Deposit Insurance, Bank Incentives, and the Design of Regulatory Policy

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1. Introduction

A large literature studies bank regulatory policies intended to control moral hazard problems associated with deposit insurance and optimal regulatory design. Much of the analysis has focused on uniform bank capital requirements, risk-based capital requirements, risk-based or fairly priced insurance premium rates, narrow banking, and, more recently, incentive-compatible designs.

All formal analyses employ highly simplified treatments of an individual bank or banking system. This study is concerned with the appropriateness of modeling simplifications used to characterize banks' investment opportunity sets and access to equity financing. While the characteristics of assumed investment opportunities differ among studies, all are highly simplified relative to the actual opportunities available to banks. In some studies, banks are assumed to invest only in 0 net present value (NPV) market-traded securities while in other studies only in risky nontraded loans. In models where banks make risky nontraded loans, loan opportunity set characteristics are highly specialized. Frequently, a bank is limited to choosing between a high- and a low-risk asset. In both these cases and those in which loan opportunity sets are expanded, a well-defined relationship between risk and NPV is assumed. Further, in many analyses, banks are assumed to have unrestricted access to equity capital at the risk-free rate on a risk-adjusted basis.

In the full version of this paper (Kupiec and O'Brien [1998]), we show that these modeling specializations have been important for policy results frequently cited in the literature. The shorter version presented here is limited to showing that substantial difficulties in optimal regulatory design arise when greater complexity in bank investment opportunity sets and financing alternatives is recognized.

For the analysis, banks are assumed to maximize net shareholder value, which derives from the banks' "economic value-added" and the net value to shareholders of deposit insurance. Economic value-added comes from positive net present value loan investments and from providing liquidity or transaction services associated with deposit issuance. A bank's economic value-added is measured net of dead-weight costs associated with outside equity financing (equity issuance costs) and the present value of potential distress costs. The latter costs are incurred when outside capital is raised by the bank against its franchise value to cover a current account deficit. In contrast to previous

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models of bank regulation where loan investments are assumed to satisfy a well-defined investment opportunity locus—such as first-or second-order stochastic dominance—different loan NPV and risk configurations are permitted here.[1] Even if a bank's optimal loan choices can be limited to a subset of all its loan investment opportunities, this set will depend on the regulatory regime. Also, in determining its risk exposure, the bank has access to risk-free and risky 0 NPV market-traded securities.

Because deposit insurance can create moral hazard incentives, share value maximization need not coincide with maximization of the bank's economic value-added. In our model, the objective of regulatory policy is to minimize reductions in banks' economic value-added due to moral hazard influences on bank investment and financing decisions. Besides the determinants of economic value-added described above (that directly enter shareholder net values), optimal regulatory design must also factor in the dead-weight costs incurred in closing an insolvent bank.

If, as assumed in previous models of bank regulation, the bank has unrestricted access to equity capital at the risk-free rate on a risk-adjusted basis, the moral hazard problem associated with deposit insurance in these models can be resolved by requiring full collateralization of insured deposits with the risk-free asset and setting the insurance premium at zero. Since equity financing is available at the risk-free rate on a risk-adjusted basis, the bank will want to undertake all positive NPV loan investment opportunities and deposit issuance will be governed by the profitableness of providing deposit transaction services.

The optimal design of regulatory policy becomes much more complicated when it is recognized that outside equity financing can be costly, that is, all-in issuance costs may significantly exceed the risk-free rate on a risk-adjusted basis. When equity issuance is costly, regulatory schemes that require the bank to raise a lot of equity capital, including narrow banking, can impose significant dead-weight costs on bank shareholders and discourage positive NPV investments. Under costly equity issuance, an optimal bank capital requirement that most efficiently resolves moral hazard incentives will be tailored to each bank's investment (risk and NPV) opportunities and its access to capital financing. The optimal bank-specific capital requirements and insurance premium rates, however, are difficult to achieve because regulators must have information on banks' investment choices or opportunity sets on the level of a bank insider.

Incentive-compatible regulatory mechanisms have been proposed as a way of solving the information problems that regulators face in designing an optimal policy.[2] However, when bank investment opportunities are more complex than typically assumed, we find substantial limitations on the incentive-correcting or sorting potential of incentive-compatible proposals. Our results suggest that incentive approaches that are able to achieve optimal bank-specific results, even if possible, require extensive information gathering. More likely, feasible regulatory alternatives will be much less information-intensive and, even when usefully employing incentives, will be uneven in their effectiveness and decidedly suboptimal on an individual bank basis.

2. Bank Shareholder Value and Economic Value

2.1. Model Assumptions

Each bank makes investment and financing decisions in the initial period to maximize the net present value of shareholders' claims on bank cash flows realized in the next period. On the asset side, a bank may invest in one-period risky nontraded loans, risky 0 NPV market-traded securities, and a 0 NPV risk-free security.

Individual loans are discrete investments and a bank's loan investment opportunity set is defined to be the set of all possible combinations of the discrete lending opportunities it faces. Each loan has an associated investment requirement, NPV, and set of risk characteristics. While financial market equilibrium (absence of arbitrage) requires that the expected returns on traded assets be linearly related to their priced risk components, this condition places no restrictions on the relationship between the NPV and risk of nontraded assets. Assets with positive NPV are expected to return to bank shareholders more than their market equilibrium required rates of return. For such assets, there are no equilibrium conditions that impose a relationship among NPV, investment size, or risk. Thus, a bank's loan investment opportunity set could be characterized by a wide variety of investment size, loan portfolio NPV, and risk combinations. Any subset of investment portfolios that a bank may choose to restrict itself to will depend on the regulatory policy regime.

The bank finances its investments in loans (L), risky securities (M), and the risk-free asset (T) with a combination of internal equity capital, external equity, and deposits. End-of-period deposit values (B) are government insured against default. Internal equity (W) represents the contribution of the initial shareholders. Outside equity financing (E) generates issuance costs of $d_0 \geq 0$ per dollar of equity issued. While deposit accounts provide transactions or liquidity services, the model treats these accounts as equivalent to one-period discount bonds. Deposits earn the one-period risk-free return of r, less a charge for liquidity services that earns the bank a profit of π per dollar of deposits. Both these profits and the bank's deposit insurance premium payments, denoted by $\phi B e^{-r}$, are paid at the beginning of the period. The bank has a maximum deposit base of $\bar{B}$ (par value).

In the second period, the bank's cash flows from its loans, risky securities, and risk-free bonds are used to pay off depositors. Shareholders receive any excess cash flows and obtain rights to a fixed franchise value, J.[3] If cash flow is insufficient to meet depositors' claims, the bank may issue equity against its franchise value. However, equity issued against J to finance end-of-period cash flow shortfalls generates "distress issuance costs" of $d_1 \geq 0$ per dollar of equity issuance. As with equity sales in nondistress periods, distress issuance costs would include both transaction fees and costs for certifying the value of the issue. The deposit insurer assumes the bank if it cannot cover its existing deposit liabilities.

2.2. Bank Shareholder Value

Under these assumptions, the net present value of initial shareholders' claims is given by

$$(1) \quad S = j_{L0} - I + e^{-r}J + \pi B e^{-r} + P_I - \phi B e^{-r} - \frac{d_1}{1-d_1}(P_D - P_I) - \frac{d_0}{1-d_0}E,$$

where

$$E = max\{(I + T + M + \phi B e^{-r} - (1+\pi)B e^{-r} - W), 0\}$$

and $I = \sum_{\forall j \in L} I_j$, $j_{L0} = \sum_{\forall j \in L} jL_j0$.

The components of shareholder value follow: j_{L0} is the value of the loan portfolio, I its required initial investment, and $j_{L0} - I$ the loan portfolio's net present value; $e^{-r}J$ is the present value of the bank's end-of-period franchise value; $Be^{-r}\pi$ are the profits from deposit-generated fee income; $P_I - \phi B e^{-r}$ is the net value of deposit insurance to bank shareholders. P_I has a value equivalent to that of a European put option written on the bank's total asset portfolio with a strike price of $j_d = B - Te^{r} - (1-d_1)J$. This strike price is the cash flow value below which the bank's shareholders default on the bank's deposit liabilities. For $j_d \leq 0$, $P_I \equiv 0$.

The second line in equation 1 captures the costs associated with outside equity issuance. E covers any financing gap that remains after deposits, inside equity, and deposit profits net of the insurance premium, $(\pi - \phi)Be^{-r}$, are exhausted by the bank's investments. Each dollar of external finance generates d_0 in issuance costs, requiring that $\frac{1}{1-d_0}$ dollars of outside equity be raised. $\frac{d_1}{1-d_1}(P_D - P_I)$ is the initial value of the contingent liability generated by end-of-period distress costs. The distress costs are proportional to the difference between two simple put options, P_D and P_I, where both options are defined on the underlying value of the bank's asset portfolio. P_D is the value of a put option with a strike price of $j_{ds} = B - Te^{-r}$, the threshold value below which the bank must raise outside equity to avoid default. The strike prices of these options define the range of cash-flow realizations, (j_d, j_{ds}), within which shareholders bear financial distress costs.[4] Distress costs reduce shareholder value since $P_D \geq P_I$.[5]

2.3. Shareholder Value Maximization

The shareholder value function, S, must be maximized using integer programming methods. This is necessitated by the assumption that loans are discrete nontradeable investments with individualized risk and return characteristics.

Let j_{L_k0} represent the risk-adjusted present value of loan portfolio k that can be formed from the bank's loan investment opportunity set. The loan portfolio has a required investment of I_k and an NPV equal to $jL_k0 - I_k$. The bank shareholder maximization problem can be written as,

$$(2)\, maxS = e^{-r}J + \underset{\forall k}{max} \left\{ (j_{L_k0} - I_k) + max\left\{ K(L_j)\big|_{L_j - L_k} \right\} \right\},$$

where

$$K(L_j) = P_I + (\pi - \phi)Be^{-r} - \frac{d_0}{1-d_0}E - \frac{d_1}{1-d_1}(P_D - P_I)$$

and $K(L_j)\big|_{L_j = L_k}$ indicates that the function K is to be evaluated conditional on the loan portfolio L_k. The conditional value of K is maximized over T, M, B, W, and the risk characteristics of the market-traded securities portfolio with E satisfying the financing constraint in equation 2, $B \in (0, \bar{B})$ and $I, T, M, W, E \geq 0$. Thus, for each possible loan portfolio (including the 0 investment loan portfolio), the bank maximizes the portfolio's associated K value by making the appropriate investment choices for risk-free and risky securities, outside equity issuance, and inside capital (or dividend payout policy). The bank then chooses the loan portfolio for which the *sum* of loan portfolio NPV and associated maximum K value is the greatest.

2.4. Bank Economic Value-Added

For analyzing the efficiency of alternative regulatory environments, we define a measure of the bank's economic value-added. As a simplification, the bank is assumed to capture entirely the economic value-added from its investment and deposit activities. That is, the bank's profits from deposit taking mirror the depositor welfare gains generated by transaction accounts, and the bank's asset portfolio NPV reflects the entire NPV produced by its investment activities. This avoids modeling the production functions, utility functions, and bargaining positions of the bank's counterparties when constructing a measure of social welfare. The bank's franchise value, J, is assumed to reflect entirely economic value-added (the future NPV of lending opportunities, providing deposit liquidity services, with no net insurance value).[6]

Netted against these economic value-added components are the bank's dead-weight equity issuance costs and distress costs, and the dead-weight costs borne by the insurer if the bank is closed. Under insolvency, the insurer pays off depositors with the realized cash flow from the bank's investments, the sale of the bank's franchise, and a drawdown on its cash reserve from accumulated premium payments. Dead-weight closure costs arise if, in disposing of the bank's franchise, the insurer loses a fraction of the initial value J. While the magnitude of such losses is unclear in practice, the simplest approach is to assume this fraction is the same as that lost by shareholders in a distress situation, d_1.[7] Under this assumption, the insurer's dead-weight closure costs are $d_1 J$. Aggregating across all of the bank's claimants the realized end-of-period payments (payouts), taking their risk-adjusted present expected values, and subtracting initial investment outlays yield the bank's economic value-added. Where closure costs are equal to $d_1 J$, the bank's economic value-added (EVA) is,

$$(3)\ EVA = j_{L0} - I + \pi Be^{-r} + Je^{r} - \frac{d_0}{1-d_0}E - \frac{d_1}{1-d_1}(P_D - P_I).$$

Because of the influence of deposit insurance on bank investment and financing choices, bank policies that maximize the net value of shareholder equity may not maximize the banks' EVAs. In the present analysis, an optimal regulatory policy consists of an insurance pricing rule and supplemental regulations, that is, capital requirements, that minimize the distortive incentive effects of deposit insurance, taking into account the direct effects on EVAs of the regulatory policy as well. The insurer or regulator is constrained to providing deposit insurance to an ongoing bank without subsidy, which is always possible in our model (see below).

3. Optimal Regulatory Policy When Equity Issuance Is Costless

First, consider the possibility of fairly priced insurance when the bank has perfect access to equity capital financing, that is, there are no equity issuance costs ($d_0 = 0$). The insurance is said to be fairly priced if the insurance premium is equal to the value of deposit insurance to bank shareholders, that is, $\phi B e^{-r} = P_I$.[8] Under a fair-pricing condition, no equity issuance costs, and access to a risk-free 0 NPV investment, net shareholder value is maximized by choosing all positive NPV loans and accepting all insured deposits. Any funding requirements in excess of the bank's internal equity capital and deposits can be costlessly met with outside equity financing. If there are potential distress costs ($d_1 > 0$), these can be costlessly eliminated by investing in the risk-free asset, as well as investing in positive NPV loans.

Further, when an intermediary can guarantee its deposit obligations by collateralizing them with risk-free bonds, if outside equity issuance is costless, the potential for costless collateralization creates the possibility of implementing fairly priced deposit insurance without any governmental subsidy to the banking system. This possibility is formalized in Proposition 1.

Proposition 1 *If (i) initial equity issuance is costless* ($d_0 = 0$) *and (ii) the bank has unrestricted access to risk-free bond investments, then a bank is indifferent between: (a) fairly priced deposit insurance and (b) a requirement that all insured deposits be collateralized with risk-free bond investments with an insurance premium equal to 0.*

Proposition 1 establishes the possibility of an efficient, fairly priced deposit insurance system in the form of a "narrow bank" deposit collateralization requirement. This proposition does not depend on banks earning deposit rents and would hold in a competitive equilibrium. Proposition 1 does require, however, that banks can issue equity at competitive risk-adjusted rates with no costs or discounts generated, for example, by informational problems or tax laws.

4. Regulatory Policy When Equity Issuance Is Costly

When it is costly to issue outside equity (the likely situation), a narrow banking requirement can generate significant social costs in the form of equity issuance costs and the opportunity cost of positive NPV investments that go unfunded. However, absent a narrow bank policy, pricing the deposit insurance guarantee is fraught with difficulties. One difficultly is that the bank regulators are unlikely to have sufficient expertise to value the bank's (nontraded) assets or assess their risk.[9] Even if regulators have sufficient expertise, the bank has an incentive to disguise high-risk investments or substitute into high-risk assets after its insurance premium has been set. Without resorting to highly intrusive monitoring, the moral hazard problem necessitates capital or other regulations that reduce risk-taking incentives arising from the deposit guarantee. The analysis here assumes that the insurer has the expertise to value individual assets banks might acquire and examines capital-based regulatory policies intended to solve the moral hazard problem.

To facilitate the analysis, we consider a hypothetical banking system comprised of four independent banks. Each bank faces a unique loan investment opportunity set

Table 1
Alternative Loan Opportunity Sets

Loan Number	Loan Amount	Expected Return[a]	Systematic (Priced) Risk[b]	Nonsystematic Risk[c]	Total Risk[d]	NPV[e]
Loan Opportunity Set A						
1	75	.20	.08	.20	.22	5.44
2	50	.10	.00	.45	.45	2.56
3	100	.25	.10	.30	.32	10.52
Loan Opportunity Set B						
1	75	.30	.10	.50	.51	12.14
2	140	.12	.05	.20	.21	2.83
3	50	.20	.10	.60	.61	2.56
Loan Opportunity Set C						
1	75	.20	.10	.45	.46	3.85
2	100	.03	-.10	.35	.36	8.33
3	50	.21	.12	.45	.47	2.04
Loan Opportunity Set D						
1	190	.21	.05	.10	.11	21.30
2	190	.75	.70	.90	1.14	0.00
3	50	.21	.12	.45	.47	2.04
Risky Market-Traded Security						
		.35	.30	.30	.42	.00

[a] One-period expected return to loan *i* defined by $\mu_i + .5\sigma_i^2$. See endnote 10.

[b] One-period systematic risk (standard deviation) for loan i, s_{0i}.

[c] One-period nonsystematic (idiosyncratic) risk for loan i, s_{1i}.

[d] Total risk for loan *i* (one-period return standard deviation), $\sigma_i = (s_{0i}^2 + s_{1i}^2)^{1/2}$.

[e] NPV is calculated using the expression in endnote 10, where the market price of systematic risk is 1, $\lambda = 1$, and $r = .05$ is the risk-free rate.

consisting of three possible loans (seven possible loan combinations). For simplicity, individual loans have log-normal end-of-period payoffs that include a single systematic (priced) risk source and an idiosyncratic risk.[10] Banks' individual loan opportunity sets are described in Table 1. Bank A's opportunity set includes loans with relatively modest overall risk. Bank B can invest in two loans with relatively high risk, one of which has substantial NPV. Bank C's opportunities also include relatively high-risk loans; its most profitable loan has negative systematic risk. Bank D's investment opportunity set includes a large, low-risk, high-NPV loan and a large, high-risk, 0 NPV loan. All four banks can invest in a risk-free bond and a risky 0 NPV security whose characteristics are described in the last row of Table 1. For simplicity, all heterogeneity across banks is assumed to arise from differences in loan investment opportunities. The three banks are subject to identical equity issuance costs ($d_0 = .2$), distress costs ($d_1 = .4$), franchise values ($J = 40$), maximum internal equity capital ($W = 27$), maximum deposits ($\bar{B} = 200$), and a common transaction service profit rate ($\pi = 0.025$). The risk-free rate is arbitrarily set at .05.

4.1. The First-Best Solution

To establish an optimal benchmark, assume that the insurer has sufficient knowledge to set a fair insurance premium and that the bank must irrevocably commit to its asset portfolio and capital structure before the insurer sets its premium. Table 2 reports each bank's optimization results.[11] Columns 2-6 report optimal loan, securities, and equity financing choices. Net share value is defined in equation 1 above. Economic value-added is the bank's net social value and is defined assuming that insurer closure costs mirror bank distress costs (equation 3). Net insurance value, $P_I - \phi B e^{-r}$, is zero by construction. For the risk capital ratio, capital is defined as the book value of loans and securities minus deposits, and risk assets are defined as the book value of loans plus risky securities. Under the closure cost assumption, if deposit insurance is fairly priced, $S = EVA$, and maximizing net share value also maximizes economic value-added. By this measure, fairly priced deposit insurance is a first-best policy with no need for capital requirements.

Implementing a fairly priced deposit insurance system is problematic when a bank's decisions cannot be completely and continuously monitored. Although each bank's insurance premium may be calibrated to fair value by assuming a bank operating policy that achieves maximum economic value-added, given this premium and an ability to alter its asset mix, a bank may face incentives to substitute into a more risky asset portfolio. In the example in Table 2, banks B and D could increase their insurance values, and net shareholder values, if they could substitute into higher risk assets at the given insurance rates (reported in footnote a). The insurance would become underpriced and, while shareholder values would increase, economic value-added would be reduced.

4.2. Optimal Policy with Imperfect Monitoring

Absent complete information on each bank's investments, deposit insurance can still be fairly priced and moral hazard incentives removed by imposing a narrow banking require-

Table 2
Fairly Priced Insurance with Perfect Monitoring
Bank Optimizing Results

Bank	Loans	Risky Security	Riskless Security	Internal Equity	Outside Equity	Net Share Value	Economic Value-Added	Net Insurance Value[a]	Risk Capital Ratio[b]
A	1, 2, 3	0.00	0.00	27.00	3.47	59.33	59.33	0.00	.154
B	1, 2	0.00	5.26	27.00	0.00	55.35	55.35	0.00	.140
C	1, 2, 3	0.00	0.00	27.00	4.57	53.58	53.58	0.00	.154
D	1	0.00	32.00	27.00	0.00	64.08	64.08	0.00	.167
							232.34		

[a] $P_I - \phi B e^{-r}$. For banks A, B, C, and D, the fair premium rates are .002, .008, .009, and 0, respectively.

[b] Book capital to risk assets. Book capital equals investments in loans and securities minus deposits. Risk assets equal loans plus risky securities.

ment that all deposits be collateralized with the risk-free asset. While feasible, the narrow banking solution can entail large reductions in banks' EVAs due to equity issuance costs and foregone positive NPV loan opportunities for which financing costs are now too high (see Kupiec and O'Brien [1998] for numerical illustration). However, if the regulator has complete information about each bank's investment opportunities and can enforce a minimum capital requirement, moral hazard incentives can be eliminated and fair insurance premiums can be set at a smaller social cost than is incurred under narrow banking. In determining optimal minimum capital requirements, the regulator must determine the minimum capital requirement and insurance premium rate combination that maximizes each bank's economic value-added, subject to a fair-pricing condition and incentive-compatible condition that the bank have no incentive to engage in asset substitution at its required capital and insurance premium settings.[12] The optimal capital requirement will vary with each bank's investment opportunity set.

The optimal bank-specific capital requirements are calculated for each bank in Table 3. The second and third columns in the table present bank-specific minimum capital requirements and fair-premium rates for the four banks. The fourth column shows the maximum economic value-added for each bank and, for comparison, the fifth column shows the first-best economic value-added reported in Table 2. The minimum capital requirements remove the moral hazard incentives for banks B and D that would exist at first-best capital requirements and premium rates. The costs of imposing the capital requirements are a small reduction in bank B's EVA due to a reduced loan portfolio NPV and equity issuance costs incurred by bank D. In general, the incentive-compatibility constraints required when the regulator cannot perfectly monitor bank actions will result in an optimal policy that is not a first-best solution.

Notice that the optimal bank-specific capital requirements are not "risk-based" capital requirements as defined under current bank capital regulations but are designed to solve the moral hazard problems. The insurance premium rates, being fair premiums, are risk-based. This is a more efficient solution than "risk-based" capital requirements with a fixed deposit insurance rate. Also note that the costs associated with a minimum risk-asset capital standard do not include a loss in the value of "liquidity services." Because the capital requirement applies to risk assets defined to exclude an identifiable risk-free asset (such as Treasury bills), there is no incentive for banks to reduce deposit levels. This result contrasts with studies that suggest an important cost of more stringent capital requirements is a reduction in the provision of socially valuable liquidity services (for example, John, John, and Senbet [1991]; Campbell, Chan, and Marino [1992]; and Giammarino, Lewis, and Sappington [1993]).

4.3. Imperfect Monitoring and Incomplete Information

The design of an optimal bank-specific capital policy imposes the unrealistic requirement that the regulator know each bank's investment opportunity set. A growing literature has proposed the use of incentive-compatible

Table 3

OPTIMAL BANK-SPECIFIC CAPITAL REQUIREMENTS AND FAIR INSURANCE RATES WITHOUT PERFECT MONITORING

Bank	Required Risk-Capital Ratio	Premium Rate	Economic Value-Added	First-Best Economic Value-Added[a]	Net Insurance Value
A[b]	≥ .154	.002	59.33	59.33	0.00
B	≥ .247	.005	55.30	55.35	0.00
C[c]	≥ .154	.009	53.58	53.58	0.00
D	≥ .351	.000	55.36	64.08	0.00
			223.57	232.34	

[a] Figures taken from Table 2.

[b] Bank A's optimal strategy for any minimum required risk-capital ratio between 0 and .154.

[c] Bank C's optimal strategy for any minimum required risk-capital ratio between .045 and .154.

contracting mechanisms that can simultaneously identify the investment opportunity sets specific to individual banks and control moral hazard behavior even when the regulator is not fully informed a priori. Among others, Kim and Santomero (1988a); John, John, and Senbet (1991); Chan, Greenbaum, and Thakor (1992); Campbell, Chan, and Marino (1992); Giammarino, Lewis, and Sappington (1993); and John, Saunders, and Senbet (1995) provide formal analyses of incentive-compatible policies.

In the spirit of this approach, assume as before that there are four banks each with a loan investment opportunity set that is one of the types presented in Table 1, either A, B, C, or D. While an individual bank knows its type, the regulator only knows the characteristics of the alternative investment opportunity sets but does not know the opportunity set associated with each individual bank. Because it cannot distinguish bank types, the regulator cannot directly set the bank-specific capital requirements and insurance premiums that achieve the results in Table 3, that is, that solve the policy problem when the regulator has complete information on investment opportunity sets. The incentive-compatible literature suggests, however, that the risk types can be identified by an appropriate set of contracts.

Consider, as in Chan, Greenbaum, and Thakor (1992), an ex ante incentive-compatible policy based on a menu of contracts whose terms consist of combinations of a required minimum capital ratio and insurance premium rate, assuming the regulator can enforce a minimum capital requirement. As in the preceding case, the optimal capital and insurance premium combinations will satisfy the constraint that each individual bank will not "asset-substitute" given its minimum capital requirement and insurance premium. In addition, the menu offered to banks must be such that each bank not prefer a capital requirement–insurance premium rate combination intended for another bank type.

In general, the capital requirement–premium rate combinations that satisfy these incentive-compatibility constraints will differ from those that solve the policy problem where there is imperfect monitoring but complete information. For example, if banks were offered a menu of contract terms taken from columns 1 and 2 of Table 3—the capital requirements and premium rate combinations that maximize firm values under the full information assumption—bank optimizing choices would not identify their types. Given such a menu, all banks would claim to have a type A investment opportunity set.

If bank A is excluded from the table, the fair-pricing contract terms for the remaining banks in Table 3 show a monotonic inverse relationship between the contract's capital requirement and its insurance premium. The inverse relationship is consistent with the ordering of terms proposed by Chan, Greenbaum, and Thakor (1992) as an incentive-compatible policy when the regulator is not completely informed of banks' specific investment opportunity sets. This inverse relationship will not, however, produce a correct sorting of banks in the table as type B and D banks would reveal themselves to be type C banks. They would choose higher risk investments and produce lower EVAs than the full information results presented in Table 3, and their insurance would be underpriced.

Table 4
OPTIMAL INCENTIVE-COMPATIBLE CAPITAL REQUIREMENTS AND FAIR INSURANCE RATES WITH INCOMPLETE INFORMATION

Bank	Required Bank-Capital Ratio[a]	Premium Rate	Economic Value-Added	First-Best Economic Value-Added[b]	Net Insurance Value
A	≥ .351	0	52.17	59.33	0.00
B	≥ .351	0	54.16	55.35	0.00
C	≥ .351	0	49.59	53.58	0.00
D	≥ .351	0	55.36	64.08	0.00
			211.28	232.34	

[a] Banks A, C, and D will optimally operate at the minimum required capital ratio. Bank B will optimally choose to operate at a capital ratio of .423.

[b] Figures taken from Table 2.

The optimal solution to the incentive-compatible contracting problem is given in Table 4. The optimal incentive-compatible contract imposes a uniform minimum risk-asset capital requirement and a uniform insurance premium on all banks. Bank EVAs also are mostly smaller than those presented in Table 3. This occurs because greater limits on regulators' information impose additional incentive-compatibility conditions on the regulator that constrain further the set of feasible policies from which to choose. Given the bank investment opportunities (and equity issuance costs) in this example, the incentive-compatible policy even fails to distinguish banks. However, because it allows for some deposit-financed lending, the optimal policy is still more efficient than the narrow banking solution.

Contracts like those in Chan, Greenbaum, and Thakor (1992) fail to generate a separating equilibrium in this example because our investment opportunity set and financing structures are more complex than those that underlie their model. By assumption, all bank loan investment opportunity sets in Chan, Greenbaum, and Thakor can be ranked according to first-order or second-order stochastic dominance.[13] In our model, the set of possible asset portfolios represents investment opportunities whose combinations of risk, NPV, and financing requirements do not fit any well-defined risk ordering. In particular, the opportunity sets cannot be uniquely ordered by a one-dimensional risk measure such as first- or second-order stochastic dominance.

This last example illustrates that, with less stylized investment opportunity sets, designing incentive-compatible policies that achieve a high degree of sorting among bank types can impose formidable information requirements on regulators. In some respects, the information assumptions made here are still very strong in that regulators are unlikely to have a clear idea of the constellation of investment opportunities available to banks. In the present model, if regulators had to consider a wider set of investment opportunities for each bank than the four assumed, an optimal policy would produce an economic value-added for each bank somewhere between that shown in Table 4 and the results under a narrow banking approach.

5. Conclusions

The preceding analysis has shown the difficulties inherent in designing an optimal bank regulatory policy where commonly used modeling stylizations on banks' investment and financing choices are relaxed. When banks can issue equity at the risk-adjusted risk-free rate, a common modeling stylization, collateralization of deposits with a risk-free asset costlessly resolves moral hazard inefficiencies and insurance pricing issues addressed in the literature. With costly equity issuance, this narrow banking approach can impose large dead-weight financing costs and reduce positive NPV investments funded by the banking system. When equity issuance is costly, the most effective and efficient capital requirements are bank-specific, as they depend on individual banks' investment opportunities and financing alternatives. Directly implementing optimal bank-specific capital requirements, however, requires detailed regulatory information on the investment opportunities and financing alternatives of individual banks.

Incentive-compatible designs have been proposed in the theoretical literature as a way of minimizing regulatory intrusiveness and information requirements in obtaining optimal bank-specific results. However, in relaxing previous modeling stylizations, we found that heavy information requirements also inhibited incentive-compatible designs in obtaining optimal bank-specific results. Despite the potential benefits of incentive approaches over rigid regulations, feasible approaches are still likely to be substantially constrained by limited regulatory information and by "level playing field" considerations and thus are likely to be decidedly suboptimal at the individual bank level.

ENDNOTES

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1. For example, see Gennotte and Pyle (1991); Chan, Greenbaum, and Thakor (1992); and Giammarino, Lewis, and Sappington (1993) for use of stochastic dominance assumptions.

2. For example, see Chan, Greenbaum, and Thakor (1992); Giammarino, Lewis, and Sappington (1993); Kim and Santomaro (1988); John, John, and Senbet (1991); Campbell, Chan, and Marino (1992); and John, Saunders, and Senbet (1995).

3. Franchise value may arise from continuing access to positive NPV loan opportunities, the ability to offer transaction accounts at a profit, and the net value of deposit insurance in future periods.

4. $\frac{d_1}{1-d_1}P_D$ is a hypothetical value of the distress costs the bank would face if it could not default on its deposit obligations. Because bank shareholders will not have to bear distress costs for portfolio value realizations less than j_d, the default threshold, the term $\frac{d_1}{1-d_1}P_I$, credits shareholders with the default portion of the distress costs.

5. See Kupiec and O'Brien (1998) for a more complete development of the option components of the bank's net shareholder value.

6. This assumption is consistent with the regulatory policies analyzed below.

7. See James (1991) for a description and estimates of bank closure costs.

8. The fairly priced premium will equal the insurer's liability value if the insurer's costs in liquidating the bank are the same as the distress costs to shareholders (see above).

9. Flannery (1991) emphasizes this point and considers the consequences for insurance pricing and bank capital policy, although his analysis does not incorporate moral hazard behavior.

10. In terms of earlier notation (see equation 1), the second period cash flow from loan i is $j_{i1} + I_{i0}e^{\mu_i + s_{0i}z_0 + s_{1i}z_{1i}}$, where I_{i0} is the bank's initial required outlay for loan i, μ_i the expected return, $s_{0i}z_0$ the systematic risk component, $s_{1i}z_{1i}$ the idiosyncratic component, and the z terms are independent standard normal variates. The initial value of loan i is $j_{i0} = I_{i0}e^{\mu_i + \frac{1}{2}(s_{0i}^2 + s_{1i}^2) + \lambda s_{0i} - r}$, where λ is the market price of risk and r the one-period risk-free rate. For positive NPV loans, $j_{i0} > I_{i0}$.

11. The shareholder equity maximization problem is solved numerically using integer programming as described in equation 2 above. As the sum of lognormal variables is not lognormal and does not have a closed form density function, all option values are calculated using numerical techniques. A lognormal distribution approximation to the sum of lognormal variables is used (see Levy [1992] for details). Option values from the use of the lognormal approximating distribution were similar to values calculated using Duan and Simonato's (1995) empirical martingale simulation technique.

12. See Kupiec and O'Brien (1998) for the formal incentive-compatibility conditions.

13. This ordering is also assumed in Giammarino, Lewis, and Sappington (1992); John, John, and Senbet (1991); and John, Saunders, and Senbet (1995).

REFERENCES

Campbell, Tim, Yuk-Shee Chan, and Anthony Marino. 1992. "An Incentive-Based Theory of Bank Regulation." JOURNAL OF FINANCIAL INTERMEDIATION 2: 255-76.

Chan, Yuk-Shee, Stuart I. Greenbaum, and Anjon Thakor. 1992. "Is Fairly Priced Deposit Insurance Possible?" JOURNAL OF FINANCE 47, no. 1: 227-45.

Craine, Roger. 1995. "Fairly Priced Deposit Insurance and Bank Charter Policy." JOURNAL OF FINANCE 50, no. 5: 1735-46.

Duan, Jin-Chuan, and Jean-Guy Simonato. 1995. "Empirical Martingale Simulation for Asset Prices." Manuscript, McGill University.

Flannery, Mark J. 1991. "Pricing Deposit Insurance When the Insurer Measures Bank Risk with Error." JOURNAL OF BANKING AND FINANCE 15, nos. 4-5: 975-98.

Gennotte, Gerard, and David Pyle. 1991. "Capital Controls and Bank Risk." JOURNAL OF BANKING AND FINANCE 15, nos. 4-5: 805-24.

Giammarino, R., T. Lewis, and D. Sappington. 1993. "An Incentive Approach to Banking Regulation." JOURNAL OF FINANCE 48, no. 4: 1523-42.

James, Christopher. 1991. "The Losses Realized in Bank Failures." JOURNAL OF FINANCE 46, no. 4: 1223-42.

John, Kose, Teresa John, and Lemma Senbet. 1991. "Risk-Shifting Incentives of Depository Institutions: A New Perspective on Federal Deposit Insurance Reform." JOURNAL OF BANKING AND FINANCE 15, nos. 4-5: 895-915.

John, Kose, Anthony Saunders, and Lemma W. Senbet. 1995. "A Theory of Bank Regulation and Management Compensation." New York University Salomon Center Working Paper S-95-1.

Kim, Daesik, and Anthony Santomero. 1988a."Deposit Insurance Under Asymmetric and Imperfect Information." Manuscript, University of Pennsylvania, March.

———. 1988b. "Risk in Banking and Capital Regulation." JOURNAL OF FINANCE 43, no. 5: 1219-33.

Kupiec, Paul H., and James M. O'Brien. 1998. "Deposit Insurance, Bank Incentives, and the Design of Regulatory Policy." FEDS working paper no. 1998-10, revised May 1998.

Levy, Edmound. 1992. "Pricing European Average Rate Currency Options." JOURNAL OF INTERNATIONAL MONEY AND FINANCE 11: 474-91.