lower equilibrium return and a higher investment in production.

Banks assume nondiversifiable risks by pledging their capital in addition to diversifying risks. The explicit pledge of financial capital to reduce nondiversifiable risks distinguishes banks from mutual funds that also diversify risks and provide liquidity, but are immune from bank runs.[2] Of course,

[2] Some previous studies focus on the possibility of bank runs to distinguish between bank deposits and mutual fund shares. For example, Jacklin and Bhattacharya (1988) show that with a possibility of information-based bank runs, deposit contracts are preferred to equity contracts (mutual fund shares) for financing low-risk assets.

as suggested by Boot *et al.* (1993), mutual funds may implicitly guarantee a minimum return to investors in order to preserve reputational capital. However, when the financial loss associated with the implicit guarantee is large, mutual funds repudiate the implicit guarantee to preserve financial capital in equilibrium. By contrast, banks in our model offer a fixed return to savers and absorb losses with their explicitly dedicated financial capital if the bad state occurs.

Complete diversification and sufficient bank capital make bank deposits risk free (Case 3). When saving becomes risk free, the expected utility of savers is

$$E(U_{s3}) = U\{(1 - \theta) + \theta R^{D3}\}. \tag{5}$$

The following lemma summarizes solutions to this maximization problem.

LEMMA 3. $R^D = E(R^E) = 1$ *when deposits are risk free and when banks make zero profit.*

See Appendix for a proof. When $R^D = E(R^E) = 1$, all sound production projects are undertaken. In sum, the diversification and transfer of risks result in a lower equilibrium return on saving and a higher investment.

2.6. *Monitoring of Banks*

If depositors fail to monitor banks perfectly, banks can increase their "option value," an expected profit arising from limited liability, by diversifying less and/or reducing their capital. This moral hazard problem is widely recognized (e.g., Keeley, 1990; Marcus, 1984; and Merton 1977). Depositors need to observe asset portfolios and capital ratios to monitor banks to assure the solvency of banks. For analytical convenience, assume that depositors observe asset portfolios accurately but observe capital ratios with noise.[3] Thus, banks diversify perfectly but attempt to reduce capital ratios.

When banks assets are fully invested in production, bank capital K can absorb all losses in the bad state if

$$(1 - P_f)R^E K \geq \{R^D - (1 - P_f)R^E\}D.$$

Solving for K,

[3] Qualitative results are similar when depositors observe asset portfolios, instead of capital ratios, with noise or observe both variables with noise. The option value of banks arises from the possibility of negative net worth. By diversifying less and/or holding less capital, banks in this model can increase the expected negative worth, while preserving the expected return on assets, thereby, increasing the expected profit. Thus, it is sufficient to consider one of the two variables. Since the distribution of return on assets changes with the degree of diversification, the analysis becomes unnecessarily complicated when diversification is allowed to vary.

$$K \geq [\{R^{D} - (1 - P_{f})R^{E}\}D]/[(1 - P_{f})R^{E}] \equiv K^{*}.$$

The expected profit of a bank net of the opportunity cost of capital is

$$E(\pi_{b}) = \begin{array}{ll} P_{B}\{(1 - P_{f})R^{E} - R^{D}\}D + (1 - P_{B})(R^{E} - R^{D})D & \text{if } K \geq K^{*} \\ -P_{B}(1 - P_{f})R^{E}K + (1 - P_{B})(R^{E} - R^{D})D & \text{if } K < K^{*}. \end{array} \tag{6}$$

In the case of failure, the loss is limited to the return on capital in the bad state. If depositors fail to price the riskiness of the bank due to incomplete information, $R^{D} = (1 - P_{B}P_{f})R^{E}$, which is the expected return on investment. Substituting $R^{D}/(1 - P_{B}P_{f})$ for R^{E},

$$E(\pi_{b}) = \begin{array}{ll} 0 & \text{if } K \geq K^{*} \\ P_{B}(1 - P_{f})R^{E}(K^{*} - K) > 0 & \text{if } K < K^{*}. \end{array} \tag{7}$$

The option value is zero when the bank maintains sufficient capital. With insufficient capital, the option value is the expected shortage of assets, which represents the transfer from depositors to the bank.

$$\partial E(\pi_{b})/\partial K = \begin{array}{ll} 0 & \text{for } K > K^{*} \\ -P_{B}(1 - P_{f})R^{E} & \text{for } K < K^{*}. \end{array}$$

Thus, once capital falls below K^{*}, reducing capital increases expected profit.

A large number of banks compete for deposits. Each bank perceived to be safe attracts D units of deposits. Depositors, of course, avoid banks perceived to be risky.[4] The probability that a bank is perceived to be safe is an increasing function of the ratio of actual capital to the critical level of capital, K^{*}. Banks maximize the expected profit by selecting the optimal level of capital. From Eq. (7),

$$E(\pi_{b}) = (1 - P_{S})0 + P_{S}P_{B}(1 - P_{f})R^{E}(K^{*} - K), \tag{8}$$

where P_{S} is the probability that a bank is perceived to be safe. If a bank is perceived to be risky, the profit is zero because it is forced out of business. When it is perceived to be safe by depositors, the expected profit is the option value. Dividing Eq. (8) with $P_{B}\,(1 - P_{f})R^{E}K^{*}$,

[4] Riskier banks need to offer higher expected returns to attract risk-averse savers. Risky banks making zero profit can offer higher contracted returns but not higher expected returns. In this model, thus, risky banks cannot attract deposits with high returns.

$$E(\pi_{\mathrm{b}})/\{P_{\mathrm{B}}(1 - P_{\mathrm{f}})R^{\mathrm{E}}K^*\} = P_{\mathrm{S}}(1 - \alpha) \equiv E(\pi_{\mathrm{bS}}), \tag{9}$$

where α is K/K^*.
The profit maximizing condition is

$$\partial E(\pi_{\mathrm{bS}})/\partial\alpha = (\partial P_{\mathrm{S}}/\partial\alpha)(1 - \alpha) - P_{\mathrm{S}} = 0.$$

Let the probability be a simple function of α,

$$P_{\mathrm{S}} = \alpha^{\beta},$$

where β is a positive constant determined by the quality of information available to depositors. When β is large, it is highly unlikely for a risky bank with low α to be perceived safe. Thus, a larger value of β indicates that depositors have more accurate information and, hence, better monitoring ability of depositors. The quality of information, β, is known to depositors. In other words, depositors understand their limitation in monitoring banks.

Although an analytical solution cannot be obtained with the probability function specified above, numerical results show a positive relationship between the profit-maximizing capital ratio, α^*, and β:

β	0.1	0.3	0.5	0.8	1.0	3.0	5.0	10.0	20.0
α^*	0.09	0.23	0.33	0.44	0.50	0.75	0.83	0.91	0.95.

Thus, banks maintain larger capital when depositors are better able to monitor banks.

Rational depositors take this maximizing behavior into consideration. When α is less than one, the expected return on deposits is less than R^{D} because banks fail in the bad state. Knowing that the return is lower in the bad state, depositors demand a risk premium as well as compensation for the lower expected value. A deposit contract offering $R^{\mathrm{D}} = 1$ is unacceptable to savers when monitoring is imperfect, and it becomes necessary for banks to raise the lending rate.

When savers monitor imperfectly (Case 4) and hence estimate a positive probability of bank failure ($\alpha < 1$), their maximization problem is similar to the case without the transfer of risks,

$$E(U_{\mathrm{s4}}) = P_{\mathrm{B}}U\{(1 - \theta) + \theta Z\} + (1 - P_{\mathrm{B}})U\{(1 - \theta) + \theta R^{\mathrm{D4}}\},$$

where $Z = (1 - P_{\mathrm{f}})R^{\mathrm{E4}} + \alpha^* \{R^{\mathrm{D4}} - (1 - P_{\mathrm{f}})R^{\mathrm{E4}}\}$, the estimated amount recovered per unit of deposits in the bad state ($Z < 1$). The critical level of capital, K^*, is the level that is just enough to repay depositors. Thus, $Z = R^{\mathrm{D}}$ when $K = K^*$ ($\alpha = 1$). The optimum ratio of actual capital to the critical level of capital, α^*, represents the proportion of the gap between the promised payment to depositors and the return on investment to be filled by bank capital in the bad state. Setting $R^{D4} = (1 - P_B P_f) R^{E4}$,

$$E(U_{s4}) = P_B U[(1-\theta) + \theta\{(1-P_f)R^{E4} + \alpha^*(P_f - P_B P_f)R^{E4}\}] + (1-P_B)U\{(1-\theta) + \theta(1-P_B P_f)R^{E4}\}, \tag{10}$$

where R^{E4} is the equilibrium return with a monitoring problem.[5] As shown above, the maximization of this expected utility with respect to θ will produce an upward sloping supply curve of deposits. Then in expected value terms, the equilibrium return is greater than one ($E(R^{E4}) > 1$).

The higher equilibrium return resulting from the difficulty of monitoring banks can be decomposed into three parts:

$$E(R^{E4}) = E(R^{E3}) + P_B(1-\alpha^*)(P_f - P_B P_f)R^{E4} + \gamma. \tag{11}$$

The first term is the expected value of the equilibrium return without monitoring problems. The second term is the option value per unit of deposit captured by banks (the expected shortage per unit of deposit), and γ is the risk premium paid to depositors, which is $(E(C_{s4}) - 1)/\theta$. At this new equilibrium with monitoring problems, both bankers and depositors are better off at the expense of entrepreneurs; bankers enjoy a positive option value, and depositors benefit from a higher return on saving. Since depositors rationally infer the average behavior of banks in this economy, incomplete information results in wealth transfer from entrepreneurs, instead of depositors, to bankers in the form of higher interest rates. When $E(R^E) > 1$, depositors choose θ such that deposits are equally attractive to self-storage at the margin. Thus, depositors gain from infra-marginal units in utility terms as well as in expected value terms. Imperfect monitoring, however, results in a deadweight loss. A higher equilibrium return on saving decreases investment and, hence, production.

More serious monitoring problems (lower β) and attempts to increase the option value (lower α^*) will induce depositors to perceive deposits to

[5] It is possible that competition forces banks to pass on some of the option value to depositors. I rule out this possibility by assuming a signaling effect of R^D, where the zero profit condition is $R^D = (1 - P_b P_f)R^E$. A bank offering R^D greater than $(1 - P_b P_f)R^E$ is perceived to be riskier. Thus, the bank fails to attract depositors. Even if banks pass on some or all of the option value to depositors, the qualitative result does not change. Imperfect monitoring still requires higher lending rates. When $E(R^E) = 1$, the combined expected return to banks and depositors is one. Thus, if banks set R^D such that their expected profits with the option value are zero, $E(R^D)$ is one. When $\alpha < 1$, the variance of return on deposits is positive because depositors do not fully recover their principal in the bad state. A contract offering zero expected rate of return and a positive variance is unacceptable to risk-averse savers.

be riskier, which is characterized by a smaller Z. With a reduced Z, the attractiveness of deposits is lower. Thus, holding R^{D} constant, θ^{*} is smaller. Accordingly, the supply curve of saving becomes steeper. The results are a higher equilibrium return on saving and a lower level of investment. When deposits become riskier, the deadweight loss increases unambiguously. The changes in the gains of bankers and depositors depend on the elasticity of demand, which in turn depends on the degree of risk aversion. In sum, monitoring problems reduce the effectiveness of financial intermediation in this economy.

3. GOVERNMENT-BACKED DEPOSIT INSURANCE

This economy needs an additional arrangement to completely transfer risks from risk-averse savers to risk-neutral agents. One possibility is governmental deposit insurance. In the first period, the government collects insurance premiums from banks. If the good state is realized in the second period, banks fully repay depositors and are reimbursed for the premiums. If the insurance fund turns out to be insufficient in the bad state, the government taxes surviving entrepreneurs in the second period to finance deposit insurance. Assuming that the endowments of entrepreneurs and bankers are greater than or equal to the loss from production in the bad state, the government can raise enough tax revenue to fully repay depositors.[6] In this case, deposit insurance transfers all risks from depositors to entrepreneurs and bankers.

Propositions 2 and 3 summarize the key effects of deposit insurance.

PROPOSITION 2. *Expected output is maximized if the tax financing of deposit insurance does not affect investment demand.*

A tax levied on net profits in expected value terms will not affect the investment decisions of the entrepreneurs. When deposit insurance renders deposits risk free, the supply of funds becomes perfectly elastic at the return on saving of one. Then all sound investment opportunities are utilized.

The elimination of risks for risk-averse agents offers an additional gain. The reduced interest rate resulting from deposit insurance consists of the option value captured by banks and the risk premium paid to depositors. The transfer needed to make savers equally well off is smaller than the risk premium. For risk-averse agents, the certainty-equivalent income is smaller than the expected income with a positive variance. Thus, depositors

[6] If the endowments of entrepreneurs and bankers are not large enough to guarantee the endowments of depositors, deposit insurance will reduce but not eliminate risks. The qualitative effects of deposit insurance, a lower cost of capital and higher production, will remain.

can be satisfied with a smaller expected amount of consumption if deposit insurance eliminates all risks for them. Algebraically,

$$
\begin{aligned}
&1 + \theta\gamma = P_{\mathrm{B}}\{(1-\theta) + \theta Z\} + (1 - P_{\mathrm{B}})\{(1-\theta) + \theta R^{\mathrm{D}}\}\\
&U_{\mathrm{s}}(1+\theta\gamma) > P_{\mathrm{B}} U_{\mathrm{s}}\{(1-\theta) + \theta Z\} + (1 - P_{\mathrm{B}}) U_{\mathrm{s}}\{(1-\theta) + \theta R^{\mathrm{D}}\}\\
&\quad = U_{\mathrm{s}}(1 + \theta\gamma - \delta),
\end{aligned}
$$

where δ is a positive constant between 0 and $\theta\gamma$. Since the certainty-equivalent income is $1 + \theta\gamma - \delta$, the transfer needed to make savers equally well off is $(\theta\gamma - \delta)N$. Thus, the expected gain, holding the utilities of savers constant, consists of increased production and the gap between the risky income and certainty-equivalent income,

$$E(G) = \sum_{j=i+1}^{m} \{E(R_j) - 1\}X + \delta N,$$

where i is the number of profitable projects at the equilibrium return without deposit insurance. The government can improve welfare of all three types of agents by distributing this gain resulting from risk transfer.

PROPOSITION 3. *When deposit insurance is financed with a flat-rate tax on realized profits, the option value inducing the same number of entrepreneurs to undertake production projects is larger with deposit insurance.*

Proof. The expected tax burden on entrepreneurs equals the option value captured by banks. Thus, the per-unit borrowing cost without deposit insurance is

$$\Gamma^4 = E(R^{\mathrm{E}4}) = 1 + V^4(1/i)\{1/(X-1)\} + \gamma,$$

where V^4 is the total option value captured by banks without deposit insurance. Solving the zero profit condition for the ith entrepreneur for V^4,

$$V^4 = \{E(R_i) - 1 - \gamma\}i(X-1).$$

With insurance, the expected per-unit borrowing cost for entrepreneur j is

$$E(\Gamma^5) = 1 + V^5\{E(\pi_{\mathrm{e}j})/E(\pi_{\mathrm{eT}})\}\{1/(X-1)\},$$

where V^5 is the total option value captured by banks with deposit insurance, $E(\pi_{\mathrm{e}j})$ is the profit of entrepreneur j, and $E(\pi_{\mathrm{eT}})$ is the total profit of entrepreneurs. Entrepreneurs share the total tax burden, V^5, based on profitability. In this case, the expected profit of the ith entrepreneur is zero when

$$V^5 = \{E(R_i) - 1\}\{E(\pi_{eT})/E(\pi_{ei})\}X.$$

$V^5 > V^4$ since $E(R_i) - 1 > E(R_i) - 1 - \gamma > 0$, $E(\pi_{eT})/E(\pi_{ei}) > i > 0$, and $X > X - 1 > 0$. ■

In words, $V^5 > V^4$ for three reasons: eliminated risk premiums for savers, a smaller share of the option value borne by the marginal entrepreneur, and a lower opportunity cost of capital. The opportunity cost of capital, which is the equilibrium return on capital, is $E(R^{E4})$ without insurance and one with insurance. Under the assumption that the government taxes realized profits, a large expected tax burden affects investment. By Proposition 3, however, deposit insurance induces more entrepreneurs to undertake production projects unless the government is substantially inferior to depositors in monitoring banks.

Propositions 2 and 3 show that risk transfer through deposit insurance increases aggregate investment. In this model, imperfect monitoring by depositors lowers production, while imperfect monitoring by the government results mainly in income transfer from entrepreneurs to bankers. Therefore, deposit insurance is likely to improve social welfare, defined as the aggregate utility of economic agents, even if the monitoring ability of the government is inferior to that of depositors. Furthermore, an appropriate redistribution scheme can improve the welfare of all three types of agents.

4. GOVERNMENT VS PRIVATE INSURANCE

Complete risk transfer requires sufficient resources to guarantee the endowments of savers and incentives of the parties assuming risks to meet their obligations. The government provision of deposit insurance fulfills the two conditions. The government with the taxing authority faces the least binding resource constraint. Deposit insurance financed entirely with taxes on entrepreneurs and bankers clearly eliminates the risk of deposits. If entrepreneurs and bankers do not have enough resources, taxing savers is necessary to honor the deposit guarantee. Even in this case, deposit insurance may induce savers to choose deposits over self-storage. Since the expected tax burden lowers the after-tax return on self-storage as well as that on deposits, deposit insurance still increases the attractiveness of deposits relative to self-storage. Thus, the expected tax burden may not reduce the effectiveness of deposit insurance in increasing investment.

Considering that bank runs might seriously diminish economic activities, the government has an incentive to honor depositors' claims. An alternative way for the government to contain bank runs and reduce the risk of deposits is to function as a lender of last resort. Although it effectively manages liquidity crises, the lender of last resort alone does not resolve fundamental solvency problems (cases in which the value of liabilities exceeds that of assets at fair market prices).[7] If the depositors' main concern is the liquidity of banks, liquidity provision by the lender of last resort should contain bank runs. However, when they believe that many banks are fundamentally insolvent, rational depositors would withdraw regardless of the liquidity situation. After repaying the temporary loans by the lender of last resort, fundamentally insolvent banks would not be able to meet their obligations. Previous studies examining historical episodes support this hypothesis. For example, Park (1991) shows that liquidity provision needs to be accompanied by a verification of solvency to subdue financial crises. According to Donaldson (1992), the lender of last resort failed to contain the bank runs of 1933 because they were fundamental, as opposed to liquidity, runs. Thus, although a complement, the lender of last resort is not a good substitute for deposit insurance. The risk of deposits, therefore, is the lowest when deposit insurance is provided by the government that has enough resources and incentives to honor the insurance contract. Government intervention, however, has some drawbacks.

Government deposit insurance is typically accompanied by regulation. Government regulation seems necessary to abate moral hazard problems associated with deposit insurance (see, for example, Kane, 1990) because fairly pricing deposit insurance may be impossible (see Chan *et al.,* 1992). Government regulation involves distortions, however. For example, the government may offer various forms of subsidies such as the underpricing of deposit insurance, entry restrictions, and deposit interest rate ceilings to either deter bank risk taking or to induce banks to accept otherwise onerous regulations (Bhattacharya, 1982; Buser *et al.,* 1981; Thakor and Beltz, 1994). These subsidies may interfere with market forces, however, and result in deadweight losses.

Besides subsidies, there are other distortions associated with government regulation (see Bhattacharya and Thakor, 1993, for a review of the literature). Politicized regulation may distort credit allocation (Thakor and Beltz, 1994). Self-interested regulators may not pursue the social optimum (Boot

[7] In a financial crisis, withdrawal demands force banks to liquidate assets and hence depress asset prices. Decreased asset prices make many banks that would be solvent otherwise (fundamentally solvent banks) insolvent, worsening the crisis. The liquidity crisis may be defined as a case in which most banks are fundamentally solvent. Induced by an expectations bubble, depositors run on fundamentally solvent banks (see Diamond and Dybvig, 1983). On the other hand, a solvency crisis occurs when many banks are fundamentally insolvent and when solvency problems cause depositors to lose confidence in banks.

and Thakor, 1993; Campbell *et al.,* 1992; Kane, 1990). For example, regulators with reputational concerns may delay the closure of problem banks. According to Boot and Greenbaum (1992), bank regulation that indirectly promotes socially desirable activities may cause inefficiency because an unrealistic informational burden on regulators leads to intrusive and discretionary supervision. These costs associated with government regulation could outweigh the benefit from transferring risks. In the model presented here, if regulation induced banks to lend to entrepreneurs with negative net-present-value projects, the net effect could be lower output.

If they were equally effective in transferring risks, private arrangements would be preferred to government provision of deposit insurance combined with regulation. The possibility of an effective private arrangement depends on the incentives of bankers and entrepreneurs to assume risks. For bankers, eliminating moral hazard through an arrangement like private deposit insurance means extinguishing the option value. In a perfectly competitive market without government regulation, however, the option value deriving from information problems may be the only source of above-normal profits. Since they do not benefit from lower interest rates in a competitive market, banks may not desire an arrangement eliminating moral hazard problems. Even if banks have incentives to provide deposit insurance, their ability to resolve information problems is questionable since the difficulty of pricing deposit insurance, alluded to by Chan *et. al.* (1992), applies to private guarantors as well. Furthermore, monitoring among competitors can cause conflicts of interest (Goodhart, 1988).

Entrepreneurs benefit from low interest rates. To assume aggregate risks, entrepreneurs need to pool their resources. The return from an individual project is uncertain, and the elimination of nondiversifiable risks requires a large pool of resources. Pooling resources involves coordination problems. Although it improves the welfare of entrepreneurs as a group, a lower equilibrium return disadvantages many entrepreneurs who previously invested in others' projects at a higher return. Those entrepreneurs would refuse to assume risks to lower the interest rate. Even among entrepreneurs who benefit from a lower interest rate, there may be a free-rider problem. The participation of an individual entrepreneur in the resource pool may have a negligible effect on the interest rate. Then even a small cost of assuming risks would discourage entrepreneurs from joining the pool. These problems may make coordination among entrepreneurs difficult.

Matutes and Vives (1996) discuss the welfare effect of deposit insurance in a different framework: Moral hazard problems do not exist, and depositors are risk neutral. Since deposit insurance makes the riskiness of banks irrelevant, small, risky banks can compete with well-diversified large banks, and the supply of deposits is more elastic with respect to interest rates. Deposit insurance thus reduces "diversification economies" and induces banks to excessively bid up interest rates. This perverse competition increases failure probabilities and hence generates a deadweight loss. When the market structure is competitive, this negative effect is large and can outweigh the benefits of deposit insurance, namely eliminating bank runs and increasing deposit supply. This welfare implication might change if the negative effect were weighed against the added benefit of deposit insurance associated with risk transfer and moral hazard problems. Furthermore, the negative effect applies to private deposit insurance as well.

The modern financial market offers financial derivatives such as options and swaps designed to hedge risks. Currently, these instruments may be motivated by differing beliefs about the future state of the economy or large fee income and are not prevalent among small, risk-averse investors. It is doubtful that there would be enough supply of hedging instruments at little cost when all risk-averse agents attempted to hedge nondiversifiable risks using those instruments. For example, suppose every saver attempts to hedge risks by purchasing an equity share and a put option and selling a call option written on the share. In this case, entrepreneurs might need to commit most of their resources to honor put options in the bad state. Lacking incentives, however, many entrepreneurs might not sell put options unless they were rewarded with a positive expected return.

In sum, the government with its taxing authority has a clear advantage in securing sufficient resources to guarantee a fixed return, at least in nominal terms, to savers. Government intervention, however, can be inefficient in other respects. Although private arrangements might be less costly, it is questionable if an effective private arrangement to transfer risks could replace deposit insurance provided by the government.

5. CONCLUSION

This paper has shown that the transfer of nondiversifiable risks from risk-averse savers to other risk-neutral agents increases aggregate investment. Nondiversifiable risks can be transferred by a debt contract and pledge of capital by a financial intermediary. These conditions are insufficient to transfer risks completely if monitoring of financial intermediaries is less than perfect. A solution to the monitoring problem is intervention by the government with power to reallocate realized income (deposit insurance backed by the taxing authority). Imperfect monitoring by the government results mainly in income transfer among risk-neutral agents rather than lower production. Thus, deposit insurance can improve welfare even if the monitoring ability of the government is inferior to that of depositors. This analysis suggests another rationale for the traditional banking arrangement characterized by deposits backed by the government and risky lending.

The government is advantaged in securing resources to honor risk transfer contracts, but government intervention can be costly because it interferes with free market forces. Risk transfer might be possible through private arrangements. Insuring aggregate risks, however, requires extensive coordination among risk-neutral agents. Full coordination is unlikely because of conflicting interests among risk-neutral agents. Thus, it is questionable whether a private arrangement would be as effective as government-backed deposit insurance.

APPENDIX

Proof of Proposition 1. Differentiating Eq. (2) with respect to θ,

$$\partial E(U_{\mathrm{s}})/\partial\theta = P_{\mathrm{L}}\{\partial U(C_{\mathrm{L}})/\partial C_{\mathrm{L}}\}(R^{\mathrm{L}} - 1) + P_{\mathrm{H}}\{\partial U(C_{\mathrm{H}})/\partial C_{\mathrm{H}}\}(R^{\mathrm{H}} - 1),$$

where $C_{\mathrm{L}} = (1 - \theta) + \theta R^{\mathrm{L}}$ and $C_{\mathrm{H}} = (1 - \theta) + \theta R^{\mathrm{H}}$. The second derivative

$$\begin{aligned}\partial^2 E(U_{\mathrm{s}})/\partial\theta^2 = {} & P_{\mathrm{L}}\{\partial^2 U(C_{\mathrm{L}})/\partial C_{\mathrm{L}}^2\}(R^{\mathrm{L}} - 1)^2 \\ & + P_{\mathrm{H}}\{\partial^2 U(C_{\mathrm{H}})/C_{\mathrm{H}}^2\}(R^{\mathrm{H}} - 1)^2 \leq 0\end{aligned}$$

since $\partial^2 U_{\mathrm{s}}/\partial C^2 < 0$. ■

Proof of Lemma 2.

$$\begin{aligned}\partial E(U_{\mathrm{s1}})/\partial\theta = {} & P_{\mathrm{B}}P_{\mathrm{f}}\{\partial U(C_{\mathrm{L1}})/\partial C_{\mathrm{L1}}\}(-1) \\ & + (1 - P_{\mathrm{B}}P_{\mathrm{f}})\{\partial U(C_{\mathrm{H1}})/\partial C_{\mathrm{H1}}\}(R^{\mathrm{E1}} - 1),\end{aligned}$$

where $C_{\mathrm{L1}} = 1 - \theta$ and $C_{\mathrm{H1}} = (1 - \theta) + \theta R^{\mathrm{E1}}$.

$$\begin{aligned}\partial E(U_{\mathrm{s2}})/\partial\theta = {} & P_{\mathrm{B}}\{\partial U(C_{\mathrm{L2}})/\partial C_{\mathrm{L2}}\}\{(1 - P_{\mathrm{f}})R^{\mathrm{E2}} - 1\} \\ & + (1 - P_{\mathrm{B}})\{\partial U(C_{\mathrm{H2}})/\partial C_{\mathrm{H2}}\}(R^{\mathrm{E2}} - 1),\end{aligned}$$

where $C_{\mathrm{L2}} = (1 - \theta) + (1 - P_{\mathrm{f}})\theta R^{\mathrm{E2}}$ and $C_{\mathrm{H2}} = (1 - \theta) + \theta R^{\mathrm{E2}}$.

$$\begin{aligned}\partial E(U_{\mathrm{s2}})/\partial\theta - \partial E(U_{\mathrm{s1}})/\partial\theta = {} & P_{\mathrm{B}}(1 - P_{\mathrm{f}})(R^{\mathrm{E}} - 1)\{\partial U(C_{\mathrm{L2}})/\partial C_{\mathrm{L2}} \\ & - \partial U(C_{\mathrm{H1}})/\partial C_{\mathrm{H1}}\} \\ & + P_{\mathrm{B}}P_{\mathrm{f}}\{\partial U(C_{\mathrm{L1}})/\partial C_{\mathrm{L1}} - \partial U(C_{\mathrm{L2}})/\partial C_{\mathrm{L2}}\} > 0\end{aligned}$$

since $C_{\mathrm{L1}} < C_{\mathrm{L2}} \leq C_{\mathrm{H1}}$ implies, by concavity of U, that $U_{\mathrm{s}}(C_{\mathrm{H1}})/\partial C_{\mathrm{H1}} <$

$U_s(C_{L2})/\partial C_{L2} < U_s(C_{L1})/\partial C_{L1}$. Since $\partial E(U_{s2})/\partial\theta > \partial E(U_{s1})/\partial\theta$ for all θ, $\theta^{*2} > \theta^{*1}$, and in turn $R^{E2} < R^{E1}$. ■

Proof of Lemma 3.

$$\partial E(U_{s3})/\partial\theta = \{\partial U(C_3)/\partial C_3\}(R^{D3} - 1).$$

Thus, $\theta = 1$ for $R^D \geq 1$. Then $R^{D3} = 1$ because the supply of deposits is infinitely elastic at $R^{D3} = 1$. By the zero profit condition, $E(R^D) = E(R^E) = R^D = 1$. ■

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