ALTERNATIVE REGULATORY MECHANISMS IN AN INSURANCE INDUSTRY WITH A GUARANTY FUND

J. Gandar* and C.W. Sealey†

*Professor of Economics, University of North Carolina at Charlotte

†The Torrence E. Hemby, Sr., Distinguished Professor in Banking, University of North Carolina at Charlotte

ALTERNATIVE REGULATORY MECHANISMS IN AN INSURANCE INDUSTRY WITH A GUARANTY FUND

Abstract

Third-party guarantees of the liabilities of financial institutions, such as guaranty funds in the insurance industry, are a potential source of adverse incentives. Empirical evidence supports the risk-taking hypothesis in both property-liability insurance and commercial banking. Solutions to these incentive problems are much less understood. The purpose of this research is to develop a model of the guaranty fund-insurance company relationship under conditions of moral hazard, and to examine the nature of adverse incentives in this setting. The results show that a set of workable mechanisms exists.

1 Introduction

It is widely conjectured that governmentally sanctioned, third-party guarantees of the liabilities of financial institutions are a potential source of moral hazard, resulting in suboptimal behavior towards risk. State guaranty funds in the insurance industry and federal deposit insurance in banking are examples of such guarantees. Empirical evidence supports the conjecture, finding that risk-taking is greater in the presence of guarantees in both property-liability insurance[1] and commercial banking[2]. Solutions to the moral hazard problem, and the resulting adverse incentives, are much less understood. To date, policy proposals have been directed almost exclusively to the banking

[1] See, e.g., Lee, Mayers and Smith (1997) and Downs and Sommers(1999).

[2] The unprecedented deposit insurance losses during the 1980s and early 1990s were the result of numerous factors. Excessive risk-taking by banks resulting from moral hazard is thought to be prominent among those factors. A comprehensive discussion of this issue can be found in Benston, et al. (1987), among others.

industry. Since both the business of insurance and its system of third-party guarantees are considerably different from its banking counterpart, the solution to the moral hazard problem may also differ considerably.

The purpose of this research is to develop a game-theoretic model, under conditions of moral hazard, of the insurance industry and its relationship to regulators, the guaranty fund, and policyholders. The nature of adverse incentives will be examined in this setting. The results show the existence of a set of workable mechanisms that address the moral hazard problem in insurance. Moreover, the results should provide the basis for policy proposals that benefit the insurance industry and those it insures.

The wide range of tools employed to regulate insurance can, for convenience, be classified into two broad groups: (1) those that rely on regulatory controls and supervision, and (2) those that rely on market discipline. Starting with the former, even though historically regulation in insurance has relied heavily on the discretion of regulators, in recent years regulatory discretion has acquired a bad reputation among certain experts, and favor has gravitated towards greater reliance on rule-based regulation.[3]

In terms of market-based solutions to the problem of adverse incentives, there are two ways that such solutions can be formulated. First, there are market solutions that involve the monitoring of risk by at least some principles, usually private-sector claimholders such as large policyholders or reinsurers. Monitoring requires the production of information concerning the institution's risk; and then undertaking feasible actions based on the acquired information. Possible actions might include adjustments in pricing to ensure proper compensation for risk.

There are a number of problems with the monitoring approach. First, since the risk taken by an insurance company is private information, and claimholders do not have inherent knowledge of this risk, monitoring can be successful only if sufficient incentives are present to induce claimholders to collect costly information concerning risk and exert market discipline on

[3]A number of analysts, academics, and regulators believe that the regulatory system has been ineffective in exercising discretion, because of political pressures, self interest, reputation, or other factors. As evidence of this failure, they cite the deposit insurance losses of a decade ago as a case where regulators did not effectively carry out their regulatory responsibilities. Congress seems to have agreed, at least to some extent, since the FDIC Improvement Act of 1991 greatly reduced the discretion that regulators had in assessing the financial condition of banks.

insurers. In other words, market discipline via monitoring can only work effectively if private-sector claimholders have proper incentives to produce information and the means to exert discipline. Information production and monitoring is costly and subject to error, and frequently there remain ways to game the system. Moreover, because of the costs involved, there may be strong incentives to free-ride. Second, recent theoretical studies in the banking literature suggest that market pricing alone is neither necessary nor sufficient, per se, to solve incentive problems.[4] Finally, and perhaps most importantly, empirical studies have found virtually no statistically significant evidence that market pricing is effective in solving the risk-shifting problem. Although studies to date deal almost exclusively with the banking industry, by implication it is doubtful that market pricing would be more effective in the insurance industry.

An alternative approach, that may or may not be market based, relies on contracting involving option-type payoffs based on ex post outcomes.[5] An advantage of this approach is that it may not require costly information production and monitoring, and incorporates ex post settlement, which is already known to be all but essential if the adverse incentives problem is to be solved. In fact, of the mechanisms that might mitigate or eliminate the problem of adverse incentives, the common element is that they all involve some type of ex post (state-contingent) contracting in order to achieve incentive compatibility. In particular, if the regulator imposes an appropriate set of ex post settlements, in the form of assessments or rebates that are triggered by ex post outcomes, then the potential returns from ex ante risk shifting must be weighed by the firm against any ex post cost associated with such behavior. Under certain conditions, firms choose lower risk ex ante than would otherwise be the case. A drawback of such schemes is that

[4]For example, John, John, and Senbet (1991) and Nagarajan and Sealey (1995) argue that moral hazard problems cannot be mitigated by risk-adjusted deposit insurance premiums or prompt (or even early) closure of insolvent banks, respectively. In fact, Chan, Greenbaum, and Thakor (1992) argue that fairly priced deposit insurance, where premiums are paid ex ante, may actually be *inconsistent* with incentive compatibility, and that deposit insurance subsidies may be required, ex post, to achieve incentive compatibility. Related literature on deposit insurance also includes Campbell, Chan and Marino (1992), and Giammarino, Lewis and Sappington (1993).

[5]Although ex post settlement seems to be necessary to solve the adverse incentive problem, the ex post settlement involved in most insurance guaranty fund assessments is not a mechanism that is incentive compatible.

optimal risk-taking behavior still may not be achieved, since limited liability caps the amount of penalties that can be assessed. Nevertheless, there are mechanisms of this general type that can achieve an optimal, or at least an improved, level of risk.

As noted above, in this research, a game-theoretic model of the insurance company, and its interaction with policyholders and the guaranty fund is developed under conditions of moral hazard. The results can be classified into three general categories:

1. As a benchmark, we develop a model of insurer-policyholder interaction with full information, no regulation, and no third-part guarantees. The insurer's optimal risk level, where the insurer acts in the interest of equity holders, is determined in this unregulated environment, and then comparisons are made with the socially optimal level of risk.

2. Next, we introduce a guaranty fund and examine the risk levels chosen by the insurer when the insurer's asset and underwriting quality are private information and cannot be freely observed. Insurers are free to take advantage of their private information.

3. Finally, we examine alternative mechanisms involving option-type claims that may mitigate the moral hazard problem, and yield more optimal risk-taking decisions. We show that such solutions exist, and improve the overall allocation of risk in the economy.

2 The Model

2.1 The Setup for the Insurer

Consider a simple one-period, two-date model of a property-liability insurance company, referred to here as the insurer. At $t = 0$, the representative insurer obtains paid-in equity capital, E, and underwrites liability insurance from which it collects premiums. Equity is assumed to be restricted to an α percent of premiums collected. For simplicity, it is assumed that the insurer invests all available funds, equity plus premiums, in risky assets, A. The underwriting activities generate liabilities to the insurer which may, but need not, be constrained by capital requirements or other restrictions set by a regulator. The insurer's managers are assumed to make decisions in the interest of shareholders, all parties in the model are risk neutral, and, for simplicity, the gross, risk-free rate of return is set equal to one.

At $t = 0$, the insurer faces a continuum of asset and underwriting options that differ only in terms of quality. Let $q_A \in (0, 1)$ denote the quality of the insurer's asset portfolio and let $q_L \in (0, 1)$ denote the quality of its underwriting liabilities. The insurer's choice variables are q_A and q_L, which are chosen ex ante by management. The return on the insurer's asset portfolio (principle plus return) and any losses from underwriting activities are realized at $t = 1$, and depends, in the first instance, on the quality decisions q_A and q_L.

Outcomes for both asset returns and underwriting losses are both assumed to be binomial. The return on assets will be favorable (relatively high) with probability q_A, or unfavorable (low) with probability $(1 - q_A)$. Thus, higher levels of q_A indicate higher asset quality. If the outcome is favorable, the insurer's total return on assets is denoted by $R(q_A)A + \widetilde{\epsilon}_A$, where $R(q_A)$ is the per dollar gross return on assets, $\widetilde{\epsilon}_A$ is unique, asset-specific noise, and $E(\widetilde{\epsilon}_A) = 0$. If the outcome is unfavorable, the total payoff on the asset portfolio is a lump sum, denoted by R_2. The payoff on assets in the favorable state is, of course, greater than the payoff in the unfavorable state, i.e., $E_{\widetilde{\epsilon}_A}[R(q_A)]A > R_2 \ \forall \ q_A \in (0,\ 1)$, where $E_{\widetilde{\epsilon}_A}$ is the expectations operator with respect to the random variable $\widetilde{\epsilon}_A$.

For underwriting losses, on the other hand, if the outcome is unfavorable, losses are relatively large. The probability of the unfavorable state is q_L. If the outcome on losses is favorable, losses are low, with probability $(1 - q_L)$. Higher levels of q_L indicate lower underwriting quality. An unfavorable outcome incurs an underwriting loss denoted by $L(q_L) + \widetilde{\epsilon}_L$, where $\widetilde{\epsilon}_L$ is unique, underwriting-specific noise, and $E(\widetilde{\epsilon}_L) = 0$. Let L_2 denote the underwriting loss in the favorable state . Underwriting losses in the favorable state are always expected to be less that losses in the unfavorable state, i.e., $L_2 < L(q_L) + E_{\widetilde{\epsilon}_L} \ \forall \ q_L \in (0,\ 1)$, where $E_{\widetilde{\epsilon}_L}$ is the expectations operator with respect to the random variable $\widetilde{\epsilon}_L$.. Moreover, losses in the favorable state are assumed to be sufficiently small not to bankrupt the insurer, irrespective of asset returns, i.e., $L_2 \leq R_2$, $\forall \ q_L \in (0,\ 1)$, Asset returns and underwriting losses are assumed to be uncorrelated.

The asset return function, $R(q_A)$, is such that $R'(q_A) < 0$, while $q_A R(q_A)$ is increasing and concave in q_A. From the description of returns and losses above, it follows that a higher asset quality level, i.e., a higher q_A, increases the likelihood of a favorable return, while at the same time decreasing the magnitude of the return in the favorable state. On the other hand, the loss function, $L(q_L)$, is assumed to be such that $L'(q_L) < 0$ [6], while $q_L L(q_L)$ is increasing and convex in q_L. Lower underwriting quality results in increased expected losses in the unfavorable loss state, and at an increasing rate.

The insurer's choice of q_A and q_L are private information, and cannot be observed, even ex post. The presence of noise in asset returns and underwriting losses, $\widetilde{\epsilon}_A$ and $\widetilde{\epsilon}_L$, ensures that neither q_A nor q_L can be inferred from the ex post realization of returns (hereafter, for notational simplicity, the expectations over the noise terms are ignored). This gives rise to a moral hazard problem in that the insurer may have an incentive to choose a level of asset and underwriting risk that may be suboptimal from a social or regulatory point of view. In the process, the insurer may attempt to take advantage of the holders of its fixed claims, such as policyholders, the guaranty fund, or a reinsurer.[7]

Specifically, an insurer interested in shifting risk to holders for fixed claims may choose lower quality assets than it would do otherwise, but in doing so may achieve a higher return on equity if success occurs. Or, the insurer can choose a lower quality of underwriting risk with a higher probability of experiencing a larger loss, where the loss is expected to be paid, at least in part, by the holders of fixed claims if bankruptcy occurs. Nevertheless, it may be possible for the insurer's quality decisions, q_A and q_L, to be controlled through either monitoring or other means as discussed in following sections.

2.2 The Insurer's Game Tree

Given the binomial outcomes of asset returns and underwriting losses, there are four possible, mutually exclusive, states that may be realized at $t = 1$. The total random dollar (gross) return for the insurer, at $t = 1$, is one of the following:

---

[6] In addition, it seems reasonable to assume that $L''(q_L) > 0$, i.e., as underwriting quality decreases, losses increase at a decreasing rate.

[7] For expositional ease, the insurer is assumed to capture all the surplus return from investments and underwriting returns. The results continue to hold as long as a positive share of the profits is captured (see Chan, Greenbaum, and Thakor 1992).

State 1: The return on the insurer's investment in assets and underwriting losses are both favorable. The insurer's dollar payoff net of underwriting losses is $[(R(q_A) + \widetilde{\epsilon}_A)A] - L_2$, which occurs with probability $q_A(1 - q_L)$. In this state, $E_{\widetilde{\epsilon}_A}[(R(q_A) + \widetilde{\epsilon}_A)A] > L_2$. The insurer is expected to be solvent.

State 2: The outcome of the asset investment is favorable but the underwriting loss is unfavorable. The insurer's payoff is $[(R(q_A)+\widetilde{\epsilon}_A)A]-[L(q_L)+\widetilde{\epsilon}_L]$, which occurs with probability $q_A q_L$. In this state, $E_{\widetilde{\epsilon}_A}[R(q_A)A + \widetilde{\epsilon}_A] > E_{\widetilde{\epsilon}_L}[L(q_L) + \widetilde{\epsilon}_L]$. The insurer is expected to be solvent.

State 3: The return on assets is unfavorable but the underwriting loss is favorable. The net payoff to the insurer is $R_2 - L_2$, which occurs with probability $(1 - q_A)(1 - q_L)$. In this state, $R_2 > L_2$ and the insurer remains solvent.

State 4: Investment returns and underwriting losses are both unfavorable. The payoff to the insurer is $R_2 - E_{\widetilde{\epsilon}_L}[L(q_L) + \widetilde{\epsilon}_L]$, with probability$(1 - q_A)q_L$. In this state, $R_2 < E_{\widetilde{\epsilon}_L}[L(q_L) + \widetilde{\epsilon}_L]$ and the insurer is insolvent. In this state, the insurer's assets are divided among various claimants according to pre-specified priority rules, which are assumed for the time being to be pro-rated based on premiums paid by policyholders. Losses to policyholders may be paid by a guaranty fund or reinsurer where in existence. Equityholders receive nothing.

2.3 Underwriting Premiums

Premiums are collected at $t = 0$ and are assumed to be a function of both asset and underwriting quality. The insurer's available funds for investments in assets is the sum of premiums collected and paid-in equity capital. Let $P(q_A, q_L)$ denote premiums collected by the insurer. Since premiums collected are themselves a function of quality, the process of determining asset and underwriting quality also determines the size of the asset portfolio, where $A \equiv P(q_A, q_L)(1 + \alpha)$.

Given the assumption of risk neutrality, the maximum premium that an insurer can charge is the present value of the expected recoverable losses by policyholders. In turn, expected recoverable losses are the policyholders total expected losses less that part of losses that are unrecoverable in the event that the insurer is insolvent at $t = 1$, as is the case in *State* 4. For the assumed discount factor of one, and in the absence of a guaranty fund or reinsurer, premiums can be expressed as follows:

$$\begin{aligned} P(q_A,\ q_L) &= [(1-q_L)L_2 + q_L L(q_L)] \\ &\quad -[q_L(1-q_A)(L(q_L)-R_2)], \end{aligned} \tag{1}$$

where the first term in brackets on the rhs is the total expected losses of policyholders, and the second term in brackets is the expected unrecoverable losses by policyholders as a result of insurer insolvency. Other things equal, the greater the expected unrecoverable losses, the smaller the premiums that policyholders are willing to pay. On the other hand, the greater policyholders' expected total losses, the greater is the premium they are willing to pay.

As equation (1) suggests, since asset quality impacts only expected unrecoverable losses to policyholders, it is easy to show that $\frac{\partial P(q_A,\ q_L)}{\partial q_A} > 0$ and $\frac{\partial^2 P(q_A,\ q_L)}{\partial q_A^2} = 0$. The premiums collected by the insurer are increasing in asset quality, since expected unrecoverable losses are declining, but at a linear rate.

The first and second derivatives of (1) with respect to q_L are as follows: $\frac{\partial P(q_A,\ q_L)}{\partial q_L} = q_A \left(\frac{\partial q_L L(q_L)}{\partial q_L} \right) - L_2 + (1-q_A)R_2 \lesseqgtr 0$ and $\frac{\partial^2 P(q_A,\ q_L)}{\partial q_L^2} = q_A \left(\frac{\partial^2 q_L L(q_L)}{\partial q_L^2} \right) > 0$. Thus, the function for underwriting premiums is convex in q_L.

The change in premiums with respect to underwriting quality is complicated by the fact that a change in q_L impacts both expected total losses and expected unrecoverable losses. Moreover, these two effects may move in opposite directions. For example, a decrease in underwriting quality represents an increase in total expected losses of the insurer's policies, which in turn is accompanied by an increase in premiums. At the same time, expected unrecoverable losses also increase, which reduces premiums. Thus, the overall impact of a change in q_L depends, in part, on the relative strength of these two conflicting effects.

3 Optimal Quality Decisions When Quality is Observable

In this section, we examine two benchmark cases where the quality decisions of the insurer are observable. In this case, constraints on insurer behavior, such as regulatory constraints, are assumed to be absent, and in any case, are unnecessary. First, it is of interest to determine the socially optimal, first-best quality for the insurer's assets and underwriting liabilities, q_A and q_L, where these decisions are made to maximize social surplus. Such a socially optimal allocation is useful for the purpose of comparing the benefits of regulatory mechanisms that are considered later in the paper. Second, it is of interest to determine the insurer's optimal selection of quality when the insurer acts to maximize the value of equity.

3.1 The Social Planner's Problem

Turning first to the socially optimal quality, the social planner seeks to maximize expected social surplus.[8] Expected social surplus, denoted by, $\pi^{SP}(q_A,\ q_L)$, is given by

$$\begin{aligned} \pi^{SP}(q_A,\ q_L) &= q_A q_L[R(q_A)A - L(q_L)] \\ &\quad + q_A(1-q_L)[R(q_A)A - L_2] \\ &\quad + (1-q_A)(1-q_L)[R_2 - L_2] \\ &\quad + (1-q_A)q_L[R_2 - L(q_L)]. \end{aligned} \tag{2}$$

The social planner's problem is to choose q_A and q_L to maximize (2).

The social planner's optimal choices of quality, denoted by q_A^{FB} and q_L^{FB},

[8] Here, we assume that the social planner considers social surplus to be composed only of the expected monetary returns to all insurer claimholders. In the case of insurance companies, one might argue that society in general benefits from high-quality decisions by insurers through the positive externalities of financial system stability. Although difficult to quantify, if such externalities were included, the social surplus generated by high quality would increase and the first-best quality chosen by the social planner would be higher than implied by the first-order conditions in equations (3) and (4).

are given by the first-order conditions, which after rearranging, are

$$\frac{\partial q_A^{FB} R(q_A^{FB})}{\partial q_A^{FB}} = \frac{R_2 - q_A^{FB}(1+\alpha)R(q_A^{FB})P'_{q_A}(q_A^{FB},\ q_L)}{P(q_A^{FB},\ q_L)(1+\alpha)}, \tag{3}$$

and

$$\frac{\partial q_L^{FB} L(q_L^{FB})}{\partial q_L^{FB}} = L_2 + q_A(1+\alpha)R(q_A)P'_{q_L}(q_A,\ q_L^{FB}). \tag{4}$$

It can be shown that the second-order conditions are sufficient to yield a maximum for the social planner's problem.

3.2 Equityholder's Problem

Now, consider the optimal quality decisions in the presence of limited liability, where the insurer makes decisions to maximize the value of equity. Let $\pi^E(q_A,\ q_L)$ denote the value of equity. The insurer, seeking to maximize the value of equity, maximizes the following:

$$\begin{aligned} \pi^E(q_A,\ q_L) &= q_A q_L[R(q_A)A - L(q_L)] \\ &\quad + q_A(1-q_L)[R(q_A)A - L_2] \\ &\quad + q_L(1-q_A)[R_2 - L(q_L)]. \end{aligned} \tag{5}$$

The insurer's choice of quality, referred to here as the second-best quality decisions, q_A^{SB} and q_L^{SB}, are given by the first-order conditions:

$$\frac{\partial q_A^{SB} R(q_A^{SB})}{\partial q_A^{SB}} = \frac{(1-q_L)R_2 - q_L L(q_L) - q_A^{SB}(1+\alpha)R(q_A^{SB})P'_{q_L}(q_A^{SB},\ q_L)}{(1+\alpha)P(q_A^{SB},\ q_L)}, \tag{6}$$

and

$$\frac{\partial q_L^{SB} L(q_L^{SB})}{\partial q_L^{SB}} = \frac{L_2 - (1-q_A)R_2 + q_A(1+\alpha)R(q_A)P'_{q_L}(q_A,\ q_L^{SB})}{q_A}. \tag{7}$$

3.3 Optimum Quality Comparisons for the Social Planner and Equityholders

First, consider the optimal asset quality decision of the social planner, q_A^{FB}, compared to that of the insurer, q_A^{SB}. A necessary and sufficient condition for $q_A^{FB} > q_A^{SB}$ is that the rhs of (3) is less than the rhs of (6), when evaluated at the first-best solution. Simplifying, this in turn requires that

$$\frac{(1-q_L)(R_2 - L(q_L))}{(1+\alpha)P(q_A^{SB},\ q_L)} < 0, \tag{8}$$

which is clearly the case since $R_2 < L(q_L)$. Thus, it follows that $q_A^{FB} > q_A^{SB}$. In words, equityholders choose lower asset quality than the social planner, even under full information where quality is observable.

Turning now to differences in optimal underwriting quality, a comparison of (4) and (7)shows that, to determine the relative values of q_L^{FB} and q_L^{SB}, requires that the direction of the following inequality be determined:

$$R_2 \lesseqgtr L_2 + q_A(1+\alpha)R(q_A)P'_{q_L}(q_A,\ q_L^{FB}). \tag{9}$$

Unfortunately, the direction of the above inequality in ambigous, which leads to the following result:

Proposition 1 *When the quality decisions of the insurer are observable, then* $q_A^{FB} > q_A^{SB}$ *and* $q_L^{FB} \lesseqgtr q_L^{SB}$.

In words, the second-best choice for asset quality chosen by the insurer, in the absence of moral hazard, is unambiguously lower than the social optimum. This result reflects the usual impact of moral hazard on decision making. On the other hand, underwriting quality may be either higher or lower than the social optimum. The reason for the latter result is that a change in underwriting quality may have a positive or negative impact on premiums. The impact on premiums is twofold. On the one hand, lower underwriting quality increases expected losses in the insolvency state, which will be absorbed at least in part by policyholders; thus, increasing unrecoverable losses to policyholders in the event of insolvency, decreasing premiums.

On the other hand, lower underwriting quality increases expected losses, increasing premiums. The relative importance of these effects will determine if the insurer has an incentive to choose lower or higher underwriting quality. It is important to note, however, that even though the insurer prefers lower quality assets, and may choose lower quality underwriting as well, there is no shifting of risk under this full information scenario, since the insurer is fully charged for the additional risk taken through the premiums that policyholders are willing to pay.

4 The Guaranty Fund and Insurer Incentives

In the model considered in the previous section, insurer quality is freely observable. In the case where quality is private information, the problem of moral hazard may arise. In the case of moral hazard, the insurer would likely find it to be in the best interest of shareholders to shift risk to policyholders, who in turn would be unaware of the additional cost. This in turn has resulted in compulsory third party guarantees, required by state insurance regulators in the form of a guaranty fund. There are at least two possible approaches to modeling the guaranty fund, both of which are likely to lead to substantially the same conclusions. On the one hand, the fund could be considered as an agent of the industry. On the other hand, the fund could be modeled as a regulator as is most common in the banking industry. In the former case, the fund would have the goal of minimizing losses to the fund, which would be in the interest of the insurance industry. In the latter case, the fund could have the goal of prudential regulation, with the ultimate goal of protecting the integrity of the insurance system as well as limiting losses. As argued elsewhere, both approaches are likely to lead to the same behavior.[9]

5 Insurer Behavior with Guaranty Fund and Pro-Rata Loss Sharing

Guaranty funds, as they presently operate in the insurance industry, are financed exclusively by solvent insurance companies on an ex post basis. In

[9] See Sealey and Nagarajan (2000).

terms of the above model, the $t = 1$ losses incurred by insolvent insurers in a given state pool are paid at that time by the remaining solvent insurers in the pool. The share of the loss that must be paid by each insurer is proportional to the insurer's share of total premiums written in the state at $t = 0$. Thus, as such guaranty funds presently work in the United States, there is no attempt to charge insurers based on the risk they incur. In this situation, it may be in the insurer's interest to shift risk to the guaranty fund unless the fund protects itself through regulation, monitoring, or some alternative mechanism. In this section, we first examine the quality decisions of insurers when the guaranty fund acts in a passive manner, i.e., the fund does not monitor or regulate the insurer except to the extent that the equity capital is restricted to a fixed portion of premiums.

Under these conditions, the insurer faces a somewhat different environment. Specifically, premiums are as follows:

$$P(q_L) = (1 - q_L)L_2 + q_L L(q_L), \tag{10}$$

which is equal to the policyholders expected losses. Moreover, the unrecoverable losses that are incurred when the insurer becomes insolvent are paid by the guaranty fund who in turn assesses the solvent insurers within the jurisdiction (a State in the U.S.). As a result, premiums are only a function of underwriting quality; asset quality is immaterial since there are no unrecoverable losses.

The payoff to an individual insurer's equityholders is given by

$$\begin{aligned} \pi^E(q_A,\, q_L) \;\; = \;\; & q_A q_L[R(q_A) - L(q_L)] \\ & + q_A(1 - q_L)[R(q_A) - L_2] \\ & + (1 - q_L)(1 - q_A)[R_2 - L_2] - \gamma TIL. \end{aligned} \tag{11}$$

where γ is the ratio of the representative insurer's premiums as a proportion of the total premiums collected in the state, and TIL are total insurance losses to policyholders due to insurer bankruptcies. In the present setup, it is immaterial whether the insurer is large or small relative to the insurance market.

With the introduction of the guaranty fund, the quality pair that achieves an optimal social allocation remains $(q_A^{SP},\, q_L^{SP})$. The equity maximizing quality pair, $(q_A^{GF},\ q_L^{GF})$ in the presence of the guaranty fund is given by the two first-order conditions:

$$\frac{\partial q_A R(q_A)}{\partial q_A} = \frac{(1-q_L)L_2 + q_L R_2}{(1+\alpha)(P(q_L) + q_A R(q_A))}, \tag{12}$$

$$\frac{\partial q_L L(q_L)}{\partial q_L} = L_2 q_A + (1-q_A)R_2 + q_A(1+\alpha)R(q_A)P'(q_L), \tag{13}$$

both of which are somewhat similar to (6) and (7), but differ in that the insurance premium is defined by equation (10).

5.0.1 Optimal Quality Comparisons for Equityholders Under Full Information Vs. a Subsidized Guaranty Fund

As noted above, under the pro-rata loss sharing of the conventional guaranty fund, the insurance industry subsidizes the losses incurred by an individual insurer. Thus, it might be expected that this subsidy would have an impact on insurer decisions. In the present model, the insurer's equilibrium is to choose a quality pair in the presence of the subsidy. Let $(q_A^{SBGF},\ q_L^{SBGF})$ denote the quality decisions by equityholders in the presence of the guaranty fund subsidy.

To determine the impact of the subsidy on optimal decisions, first consider the asset quality decision. A comparison of the first-order conditions in (6) and (12) is required. Simplifying, if $q_A^{SBGF} < q_A^{SB}$, this requires that the following inequality holds when evaluated at the second-best solution, q_A^{SB}:

$$\frac{[P(q_L) - P(q_A,\ q_L)][-L_2(1-q_L^{SB}) - q_L^{SB} R_2]}{[P(q_L) + q_A^{SB} R(q_A^{SB})][P(q_A,\ q_L) + q_A^{SB} R(q_A^{SB})]} > 0. \tag{14}$$

Since $P(q_L) > P(q_A, q_L)$, the numerator of (14) is positive, and the denominator is clearly positive; thus, the inequality holds.

Turning now to optimal underwriting decisions, if $q_L^{SBGF} > q_L^{SB}$, then the following inequality must hold when comparing (7) and (13):

$$\frac{-(1-q_A^{SB})(L_2 - R_2)(-1 - q_A + q_A(1+\alpha)R(q_A^{SB})}{q_A^{SB}} < 0. \tag{15}$$

The direction of the inequality in (15) can be shown to hold as follows. First, since $q_A^{SB} \in (0,1)$, let $q_A^{SB} \to 0$. In this case, the numerator of (15) approaches $(L_2 - R_2) < 0$, and the fraction approaches $-\infty$. At the other extreme, let $q_A^{SB} \to 1$, in which case the numerator approaches 0, so that the fraction approaches 0. As q_A^{SB} varies between $-\infty$ and 0, from the assumptions given earlier, the function $R(q_A^{SB})$ is strictly monitone, thus the lhs of (15) is negative over the range $q_A^{SB} \in (0,1)$. Irrespective of whether equityholders choose lower or higher quality than the social planner under full information, they will choose lower quality under imperfect information with the guaranty fund subsidy.

The above results can be summarized as follows:

Proposition 2 *Under a guaranty fund scheme that prices according to a pro-rata loss rule, $q_A^{SBGF} < q_A^{SB}$ and $q_L^{SBGF} > q_L^{SB}$. In words, the insurer has an incentive to shift both asset risk and underwriting risk to the guaranty fund.*

Unlike the full information case considered earlier, when the guaranty fund subsidizes the insurer through the pro-rata loss scheme, the premiums collected by the insurer do not reflect the full risk taken by the insurer. The reason is that premiums only cover the expected losses of the policyholders. Any losses that might be incurred by policyholders due to insurer insolvency are paid for by the guaranty fund.

6 An Alternative Mechanism for Mitigating the Moral Hazard Problem

In this section, we present an example of an alternative contracting mechanism, which takes the form of an option issued by the insurer to the guaranty fund. This could be viewed as a form of payment for the insurance provided by the guaranty fund. We show that this instrument can significantly mitigate the moral hazard problem, provided the instrument is optimally designed.[10]

[10] The solution discussed in this section is in the spirit of John, John and Senbet (1991), Green (1984), and Sealey and Nagarajan (2000).

To keep the comparisons valid, the model remains much as before. We assume that the regulator sets the same equity capital requirement, E, as before, that there is no reinsurance involved, and that all insurance liabilities are covered by the guaranty fund. Asset returns are insufficient to fully pay underwriting losses only in *State* 4*;* however, losses in the insolvency state are covered in full by the guaranty fund.

As payment for guaranty fund insurance, the insurer is required to issue an option with an exercise value that is contingent on the insurers ex post returnes. The option is exercisable at the discretion of the guaranty fund, and conveys the option to charge a cash payment to the insurer. The guaranty fund will optimally exercise the option if it is in-the-money. Two options are required to deal with the moral hazard problem since there are two quality variables, q_A and q_L. Below, we first treat each case separately for analytical convenience. The solution remains qualitatively unchanged when both quality decisions are combined.

6.1 Optimal Asset Quality With Guaranty Fund Options When Underwriting Quality Is Fixed

Let $\overline{q}_L$ denote a fixed value of underwriting quality and C_A^{GFO} denote the expected option payoff[11] to the guaranty fund at $t = 1$, which can be written as

$$C_A^{GFO} = \max\{\lambda_A[q_A R(q_A)(1+\alpha)P(\overline{q}_L) - (1-\eta_A)\Phi_A] - \eta_A\Phi_A,\ 0\}, \tag{16}$$

where $0 < \eta_A \leq 1$,and $0 \leq \lambda_A \leq 1$ are constants set by the guaranty fund,[12] and $\Phi_A \equiv (1-q_A)(1-\overline{q}_L)R_2 - (1-\overline{q}_L)L_2 - q_A\overline{q}_L L(\overline{q}_L)$. In effect, the guaranty fund receives an option with an exercise price that is a portion, η_A,of the value of Φ_A. This option might be viewed as a payment for receiving the guaranty

[11]The expected payoff on the option refers to the expectation taken over the random variables $\widetilde{\varepsilon}_{q_A}$ and $\widetilde{\varepsilon}_{q_L}$ where as already noted, $E(\widetilde{\varepsilon}_{q_A}) = 0$ and $E(\widetilde{\varepsilon}_{q_L}) = 0$. As before, for notational simplicity, these expectations are not explicitly noted.

[12]As will be evident later in this section, $\eta = 0$ and $\lambda = 0$ are not possible optimal solutions for the model. In the former case, the guaranty fund is redundant, and in the latter the option is always worthless.

fund guarantee. As shown below, there are optimal values for η_A and λ_A that not only mitigate the moral hazard problem but also achieve a first-best solution.

Given the above features, the guaranty fund optimally exercises the asset quality option if and only if $\lambda_A[q_A R(q_A)(1+\alpha)P(\overline{q}_L)-(1-\eta_A)\Phi_A]-\eta_A\Phi_A \geq 0$. Now, define

$$\mathbf{1}_A^{GFO} \equiv \begin{cases} 1 & \text{if } \lambda_A[q_A R(q_A)(1+\alpha)P(\overline{q}_L)-(1-\eta_A)\Phi_A]-\eta_A\Phi_A \geq 0 \\ 0 & \text{otherwise;} \end{cases} .$$

which is an indicator variable whose value depends on whether the option is in-the-money.

The expected payoff to the insurers's stockholders for a given value of $\overline{q}_L$ can be written as

$$\begin{aligned} \pi^E(q_A,\ \overline{q}_L) \;\; &= \;\; q_A R(q_A)(1+\alpha)P(q_A,\overline{q}_L)+(1-q_A)(1-\overline{q}_L)R_2 \\ &\quad -(1-\overline{q}_L)L_2 - q_A\overline{q}_L L(\overline{q}_L) - C_A^{GFO}\times\mathbf{1}_A^{GFO} - \gamma TIL. \end{aligned} \tag{17}$$

The first-order condition for the insurer's optimal asset quality, q_A^*, that maximizes shareholder value, given that underwriting quality is fixed, is as follows:

$$\begin{aligned} &\left[\frac{\partial[q_A R(q_A)]}{\partial q_A}(1+\alpha)P(q_A,\overline{q}_L)-\frac{\partial\Phi_A}{\partial q_A}\right] - \\ &\left\{\lambda_A\left[\frac{\partial[q_A R(q_A)]}{\partial q_A}(1+\alpha)P(q_A,\overline{q}_L)-(1-\eta_A)\frac{\partial\Phi_A}{\partial q_A}\right]-\eta_A\frac{\partial\Phi_A}{\partial q_A}\right\}\times\mathbf{1}_A^{GFO}=0. \end{aligned} \tag{18}$$

The condition in (18) leads to the following result:

Proposition 3 *Let $\Omega_A \equiv R_2 - q_A^*(1+\alpha)R(q_A^*)P'_{q_A}(q_A^*, \overline{q}_L)$. The optimal option contract for the guaranty fund requires values for λ_A^* and η_A^* as follows:*

1. $\lambda_A^* \geq \left[\frac{\eta_A(\partial\Phi_A/\partial q_A)}{\frac{\partial[q_A^* R(q_A^*)]}{\partial q_A^*}(1+\alpha)P(q_A^*, \overline{q}_L) - (1-\eta_A)\frac{\partial\Phi_A}{\partial q_A}} \right]$; *and*

2. $\eta_A^* = \left[\frac{(\partial\Phi_A/\partial q_A) - \Omega_A}{(\partial\Phi_A/\partial q_A)} \right]$.

The above values for λ_A^* and η_A^* in turn induce the insurer to choose optimal asset quality, q_A^*, such that

$$\left[\frac{\partial[q_A^* R(q_A^*)]}{\partial q_A^*}(1+\alpha)P(q_A^*, \overline{q}_L) \right] - (1-\eta_A^*)\frac{\partial\Phi_A}{\partial q_A} = 0.$$

Furthermore, the insurer's optimal asset quality, q_A^*, achieves the first-best level of quality, i.e., $q_A^* = q_A^{FB}$.

6.2 Optimal Underwriting Quality With Guaranty Fund Options When Asset Quality is Given

Let C_L^{GFO} denote the expected $t = 1$ option payoff to the guaranty fund given q_A fixed. This terminal payoff can be written as

$$C_L^{GFO} = \max\{\lambda_L[-q_A q_L L(q_L) - (1-\eta_L)\Phi_L] - \eta_L\Phi_L,\ 0\}, \tag{19}$$

where $0 < \eta_L \leq 1$,and $0 \leq \lambda_L \leq 1$ are constants that are set by the guaranty fund,[13] and $\Phi_L \equiv q_A R(q_A)(1+\alpha)P(q_L) + (1-q_A)(1-q_L)R_2 - (1-q_L)L_2$.

The guaranty fund optimally exercises the underwriting quality option if and only if $\lambda_L[-q_A q_L L(q_L) - (1-\eta_L)\Phi_L] - \eta_L\Phi_L \geq 0$. Now, define

$$\mathbf{1}_L^{GFO} \equiv \begin{cases} 1 & \text{if } \lambda_L[-q_A q_L L(q_L) - (1-\eta_L)\Phi_L] - \eta_L\Phi_L \geq 0 \\ 0 & \text{otherwise.} \end{cases}.$$

[13] Analogous to the former case, $\eta_L = 0$ and $\lambda_L = 0$ are not possible optimal solutions for the model.

The expected payoff to stockholders for a given value of $\overline{q}_A$ can be written as

$$\begin{aligned}\pi^E(q_A,\ q_L) &= \overline{q}_A R(\overline{q}_A)(1+\alpha)P(\overline{q}_A, q_L) + (1-\overline{q}_A)q_L R_2 \\ &\quad -(1-q_L)\overline{q}_A L_2 - q_L L(q_L) - C_A^{GFO} \times \mathbf{1}_L^{GFO} - \gamma TIL. \qquad (20)\end{aligned}$$

The first-order condition for equity maximization is

$$\left[\frac{\partial[q_L L(q_L)]}{\partial q_L} - \Phi_{q_L}\right] -$$

$$\left\{\lambda_L\left[\frac{\partial[q_L L(q_L)]}{\partial q_L} - (1-\eta_{q_L})\Phi_{q_L}\right] - \eta_{q_L}\Phi_{q_L}\right\} \times \mathbf{1}_{q_L}^{GFO} = 0. \qquad (21)$$

Proposition 4 *Let* $\Omega_L \equiv L_2 - (1-\overline{q}_A)R_2 - \overline{q}_A(1+\alpha)R(\overline{q}_A)P'_{q_L}(\overline{q}_A, q_L)$. *The optimal option contract for the guaranty fund requires values for* λ_L^* *and* η_L^* *as follows:*

1. $\lambda_L^* \geq \left[\frac{\eta_L(\partial\Phi_L/\partial q_L)}{-(1-\eta_L)D}\right]$; *and*
2. $\eta_L^* = \left[\frac{(\partial\Phi_L/\partial q_L) - \Omega_L}{(\partial\Phi_L/\partial q_L)}\right]$.

The above values for λ_L^* *and* η_L^* *in turn induce the insurer to choose optimal asset quality,* q_A^*, *such that*

$$\left[\frac{\partial[q_L^* R(q_L^*)]}{\partial q_L^*}\right] - (1-\eta_{q_L}^*)\frac{\partial\Phi_L}{\partial q_L} = 0.$$

Furthermore, the insurer's optimal underwriting quality, q_L^*, *achieves the first-best level of quality, i.e.,* $q_L^* = q_L^{FB}$.

6.3 Discussion of Options Mechanism

An examination of the above results reveals an important feature of the option contracts discussed above; namely, if the contract is designed optimally, as shown in Propositions 3 and 4, then, in equilibrium where the insurer chooses first-best quality, and the guaranty fund's option is not expected to be exercised since it is expected to be exactly at-the-money at $t = 1$.[14] It is also interesting to note that the contract is, in principle, similar to an ex post, risk-adjusted guaranty fund pricing scheme. For example, for an optimally designed contract, the guaranty fund could set the ex ante charge such that the premium plus the value of the option would allow the to break even, thus being equivalent to risk-adjusted deposit insurance.[15]

7 Conclusion

Two main conclusions seem justified based on the analysis above. First, there are some unique aspects of insurer decision making under conditions of moral hazard. Although quality decisions that are in the interest of shareholders are not socially optimal, underwriting quality may in fact be higher than the socially optimal as opposed to lower as is the usual case. Second, socially optimal quality decisions may be restored by an optimally designed option contract that is issued by the guaranty fund.

[14]Because of asset-specific risk, $\widetilde{\varepsilon}$, the deposit linked option could be in the money in spite of the bank choosing first-best quality.

[15]Nagarajan and Sealey (1998) develop a formal model of ex post, risk-adjusted pricing for deposit insurance premiums. Their framework, however, is somewhat different from that presented here and involves ex post premiums that are based on the performance of the bank relative to the market.

References

[1] Benston, G.J., Eisenbeis, R., Horvitz, P., Kane, E., and Kaufman, G., *Perspectives on Safe and Sound Banking: Past, Present, and Future,* Cambridge: MIT Press, 1986.

[2] Bliss, R.R., and Flannery, M.J., "Market Discipline in the Governance of U.S. Bank Holding Companies: Paper presented at the 36th Annual Conference on Bank Structure and Competition, Federal Reserve Bank of Chicago, Chicago, Ill., May, 2000.

[3] Bohn, J., and Hall, B., "The Moral Hazard of Insuring the Insurers," in K.A. Froot, ed., *The Financing of Catastrophic Risk* (Chicago: University of Chicago Press, 1998.

[4] Boot, A., and Thakor, A. "Self-Interested Bank Regulation," *American Economic Review*, **83**, (1993).

[5] Buser, S., Chen, A., and Kane, E., "Federal Deposit Insurance, Regulatory Policy, and Optimal Bank Capital," *Journal of Finance*, **35**, (1981), 51–60.

[6] Campbell, T., Chan, Y.-S., and Marino, A., "An Incentive Based Theory of Bank Regulation," *Journal of Financial Intermediation*, **1** (1992), 255–276.

[7] Chan, Y., Greenbaum, S.I. and Thakor, A.V., "Is Fairly Priced Deposit Insurance Possible?" *Journal of Finance*, **47**, (1992), 227-245.

[8] Congressional Budget Office, "Reforming Federal Deposit Insurance," Congress of the United States, September, 1992.

[9] Cummins, J. D., Risk-Based Premiums for Insurance Guarantee Funds," *Journal of Risk and Insurance,* **43**, (1988), 823-839.

[10] Diamond, D. "Financial Intermediation and Delegated Monitoring," *Review of Economic Studies*, **51**, (1984), 393-414.

[11] Downs, D., and Sommers, D. "Monitoring, Ownership, and Risk-Taking: The Impact of Guaranty Funds," *Journal of Risk and Insurance*, **66**, (1999), 477-497.

[12] Flannery, M., and Sorescu, S., "Pricing Bank Default Risk in Subordinated Debenture Yields," *Proceedings: Conference on Bank Structure and Competition*, Federal Reserve Bank of Chicago, May, 1995, 459-482.

[13] Giammarino, R., Lewis, T. and Sappington, D., "An Incentive Approach to Bank Regulation," *Journal of Finance*, **48**, (1993), 1523–1542.

[14] Gilbert, R.A., "Market Discipline of Bank Risk: Theory and Evidence," Federal Reserve Bank Of St. Louis, *Review*, (January/February, 1990), 3-18.

[15] Green, R., "Investment Incentives, Debt and Warrants," *Journal of Financial Economics*, **13**, (1984), 115-136.

[16] Hall, B., "Regulatory Free Cash Flow and the High Cost of Insurance Company Failures," Discussion Paper no. 1782, Harvard Institute of Economic Research, 1996.

[17] John, K., John, T.A. and Senbet, L., "Risk-Shifting Incentives of Depository Institutions: A New Perspective on Federal Deposit Insurance Reform," *Journal of Banking and Finance*, **15**, (1991), 895–915.

[18] Kane, E.J., "No Room for Weak Links in the Chain of Deposit-Insurance Reform," *Journal of Financial Services Research*, **1**, (1987), 77–111 .

[19] Kane, E.J., "Changing Incentives Facing Financial-Services Regulators," *Journal of Financial Services Research*, **3**, (1989), 265–274.

[20] Lee, S.-J., Mayers, D., and Smith, C., "Guaranty Funds and Risk-Taking: Evidence From the Insurance Industry, *Journal of Financial Economics*, **44**, 1997, 3-24.

[21] Myers, S. "Determinants of Corporate Borrowing," *Journal of Financial Economics,* **24**, (1977).

[22] Nagarajan, S. and Sealey, C.W., "Forbearance, Deposit Insurance Pricing, and Incentive Compatible Bank Regulation," *Journal of Banking and Finance*, **19**, (1995), 1109-1130.

[23] Nagarajan, S. and Sealey, C. W., "State-Contingent Bank Regulation and the Fair Pricing of Deposit Insurance," *Journal of Banking and Finance*, **22**, (1998), 1139-1156.

[24] Rajan, R., and Winton,A., "Covenants and Collateral as Incentives to Monitor," *Journal of Finance*, **50**, (1995), 1113-1146.

[25] Wall, L. D., "A Plan for Reducing Future Deposit Insurance Losses: Puttable Subordinated Debt," *Economic Review*, (July/August,1989), 2-17.