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Nagarajan, S. and C. W. Sealey

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S. NAGARAJAN AND C.W. SEALEY

FACULTY OF MANAGEMENT, MCGILL UNIVERSITY
MONTREAL H3A 1G5 CANADA.

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STATE-CONTINGENT BANK REGULATION

ABSTRACT

Current legislation attempts to solve incentive problems in bank regulation, by instituting policies such as risk-adjusted deposit insurance premiums, strict capital requirements, prompt closure policies, etc. Recent theoretical works have shown such policies to be neither necessary nor sufficient, *per se*, to solve these problems. In this paper, we present a model of incentive compatible bank regulation under moral hazard and adverse selection. We derive a wide range of simple mechanisms that can solve *both* types of incentive problems and also achieve first-best outcomes, but only when the regulatory instruments involve *ex post* pricing based on the performance of the bank *relative* to the market. An important implication of the model is that these mechanisms need not involve a subsidy to the bank.

I. INTRODUCTION

Current legislation attempts to solve incentive problems in bank regulation, caused by moral hazard and adverse selection, by mandating policies such as risk-adjusted deposit insurance premiums, strict capital requirements, prompt closure policies, etc. The conclusions reached in recent theoretical literature suggest that bank regulatory practices which rely solely on such policies are neither necessary nor sufficient, *per se*, to solve the incentive problems. For example, John, John, and Senbet (1991) argue that risk-shifting by banks is not mitigated by the introduction of risk-adjusted deposit insurance premiums. Nagarajan and Sealey (1995) show that prompt (or even early) closure of insolvent banks is not likely to solve the moral hazard problem and, moreover, that even fixed-rate deposit insurance, if accompanied by a rational policy of forebearance, can be incentive compatible. One of the more interesting results, presented by Chan, Greenbaum, and Thakor (1992), is that fairly priced deposit insurance premiums may actually be *inconsistent* with incentive compatibility, and that deposit insurance subsidies may be required, *ex post*, to achieve incentive compatibility.[1]

[1]Related literature on deposit insurance also includes Buser, Chen and Kane (1981), Campbell,Chan and Marino (1992), and Giammarino, Lewis and Sappington (1993).

A common element of the mechanisms derived in the above papers is that they all involve some type of state-contingent (*ex post*) contracting in order to achieve incentive compatibility.[2] In particular, if the regulator imposes an appropriate set of *ex post* rewards and/or punishments that are triggered by *ex post* outcomes, then value maximizing banks are induced to weigh the potential returns from *ex ante* risk shifting against any *ex post* cost associated with such behavior. Under certain conditions, banks choose higher asset quality *ex ante* than would otherwise be the case, although they do not necessarily choose first-best.

In this paper, we present a model of bank regulation under moral hazard and adverse selection, and develop a class of optimal incentive compatible regulatory mechanisms with *ex post* settlement that help achieve first-best outcomes. In our model, the bank's total risk is decomposed into its market and idiosyncratic components, and the regulator prices deposit insurance based on the bank's performance relative to the market.[3] When the regulator is able to formulate state-contingent pricing that depends on relative performance, it is then possible to fashion a mechanism that is more informationally refined than a corresponding mechanism based on absolute performance. The reason is that the regulator can filter out that part of performance that is attributable to factors beyond the bank's control, and thus make a more informed (although still imperfect) evaluation of the bank's unobservable asset quality and/or private information.

Our main result is that moral hazard and adverse selection problems, arising from

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[2]Benston, Eisenbeis, Horvitz, Kane and Kaufman (1986), and Kane (1987) also suggest *ex post* deposit insurance pricing as a means of solving incentive problems associated with deposit insurance, but they do not present a specific model to show how *ex post* pricing might work.

[3]Our model is in the spirit of Nagarajan and Sealey (1995) in that the policy instruments in our model are based on a relative performance measure. Our model is quite different from theirs, however, since they model bank closure policy, whereas we concentrate on deposit insurance pricing. Moreover, they obtain only second-best outcomes, whereas we are able to obtain first-best here. For more on relative performance measures, see Ramakrishman and Thakor (1984).

the deposit insurance system, can be completely alleviated by simple regulatory mechanisms which rely on *ex post* settlements that are contingent on relative performance. Specifically, we derive two classes of such mechanisms that have the following properties which distinguish them from much of the literature on incentive compatible bank regulation: 1) first-best outcomes are achieved under both moral hazard and adverse selection, 2) no deposit insurance subsidy is required to achieve incentive compatibility, even when loan markets are competitive; and 3) since deposit insurance is fairly priced, these mechanisms do not create distortions in banks' optimal financing decisions.[4]

The paper is organized as follows. Section II describes the basic model. The optimal state-contingent regulatory mechanisms under moral hazard are derived in Section III. Section IV presents the adverse selection case, while Section V analyzes both moral hazard and adverse selection. Section VI discusses the results, and Section VII offers some policy implication of the model. Section VIII concludes.

II. THE MODEL

Consider a simple, one-period model of bank regulation involving a risk-neutral depository institution, referred to here as a bank, and a risk-neutral regulator. At $t = 0$, the bank takes paid-in equity capital, E, and deposit funds, D, and invests these funds in a portfolio of risky assets or loans worth A, where A is fixed. The bank can choose its desired leverage ratio subject to a minimum capital requirement (or equivalently, a ceiling on deposits) set by the regulator. As in Chan, Greenbaum and Thakor (1992), the bank captures an α fraction of the profits from the assets, where $0 \leq \alpha \leq 1$, the exact share depending on the degree of competition in the loan market. If $\alpha = 0$, the bank operates in a perfectly competitive loan market, whereas if $\alpha = 1$, the bank is a monopolist.

The deposits issued by the bank may be fully insured by the regulator, who charges an *ex ante* premium per dollar of insured deposits, p_0, at $t = 0$, which need not reflect

[4]Chan, Greenbaum, and Thakor (1992) also achieve first-best outcomes, but only with the help of subsidies from the regulator. Thus, ~~their mechanisms will cause~~ may result in economy-wide distortions in resource allocation.

the risk of the insurance contract. The regulator has the option to impose additional insurance charges (or rebates) *ex post* (i.e., after the returns are realized at $t = 1$), depending on the information available at the time. The bank's managers are assumed to act in the interest of their shareholders.

The random dollar (gross) return on the bank's asset portfolio realized at $t = 1$, depends on the following factors:

i) the realized return on a systematic factor, referred to here for simplicity as the market portfolio, $\tilde{r}_m$, and the beta of the bank's assets, $\beta > 0$, both of which are observable *ex post*.[5] The market return is assumed to be either $\bar{r}_m$ (good) with probability q_m, or $\underline{r}_m$ (bad) with probability $(1 - q_m)$.[6]

ii) the inherent risk or quality, θ, called the "type" of the bank. Specifically, the bank can be either a high-quality type, θ_H, or a low-quality type, θ_L, where $1 > \theta_H > \theta_L$. *Ceteris paribus,* the high quality bank has a higher probability of success and lower risk than a low quality bank.[7]

iii) the bank's choice of (idiosyncratic) asset quality, $q \in [\underline{q}, \bar{q}] \subset (0, 1]$, chosen at $t = 0$, where θq can be interpreted as the probability of success of the investment in assets.

iv) a borrower-specific risk $\tilde{\epsilon}$, which the bank does not control.

For simplicity, the asset returns are $R(\theta q) + \beta\tilde{r}_m + \tilde{\epsilon}$ if the investment is successful, and $\beta\tilde{r}_m$ if the investment is a failure. Since the market return can be either $\bar{r}_m$ or $\underline{r}_m$, this gives rise to four possible states at $t = 1$ (see Figure 1). The bank's state-contingent payoffs can be summarized as follows:

[5]While this is the standard case, as is evident later, the direction of our state-contingent results are reversed if $\beta < 0$.

[6]If the bank is allowed to choose the β of its portfolio, then it may potentially choose highly cyclical investments (high β), or partially hedge the market risk (low β). Neither possibility is relevant to our results, however, because β being observable, its choice cannot serve as a vehicle to shift risk. In fact, if deposit insurance is priced correctly in equilibrium, the bank's choice of β is indeterminate.

[7]The "success" or "failure" of the investment here refers to the realization of risks specific to the bank, and not those due to systematic factor or the borrower (see below).

State 1: The investment is successful and the market return is good. The dollar return on the asset is $R(\theta q) + \beta\bar{r}_m + \tilde{\epsilon}$, with probability $\theta q q_m$,

State 2: The investment is successful but the market return is bad. The return is $R(\theta q) + \beta\underline{r}_m + \tilde{\epsilon}$, with probability $\theta q(1 - q_m)$.

State 3: The investment is a failure but the market return is good. The return is $\beta\bar{r}_m$, with probability $q_m(1 - \theta q)$.

State 4: The investment is a failure and the market return is bad. The return (residual asset value) is $\beta\underline{r}_m$, with probability $(1 - \theta q)(1 - q_m)$.

In the first three states, asset returns are sufficient to pay off depositors, and the bank is solvent. On the other hand, in *State 4*, the bank is insolvent and the regulator closes the bank and assumes all deposit liabilities in excess of the bank's residual value. In order to help interpret risk-shifting, assume that $\partial R(\theta q)/\partial q < 0$. This implies that a risk-shifting bank has an incentive to choose a low quality portfolio, which generates high returns with low probability. Furthermore, $\theta q R(\theta q)$ is assumed to be increasing and concave, assuring the existence of a socially optimal (first-best) quality, $q^{FB}(\theta) \in [\underline{q}, \bar{q}]$, for the asset portfolio.[8]

III. OPTIMAL MECHANISMS UNDER MORAL HAZARD

When the bank operates under conditions of moral hazard, the game is as follows. At $t = 0$, the regulator offers a regulatory mechanism, μ_i, where $i \in \{L, H\}$, and the bank chooses the quality of its asset portfolio, q_i. Throughout this section, it is assumed that the bank's type, θ, is common knowledge, and hence the regulatory mechanisms under moral hazard can indeed depend on the bank's type.[9] The payoffs are realized at $t = 1$, and *ex post* settlement is carried out as specified in the regulatory mechanism. Because of borrower-specific noise, $\tilde{\epsilon}$, the bank's choice of asset quality, q_i, is unobservable to the regulator, even *ex post*, and hence cannot be contracted upon. This gives rise to a moral hazard problem, in the sense that the bank may have an

[8] This corresponds to Case 2 in Chan, Greenbaum, and Thakor (1992), p.236.

[9] The case of the bank's type being private information is analyzed in the next section.

incentive to choose portfolios *ex ante* that are lower in quality (higher-risk) than the socially optimal level.

In the model that follows, the *ex post* settlement is achieved through *ex post* adjustments to the deposit insurance premium, either as additional *ex post* assessments or as *ex post* rebates, depending on the realized state.[10] Formally, the regulator offers the mechanism $\mu_i = < p_{0i}, p_{ji}, E_i >$, where p_{0i} is the premium per dollar of deposits charged at $t = 0$ to a bank of type θ_i, E_i is its minimum capital requirement, and p_{ji}, is the per dollar *ex post* adjustment to the premium conditional on the occurrence of state $j \in \{1, 2, 3\}$. Note that such a mechanism potentially involves both *ex ante* and *ex post* pricing. Furthermore, the *ex post* prices are based on relative performance of the bank, in the sense that they depend on both the realized total return of the bank and the realized market return.

For a given market-contingent regulatory mechanism, $\mu_i = < p_{0i}, p_{ji}, E_i >$, the *ex ante* expected payoff $\pi^B[q_i|\theta_i]$ to a bank of type θ_i is given by:

$$\begin{aligned}
\pi^B[q_i|\theta_i] &= \alpha\left[\frac{\theta_i q_i q_m (R(\theta_i q_i) + \beta\bar{r}_m)}{(1+r)} + \frac{\theta_i q_i (1-q_m)(R(\theta_i q_i) + \beta\underline{r}_m)}{(1+r)} + \frac{(1-\theta_i q_i) q_m \beta\bar{r}_m}{(1+r)} - A\right] \\
&\quad + D_i(1-\theta_i q_i)(1-q_m) - p_{0i}D_i - \frac{D_i}{(1+r)}[\theta_i q_i q_m p_{1i} + \theta_i q_i (1-q_m) p_{2i} \\
&\quad + (1-\theta_i q_i) q_m p_{3i}] \\
&= \alpha\left[\frac{\theta_i q_i R(\theta_i q_i)}{(1+r)} + \frac{q_m \beta\bar{r}_m}{(1+r)} + \frac{\theta_i q_i (1-q_m)\beta\underline{r}_m}{(1+r)} - A\right] + D_i(1-q_m) - D_i\theta_i q_i(1-q_m) \\
&\quad - p_{0i}D_i - \frac{D_i}{(1+r)}[\theta_i q_i q_m p_{1i} + \theta_i q_i (1-q_m) p_{2i} + (1-\theta_i q_i) q_m p_{3i}]. \qquad (1)
\end{aligned}$$

Maximizing this objective function with respect to q_i, yields the first-order condition,

$$\begin{aligned}
&\frac{\alpha}{(1+r)}\frac{\partial[\theta_i q_i R(\theta_i q_i)]}{\partial q_i} + \alpha\frac{\theta_i(1-q_m)\beta\underline{r}_m}{(1+r)} - D_i\theta_i(1-q_m) \\
&\qquad - \frac{D_i\theta_i}{(1+r)}[q_m p_{1i} + (1-q_m)p_{2i} - q_m p_{3i}] = 0. \qquad (2)
\end{aligned}$$

[10] In Section VII, we discuss more general state-contingent instruments.

Moreover, fairly priced deposit insurance implies that

(3)

$$D_i p_{0i} + D_i \frac{[\theta_i q_i q_m p_{1i} + \theta_i q_i (1 - q_m) p_{2i} + (1 - \theta_i q_i) q_m p_{3i}]}{(1+r)} = [D_i - \beta \underline{r}_m](1 - \theta_i q_i)(1 - q_m).$$

Using equations (2) and (3), we can now show the existence of mechanisms that induce a bank of type θ_i to choose the first-best asset quality, q_i^{FB}. To this end, first define

(4) $$L_i(\theta_i, q_i, D_i) = \frac{\beta \underline{r}_m}{D_i}(1 - q_m)(1 - \theta_i q_i),$$

where $L_i(\theta_i, q_i, D_i)$ can be interpreted as the expected *recovery rate* of the assets in the bankruptcy state, expressed as a fraction of the total deposits. The optimal class of state-contingent mechanisms based on relative performance can now be characterized as follows:

PROPOSITION 1. *The optimal family of relative performance, state-contingent regulatory mechanisms* $\mu_i^* =< p_{0i}^*, p_{ji}^*, E_i^* >$ *implements the first-best quality level* q_i^{FB} *under moral hazard, and involves*

(i) an ex ante premium p_{0i}^*, *such that* $0 \leq p_{0i}^* \leq [1 - q_m - L_i(\theta_i, q_i^{FB}, D_i)]$,

(ii) a rebate in States 1 and 2, i.e.,

(5) $$p_{1i}^* = p_{2i}^* = -(1+r)[p_{0i}^* + L_i(\theta_i, q_i^{FB}, D_i)],$$

(iii) an additional assessment in State 3, i.e.,

(6) $$p_{3i}^* = \frac{(1+r)}{q_m}\left[1 - q_m - p_{0i}^* - L_i(\theta_i, q_i^{FB}, D_i)\right] \quad \text{and,}$$

(iv) a minimum capital requirement given by

(7) $$E_i^* \geq A - \frac{q_m \beta \bar{r}_m}{(1+r)} - \beta \underline{r}_m (1 - q_m)(1 - \theta_i q_i^{FB}),$$

PROOF: See the Appendix.

Proposition 1 identifies a family of optimal mechanisms that implements the first-best solution, indexed by the amount of deposit insurance premium collected *ex ante* as opposed to *ex post*. A particularly important attribute of these mechanisms is that they do not require a deposit insurance subsidy to achieve first-best. The multiplicity of solutions arises from the risk-neutrality of the bank and the regulator.[11] Two of these solutions, which are polar opposites, are of special interest:

Solution A: The regulator assesses all the insurance premium *ex ante*, i.e., $p_{0i}^* = [1 - q_m - L_i(\theta_i, q_i^{FB}, D_i)]$, and offers the following *ex post* settlements: $p_{1i}^* = p_{2i}^* = -(1 - q_m)(1 + r)$, and $p_{3i}^* = 0$. That is, all the premium is collected upfront, and rebates are offered in the first two states with no further charge or rebate in *State 3*. The minimum capital requirement, E_i^*, is not binding.

Solution B: No premium is collected *ex ante*, i.e., $p_{0i}^* = 0$. *Ex post*, $p_{1i}^* = p_{2i}^* = -(1+r)L_i(\theta_i, q_i^{FB}, D_i)$ and $p_{3i}^* = (1+r)[1 - q_m - L_i(\theta_i, q_i^{FB}, D_i)]/q_m$. That is, no premium is charged upfront, but rebates are offered in the first two states, and an *ex post* charge is assessed only if *State 3* occurs. The minimum capital requirement, E_i^*, is binding.

Other solutions involve different combinations of Solutions A and B, with part of the premium being charged *ex ante*, and some combination of rebates and additional assessments *ex post*. It is important to note, however, that the *ex post* assessment is charged in *State 3*, and in *States 1* and *2*, the *ex post* settlements are in the form of rebates. The minimum capital requirement is binding in all cases, except in Solution A.

It is important to note that the optimal market-contingent mechanisms μ_i^* do not

[11]If the bank's stockholders (or management) are risk-averse then the multiplicity of the solutions disappears, but first-best cannot be obtained.

imply that the bank is automatically punished if its total realized return is "low", and rewarded if the return is "high". To see this, observe that the total return in *State 2* may be less than the total return in *State 3* (i.e., $R(\theta_i q_i^{FB}) + \beta \underline{r}_m + \tilde{\epsilon} < \beta \bar{r}_m$), yet the bank may be rewarded in *State 2*, but punished in *State 3*. It is the relative performance of the bank that counts, not absolute performance.

IV. OPTIMAL MECHANISMS UNDER ADVERSE SELECTION

The game when the bank's type is private information (i.e., adverse selection) is as follows. At $t = 0$, the regulator offers a menu of regulatory mechanisms, μ_i, where $i \in \{L, H\}$, and the bank chooses a mechanism, possibly depending on its type. Because of borrower-specific noise, $\tilde{\epsilon}$, the bank's type, θ_i, is unobservable to the regulator, even *ex post*, and hence cannot be contracted upon. This gives rise to an adverse selection problem because a bank of low quality may have an incentive to feign high quality, while choosing from the menu of regulatory mechanisms. Throughout this section, the bank's choice of asset quality q_i is assumed to be given.

The analysis of the adverse selection problem is simplified considerably by the application of the Revelation Principle (Myerson 1979), which allows us to finesse the myriad possible extensive form games played by the bank and the regulator and, without loss of generality, focus only on direct revelation mechanisms where each bank truthfully reports its type to the regulator.

Given μ_i, for all $i, j \in \{L, H\}$, the expected profit to a bank of type θ_i that reports θ_j instead becomes,

$$\begin{aligned}\pi^B[\theta_j|\theta_i] \quad &= \quad \alpha\left[\frac{\theta_i q_i R(\theta_i q_i)}{(1+r)} + \frac{q_m \beta \bar{r}_m}{(1+r)} + \frac{\theta_i q_i (1-q_m)\beta \underline{r}_m}{(1+r)} - A\right] + D_j(1-q_m) \\ &\quad - D_j \theta_i q_i (1-q_m) - p_{0j} D_j - \frac{D_j}{(1+r)}[\theta_i q_i p_{1j} + (1-\theta_i q_i) q_m p_{3j}] \qquad (8)\end{aligned}$$

Incentive compatibility or truthful reporting implies that

$$\pi^B[\theta_i|\theta_i] \quad \geq \quad \pi^B[\theta_j|\theta_i] \qquad \forall i, j \in \{L, H\}. \qquad (9)$$

The following proposition characterizes the optimal mechanism in the presence of adverse selection.

PROPOSITION 2. *The optimal family of relative-performance, state-contingent mechanisms, μ_i^{**}, completely solves the adverse selection problem, and involves*

(i) an ex ante premium p_{0i}^{**}, such that $0 \leq p_{0i}^{**} \leq (1-q_m)[1-\beta \underline{r}_m / D_i]$,

(ii) a rebate in States 1 and 2, i.e.,

$$p_{1i}^{**} \quad = \quad p_{2i}^{**} = \quad -(1+r)p_{0i}^{**}, \tag{10}$$

(iii) an additional assessment in State 3, i.e.,

$$p_{3i}^{**} \quad = \quad \frac{(1+r)}{q_m}\left[1-q_m-p_{0i}^{**}-\frac{\beta \underline{r}_m}{D_i}(1-q_m)\right] \qquad \text{and,} \tag{11}$$

(iv) a minimum capital requirement given by

$$E_i^* \quad \geq \quad A - \frac{q_m \beta \bar{r}_m (1-p_{0i}^{**})}{(1+r)[1-p_{0i}^{**}-\frac{\beta \underline{r}_m}{D_i}(1-q_m)]}. \tag{12}$$

In particular, no subsidy is necessary.

PROOF: See the Appendix.

Intuitively, *ex post* pricing based on relative performance is superior to a menu of *ex ante* contracts, because deposit insurance is priced according to the bank's *ex post* performance relative to that of the market. Although the riskiness of the bank, θ_i, is unobservable (even *ex post*), the penalty-reward scheme of Proposition 2 is optimal given risk-neutrality of the bank. This results in complete revelation of the true type, since the full *ex post* settling up ensures that high risk banks have no incentive to pretend to be of low risk, thus satisfying incentive compatibility.

Note that the optimal relative performance pricing mechanisms under adverse selection have two properties that distinguish them from the screening mechanisms in standard adverse selection models. First, unlike most screening models, the *ex ante* screening variables $\{p_{oi}, E_i\}$ play no role in the optimal mechanisms here, and are indeterminate.[12] Second, neither the high type nor the low type gains any rents, unlike in standard models where the high type gets more rents than the low type. This, in turn, reduces the regulator's cost of achieving incentive compatibility. These properties attest to the power of *ex post* state-contingent pricing mechanisms, in contrast to standard *ex ante* mechanisms.

Propositions 1 and 2 imply that irrespective of whether the underlying incentive problem is caused by adverse selection or moral hazard, optimal, relative performance, state-contingent *ex post* pricing mechanisms exist, that not only are incentive compatible, but also achieve the first-best solution. Thus, both types of incentive problems can be solved completely. More importantly, this is achieved in both cases without any subsidy from the bank regulator — in contrast to the mechanisms in Chan, Greenbaum and Thakor (1992).

V. OPTIMAL MECHANISMS UNDER BOTH MORAL HAZARD AND ADVERSE SELECTION

The fact that the optimal solutions to both the moral hazard and the adverse selection problems involve state-contingent and relative-performance measures raises the interesting question of whether the *same* family of mechanisms can solve *both* types of problems simultaneously. It is straightforward to show that, in general, no mechanism exists that can solve *both* the moral hazard and the adverse selection problems simultaneously, a result that is consistent with existing literature. This leaves open the possibility that there may exist interesting special cases where the same mechanism can solve both types of problems. The following proposition characterizes the special case.

PROPOSITION 3. *Let the residual value of the bank in the bankruptcy state be zero, i.e.,* $\underline{r}_m = 0$. *Then, the same family of optimal market-contingent mechanisms solves*

[12] Of course, E_i should satisfy (12), but this constraint need not be binding.

both the moral hazard and adverse selection problems, and achieves first-best. Moreover, these mechanisms are independent of the type of bank and the first-best quality level, q_i^{FB}.

This result can be easily verified by setting $\underline{r}_m = 0$ in Proposition 1 and 2 and comparing the resulting mechanisms.

The intuition behind the above result is as follows. As long as the residual value of the bank in the bankruptcy state is positive, the optimal mechanisms that alleviate the moral hazard problem (as shown in Proposition 1) give too much rent to the low type in the case of adverse selection, requiring the regulator to subsidize the high type bank to ensure incentive compatibility. The reason why residual value is important is that fair-pricing requires a discount on the deposit insurance premium reflecting the expected residual value of the bank in the bankruptcy state. The latter, in turn, depends *inversely* on the type of the bank. Thus, in the absence of subsidies from the regulator, it is always strictly profitable for the low type to tell the truth, while it is not profitable for the high type to do so.

On the other hand, the optimal mechanisms of Proposition 2 solve the adverse selection problem and achieve incentive compatibility by making the *ex post* settlements reflect only the market risk. This ensures that neither the high type nor the low type has an incentive to lie, and hence both report the truth. However, such a mechanism does not quite induce the bank to choose first-best asset quality, because the latter requires that the choice depend on the undiscounted premium value. In short, what is good for the moral hazard problem is not good for the adverse selection problem, and vice versa, except when the residual value of the bank's assets is zero in the bankruptcy state. In this special case, the undiscounted and discounted premiums coincide, and the optimal moral hazard mechanism becomes completely independent of the bank's type, thus achieving incentive compatibility under adverse selection as well.

VI. DISCUSSION OF THE RESULTS

Propositions 1 and 2 can be understood as follows. Moral hazard and adverse selection arise because bank's asset quality cannot be uniquely inferred from realized returns. A state-contingent regulatory policy based on absolute performance does not distinguish between risks that are within the control of the bank and those that are beyond its control. On the other hand, when state-contingent policies are based on relative performance, the regulator can more accurately infer the *ex ante* quality of the assets chosen by the bank. By rewarding the bank in states where its performance is most likely due to good asset quality, and/or penalizing the bank in states where a marginal performance is most likely aided by a good performance across the market, the regulator can induce the bank to take better risks, *ex ante*. The *ex post* assessments and/or rebates serve the punishment and reward functions. Since the ability of the regulator to penalize the bank in marginal states is limited by the fact that the bank may declare bankruptcy, the regulator must either collect the premiums upfront, and/or set the threshold for bankruptcy by requiring a minimum level of capital from the bank's shareholders. Note that the above results hold for all α, irrespective of whether the bank makes positive expected profits.

Our result that it is possible to price deposit insurance fairly (i.e., *sans* subsidies) and still achieve incentive compatibility is in contrast to the impossibility result in Chan, Greenbaum, and Thakor (1992). This arises from the fact that *ex post* pricing in our mechanisms are made contingent on both the bank's and the market's returns, whereas their's is contingent only on the bank's total returns. Our rebates in *State 1* and *State 2* serve the same purpose as the bank's second period profits and subsidies in their model. The crucial difference is *State 3*, which can be distinguished from *States 1 & 2* owing to our conditioning on the market return. The bank can be penalized in this state because its moderate performance is most likely aided by good market conditions. In contrast, since the state-space partitions in Chan, Greenbaum and Thakor (1992) are generated only by the absolute return of the bank, their *State 3* would be indistinguishable from *States 1 & 2*. Since the bank cannot be simultaneously penalized and rewarded in the same state, subsidies must be offered to restore first-best in their model.[13] The same reasoning explains why first-best is not achieved in John, John and Senbet's (1991) model either.

Furthermore, in contrast to Chan, Greenbaum and Thakor (1992), our mechanisms meet the participation constraint with fair pricing even in a competitive banking environment, i.e., where $\alpha = 0$. In their model, the bank chooses the first-best quality in the first period in order to maximize the likelihood of realizing profits and/or subsidies in the second period. If $\alpha = 0$, the profits disappear, and the only incentive to choose first-best is the possibility of receiving a regulatory subsidy. In our model, we offer direct rebates for good behavior in *States 1 & 2*, which serve the same purpose as the second period subsidies in their model with perfect competition. Because of our more refined information structure, however, we can restore fair pricing and reinforce the first-best quality by penalizing the bank in *State 3*. Thus, our incentive compatible mechanism is independent of the degree of competition in the loan market.

VII. POLICY IMPLICATIONS

The optimal relative performance mechanisms derived here have a number of implications for bank regulatory policy. From a practical viewpoint, our mechanisms show that an incentive compatible deposit insurance system with fair premiums is indeed possible. The key element in our mechanism is the regulator's ability to adjust assessments/rebates *ex post* on the basis of relative performance. In fact, *ex post* adjustments in premiums are implicit in the newly implemented risk-adjusted insurance system under the FDIC Improvement Act of 1991.[14] Under the new system, a bank's insurance premium is based on the regulator's updated assessment of risk every period. Although,

[13]In fact, we can replicate the main result of Chan, Greenbaum and Thakor (1992), by modifying the L.H.S. of our eq. (3) to include a subsidy, δ. To induce the bank to participate, the *ex ante* premium p_{oi} must be set equal to the probability of failure, $(1-\theta_i q_i)(1-q_m)$. Since penalties are infeasible, $p_{3i} = 0$ in (4), and solving (4) and (5) gives the optimal subsidy, $\delta^* = \theta_i q_i (1-q_m) > 0$.

[14]Other examples include the Canadian Deposit Insurance Corporation, which is currently contemplating a policy to assess *ex post* penalties on banks for "excess" risk.

over time, this may approximate *ex post* pricing, our results suggest that since these prices are not based on relative performance, and since there is no provision for rebates, the system in its present form is unlikely to yield incentive compatibility.[15] By making these prices market-contingent, and adding appropriate rebates, however, this system could be reconfigured to yield incentive compatibility.

Aside from premium adjustments, FDICIA also mandates several noncash *ex post* sanctions against troubled banks, although it does not specify explicit rewards for good performance. The sanctions include replacing bank management, altering the managerial compensation structure, suspension of dividends, stricter capital standards, prompt or early closure, and close monitoring of loan portfolios. There are several reasons why these policy instruments, *per se*, cannot be used to achieve incentive compatibility in the presence of fair pricing. First, while they may be imposed to punish bank management/stockholders for bad behavior, they do not directly benefit the regulator, and as such, cannot be used to achieve fair pricing. Second, as mentioned above, the lack of direct rebates or subsidies in some states makes it difficult to reward the bank for good behavior. Third, these sanctions are not required to be market-contingent; hence, per our results, they can not achieve first-best. On a more general level, *ex post* instruments of regulatory control, irrespective of the form they take, must be based on relative performance if they are to be effective. Rewarding and penalizing banks for performance that is beyond their control will not encourage better quality, at least not in a fair pricing environment.

VIII. CONCLUSION

The results in this paper reconfirm an emerging view in the literature that bank regulatory mechanisms which rely on unconditional instruments are not incentive compatible. We have shown that more informationally efficient mechanisms are possible

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[15]Historically, in fact, rebates of deposit insurance premium were not uncommon. These rebates, however, were based on the aggregate performance of the insurance fund, and not on either the relative or even the absolute performance of individual banks.

if the regulator decomposes bank asset risk into market and unique components, and implements *ex post* pricing that is contingent on the state of the market. Our main result is that a wide range of simple mechanisms involving only a minimum capital requirement and market-contingent deposit insurance pricing is, in general, sufficient to induce banks to choose the first-best asset quality, and reveal their true risk profile. More importantly, such mechanisms do not require a subsidy to the bank.

APPENDIX

Proof of Proposition 1. Set $p_{1i}^* = p_{2i}^*$ without loss of generality. Then the first best solution can be restored in (2) by setting

$$\text{(A1)} \qquad q_m p_{3i} - p_{1i} \quad = \quad (1 - q_m)(1 + r).$$

Fair-pricing implies

$$\text{(A2)} \qquad p_{0i} + \frac{(1 - \theta_i q_i^{FB}) q_m p_{3i} + p_{1i} \theta_i q_i^{FB}}{(1 + r)} \quad = \quad \left[1 - \frac{\beta \underline{r}_m}{D_i}\right](1 - q_m)(1 - \theta_i q_i^{FB}).$$

For a given p_{0i}^*, solving equations (A1) and (A2) and using (2), yields the following rebates in the first two states: i.e., $p_{1i}^* = p_{2i}^* = -(1 + r)[p_{0i}^* + L_i(\theta_i, q_i^{FB}, D_i)]$, and the additional assessment in the third state,

$$p_{3i}^* \quad = \quad \frac{(1 + r)}{q_m}\left[1 - q_m - p_{0i}^* - L_i(\theta_i, q_i^{FB}, D_i)\right].$$

Finally, limited liability in the third state implies that

$$\text{(A3)} \qquad \frac{\beta \bar{r}_m}{(1 + r)} - D_i - D_i \frac{p_{3i}^*}{(1 + r)} \quad \geq \quad 0.$$

Substituting p_{3i}^* in (A3), together with $(1 - p_{0i})D_i + E_i = A$, gives the minimum capital requirement (7). ▮

Proof of Proposition 2.

$$\begin{aligned}
\pi^B[\theta_j|\theta_i] \quad &= \quad \alpha\left[\frac{\theta_i q_i R(\theta i q_i) + q_m \beta \bar{r}_m + \theta_i q_i (1 - q_m)\beta \underline{r}_m}{(1 + r)} - A\right] + D_j(1 - q_m) \\
&\quad - D_j \theta_i q_i (1 - q_m) - p_{oj} D_j - \frac{D_j}{(1 + r)}[\theta_i q_i p_{1j} + (1 - \theta_i q_i) q_m p_{3j}] \\
&= \quad \pi^B[\theta_i|\theta_i] + D_j(1 - q_m) - D_i(1 - q_m) - D_j \theta_i q_i (1 - q_m) + D_i \theta_i q_i (1 - q_m) \\
&\quad - p_{oj} D_j + p_{oi} D_i - \frac{D_j}{(1 + r)}[\theta_i q_i p_{1j} + (1 - \theta_i q_i) q_m p_{3j}] \\
&\quad + \frac{D_i}{(1 + r)}[\theta_i q_i p_{1i} + (1 - \theta_i q_i) q_m p_{3i}].
\end{aligned}$$

Fair-pricing implies,

$$p_{oi}D_i + \frac{D_i}{(1+r)}\left[\theta_i q_i p_{1i} + (1-\theta_i q_i)q_m p_{3i}\right] = \left[D_i - \beta \underline{r}_m\right](1-\theta_i q_i)(1-q_m).$$

Therefore,

$$\begin{aligned}
\pi^B[\theta_j|\theta_i] &= \pi^B[\theta_i|\theta_i] - \beta \underline{r}_m(1-\theta_i q_i)(1-q_m) + D_j(1-\theta_i q_i)(1-q_m) \\
&\quad - p_{oj}D_j - \frac{D_j}{(1+r)}\left[\theta_i q_i p_{1j} + (1-\theta_i q_i)q_m p_{3j}\right] \\
&= \pi^B[\theta_i|\theta_i] - \beta \underline{r}_m(\theta_j q_j - \theta_i q_i)(1-q_m) \\
&\quad + D_j(\theta_j q_j - \theta_i q_i)\left[(1-q_m) + \frac{p_{1j} - q_m p_{3j}}{(1+r)}\right]. \qquad \text{(A4)}
\end{aligned}$$

Incentive compatibility is achieved in (A4) by setting,

$$\begin{aligned}
\left[(1-q_m) + \frac{p_{1j} - q_m p_{3j}}{(1+r)}\right] &= \left[1 - \frac{\beta \underline{r}_m}{D_j}\right](1-q_m), \text{ or} \\
p_{1j} &= q_m p_{3j} - \left[1 - \frac{\beta \underline{r}_m}{D_j}\right](1-q_m)(1+r).
\end{aligned}$$

Plugging this into the fair-pricing equation above and rearranging yields,

$$\begin{aligned}
p_{3j} &= \frac{(1+r)}{q_m}\left[1 - q_m - p_{0j} - \frac{\beta \underline{r}_m}{D_j}(1-q_m)\right], \text{ and} \\
p_{1j} &= -p_{0j}(1+r).
\end{aligned}$$

The capital constraint is obtained as in the proof of Proposition 1. ∎

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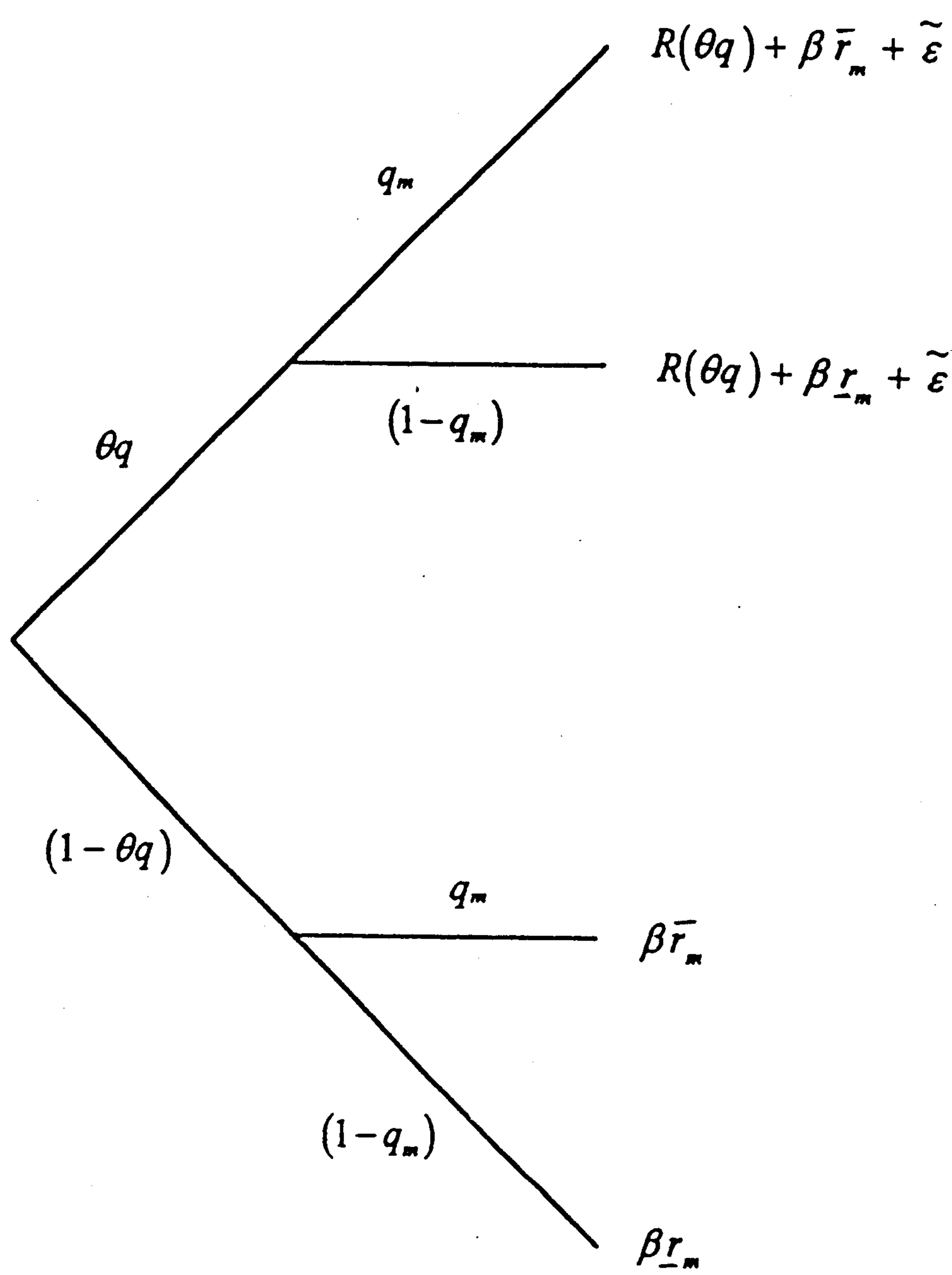
$R(\theta q)+\beta\bar{r}_m+\tilde{\varepsilon}$
q_m
$R(\theta q)+\beta\underline{r}_m+\tilde{\varepsilon}$
$(1-q_m)$
θq
$(1-\theta q)$
q_m
$\beta\bar{r}_m$
$(1-q_m)$
$\beta\underline{r}_m$

Figure 1