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## Effort Allocation of Insurance Agent under Asymmetric Information: An Analytical Approach

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## **Effort Allocation of Insurance Agent under Asymmetric Information: An Analytical Approach**

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### **Abstract**

This study examines the relationship between incentive contracts for managers and the allocation of efforts by the managers as well as the stock market's role in monitoring allocation of the efforts. It also evaluates solvency regulation in Japan and its effects on the compensation of a manager and allocation of the manager's efforts and on the shareholders' profits in a market with asymmetric information. Particularly, we employ a principal-agency model to demonstrate how uncertainty in the insurance market affects the way managers allocate their efforts so that their companies can achieve a higher solvency ratio in order to meet not only regulatory requirements but also stock market expectation. We find presence of a solvency margin ratio that, subject to certain conditions, increases the level of "good" effort, decreases the level of "bad" effort by the manager and increases the expected stock price.

**Key Words:** Solvency margin ratio regulation, asymmetric information, principal-agency model

### **I. Introduction**

The effectiveness of solvency regulation in insurance has been widely debated in the United States and Japan. For example, Hamwi et al. (2004) showed that proposals to improve the current regulatory system, such as setting up guaranty funds or increasing the level of federal intervention, in the United States are generally not necessary or effective. Ushikubo et al. (2005) proposed that regulation of insurance companies in Japan should be changed from the old "command and control" approach, whereby the authority controls every step of insurance business and insurer activity, to a new model, whereby both financial market systems and the regulator monitor the insurance market and supervise insurer activities. However, no studies are known to have examined how solvency regulation affects the level of effort generated by a manager of an insurance company, the size of compensation for the manager, and the role of the stock market in that context.

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The insurance industry in Japan has been subject to several dramatic changes in recent years. In particular, all insurance companies are subject to solvency margin ratio regulation from the fiscal year of 1996.<sup>1</sup> The Japanese Financial Services Agency (FSA) uses this measurement tool to assess the financial health of insurance companies, including their ability to meet policy obligations. An insurance company that has failed to meet a minimum ratio can be subject to regulatory action by the FSA.

Ensuring full compliance with solvency regulation is thus an important duty of managers of insurance companies in Japan. News about a possible regulatory action resulting from a company's failure to meet the minimum solvency margin can affect the share price of the company. Hence arises our research interest – how insurance managers allocate their efforts to achieve a (higher-than-minimum) solvency ratio to avoid not only regulatory action but also any adverse development in the stock market.<sup>2</sup> We believe that stock market performance and the solvency regulation affect the behaviors of insurance managers. In fact, the recent sluggish stock market performance has resulted in insurers' commonly carrying much lower solvency margin ratios.<sup>3</sup>

Using an agency model similar to that employed by Kojima (2003), who extended Hughes and Thevaranjan's (1995) analytical model, we prove that managers always improve their efforts in a (stock) market with information asymmetry. We also demonstrate that, in a controlled environment, there is an optimal level of solvency margin ratio that increases the level of "good" effort while decreasing the level of "bad" effort by the managers.

This paper is organized as follows. The next section reviews existing literature and the basic agency model. We then introduce an extended model and derive the first-best solution where the manager's effort is observable with no uncertainty and the second-best solution where the manager's compensation is based on the stock price of the insurance company. Section III presents the influence of solvency regulation in Japan. Section IV concludes with a discussion of the key findings and possible extensions of this study.

## **II. Literature Review and Model Development**

Principal-agent models have been studied extensively, especially regarding incentive contracts and the allocation of firm manager's effort (Jensen and Meckling, 1976; and Jensen and Murphy, 1990) and the stock market's role in monitoring the manager's allocation of effort (Diamond and Verrecchia, 1982; and Holmström and Tirole, 1993). In this study, we employ a principal-agency model similar to that of Hughes and Thevaranjan (1995) and Kojima (2003), but we add additional uncertainty conditions by introducing the stock market to the model.

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<sup>1</sup> See the appendix for an explanation of the solvency margin ratio regulation in Japan.

<sup>2</sup> Evidence shows that, during the 2002-2004 bearish stock market period, insurance companies systematically increased their equity capital to improve their solvency margin ratios and avoid possible regulatory interventions.

<sup>3</sup> The Nikkei Economic Daily (*Nihon Keizai Shinbun*) reported that the solvency margin ratios of the top ten Japanese insurance companies significantly decreased from the previous fiscal year. It also reported that six insurance companies recorded a total of one trillion yen in unrealized losses from their holdings of securities (November 27, 2002). Later, they reported that some insurers might have employed nonstandard accounting practices to inflate their financial soundness (May 24, 2004).

Hamwi et al. (2004) analytically examined the need for guaranty funds and the effectiveness of solvency regulation in the insurance market. They focused on how solvency regulation could benefit consumers and demonstrated that guaranty funds are always desirable but solvency regulation or insurance companies' efforts to improve their solvency margin ratios may not be. We offer a different view.

Our model assumes that the principal (shareholder) of an insurance company wants to maximize profits and the agent (management) wants to maximize his or her compensation from the principal while minimizing his or her cost for the effort.<sup>4</sup> We also assume the shareholder is risk neutral and the manager is weakly risk averse. The manager is then assumed to have an exponential utility:<sup>5</sup>

$$u(\omega) = 1 - e^{-r\omega} \quad (2.1)$$

where  $r$  denotes a risk parameter ( $r \geq 0$ ) and  $\omega$  denotes income from compensation derived from the pecuniary equivalent cost of effort involved in the manager's decisions.

We also assume that the manager can choose a combination of "good" (superior) effort and "bad" (deficient) effort. For the purposes of our model, we define good effort and bad effort as follows.<sup>6</sup>

**Good effort** – effort such as issuing new equity, reducing risky assets, or increasing safe assets (e.g., government bonds) that produces a desirable outcome for the shareholder.

**Bad effort** – effort such as manipulation of accounts that delivers no substantial value to the shareholder.

The cost of good effort  $a$  and bad effort  $b$  can be determined as follows:

$$C(a,b) = \frac{1}{2}(a^2 + \kappa b^2) \quad (2.2)$$

where  $\kappa \in [0, \infty]$  implies the degree of accounting flexibility. When  $\kappa = 0$ , bad effort is costless because accounting practice is very flexible (to be discussed later). As  $\kappa$  increases, bad effort becomes more costly to the manager.

The manager's compensation is therefore described as follows:<sup>7</sup>

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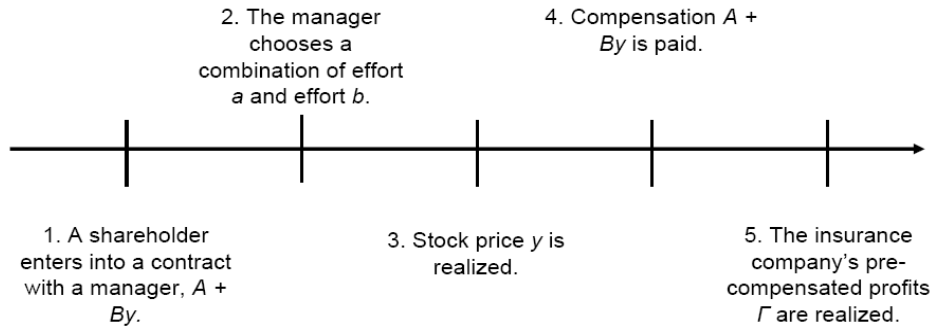
<sup>4</sup> Refer to Lambert (2001) for application of agency theory to accounting research.

<sup>5</sup> The development of this model is based on that of Hughes and Thevaranjan (1995).

<sup>6</sup> These examples of good effort do not necessarily increase an insurance company's profits (i.e., net income), and thus they may not be in the best interest of the shareholder. However, as an anonymous referee pointed out, the manager's effort to improve the solvency margin ratio can be considered good effort, i.e., beneficial to the shareholder, because such an effort can reduce the risk of regulatory intervention.

<sup>7</sup> Following Holmström and Milgrom (1987), Feltham and Xie (1994), and Banker and Thevaranjan (2000), we assume the compensation plan is linear in the measure of market performance, stock price, and the manager's compensation.

Figure 1: Sequence of Events



$$c(y) = A + By \tag{2.3}$$

where  $A$  is a fixed component of the compensation, and  $By$  is a variable component based on the fixed compensation rate  $B$  and stock price  $y$ :

$$y = a + (1 - \pi)b + \varepsilon \tag{2.4}$$

Stock price  $y$  can be observed by the shareholder after the manager has chosen his or her effort allocation. In this equation,  $\pi \in [0, 1]$  represents the degree of market perfection.

Consider two extreme cases,  $\pi = 0$  and  $\pi = 1$ . When  $\pi = 0$ , the market cannot distinguish between good effort and bad effort. When  $\pi = 1$ , the market can perfectly distinguish them, thus stock price  $y$  being affected only by good effort. The random error  $\varepsilon$  is assumed to be normally distributed with a zero mean and a variance of  $\sigma_y^2$ . Income from the compensation is then:

$$\omega = c(y) - C(a, b) = A + By - \frac{1}{2}(a^2 + \kappa b^2) \tag{2.5}$$

Good effort influences the value of the company (i.e., profits), but bad effort affects only the stock price. Thus, the insurance company's profits can be shown as:

$$\Gamma = a + \varepsilon \tag{2.6}$$

It is important to note that  $\Gamma$  is observable by the shareholder only *after* the manager has allocated his effort and the outcome has been realized. In other words,  $\Gamma$  is calculated and only disclosed by the manager after the manager has been compensated by the shareholder. Stock price information is available all the time. Therefore, the shareholder cannot offer a compensation plan based on  $\Gamma$ . Figure 1 shows the sequence of events in the model.

Consider now the case where the manager's effort is observable to the shareholder who pays the manager a fixed compensation. Recall that the shareholder is assumed to be risk neutral and the manager risk averse. The shareholder assumes uncertainty regarding profits and chooses  $B=0$ . If the manager's effort is observable, the shareholder can determine the effort level corresponding to the most efficient mixture of good effort and bad effort, and draw up a contract to ensure that the manager chooses that efficient mixture of efforts. This ideal case is termed as the first-best case in this paper. Under this setting, actions are chosen cooperatively by the shareholder and the manager and the company maximizes its total profits. Under this scenario, both parties choose the contract that maximizes the shareholder's expected utility, subject to satisfying the compensation contract with manager. This condition, also known as the individual rational constraint (IR constraint), expresses that manager's expected utility has to be equal to or exceed his or her reservation utility. For simplicity, the level of reservation utility is assumed to be zero. The shareholder's profit maximization problem can then be given by:

$$\begin{aligned} & \underset{a,b}{\text{Maximize}} \quad \Pi \equiv E[\Gamma] - E[c(y)], \\ & \text{Subject to: } E\left[1 - \exp\left\{-r\left(A - \frac{1}{2}(a^2 + \kappa b^2)\right)\right\}\right] \geq 0 \quad (\text{IR constraint}). \end{aligned} \quad (2.7)$$

Paying flat compensation  $A$  equivalent to the cost of effort ensures that the manager will accept the contract. In this case, the shareholder's maximization problem can be reduced to:

$$\underset{a,b}{\text{Maximize}} \quad a - \frac{1}{2}(a^2 + \kappa b^2). \quad (2.8)$$

It follows that the first-best solutions are  $a_{FB} = 1$ ,  $b_{FB} = 0$ ,  $E[y_{FB}] = 1$ , and  $E[\Pi_{FB}] = 1/2$ , where subscript  $FB$  denotes the first-best result.

In reality, the level of the manager's effort is not observable to the shareholder. Thus, the shareholder cannot determine the level of the manager's effort directly and attempt to indirectly control the manager by offering a compensation plan in lieu of a fixed compensation.<sup>8</sup> This more realistic case is termed as the "second-best" case in this paper. Under this scenario, the manager maximizes the shareholder's expected profits, subject to meeting the manager's reservation utility and satisfying the incentive compatibility (IC). Specifically, the shareholder's maximization problem is:

$$\begin{aligned} & \underset{A,B}{\text{Maximize}} \quad \Pi \equiv E[\Gamma] - E[c(y)], \\ & \text{Subject to: } E\left[1 - \exp\left\{-r\left((A + By) - \frac{1}{2}(a^2 + \kappa b^2)\right)\right\}\right] \geq 0 \quad (\text{IR constraint}), \end{aligned}$$

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<sup>8</sup> Using such a compensation scheme may induce manipulation of undesirable accounting practices. Refer to Narayanan and Davila (1998) for a case in which a trade-off arises in an agency relationship when the same signal is used for evaluation.

$$(a, b) \in \underset{(a,b)}{\operatorname{argmax}} E \left[ 1 - \exp \left\{ -r \left( (A + By) - \frac{1}{2} (a^2 + \kappa b^2) \right) \right\} \right] \quad (\text{IC constraint}). \quad (2.9)$$

We can combine a linear compensation contract with a normal distribution and an exponential utility to describe the manager's expected utility as:<sup>9</sup>

$$E[u] = 1 - \exp \left[ -r \left( A + B(a + (1 - \pi)b) - \frac{1}{2} (a^2 + \kappa b^2) - \frac{r}{2} B^2 \sigma_y^2 \right) \right] \quad (2.10)$$

If the expected compensation,  $E[A + By]$ , is set equal to the cost of effort by the manager plus the risk premium for the additional compensation for taking the uncertainty of his or her final compensation, the IR constraint and the manager's objective function can be simplified to:

$$\underset{a,b}{\operatorname{Maximize}} \quad A + B(a + (1 - \pi)b) - \frac{1}{2} (a^2 + \kappa b^2) - \frac{r}{2} B^2 \sigma_y^2. \quad (2.11)$$

In the following subsection, we analyze the cases for  $\kappa = 0$  and  $\kappa > 0$  separately, since the implied results differ depending on the level of accounting flexibility  $\kappa$ .

**When  $\kappa = 0$ .** Consider two cases with  $\pi = 1$  and  $\pi < 1$ . When  $\pi = 1$ , the manager does not choose bad effort. Thus, the shareholder chooses  $B > 0$  in order to encourage the manager to choose good effort. If  $\pi < 1$ , the shareholder does not choose  $B > 0$  since the manager can choose a very large (infinite in theory) level of bad effort. Therefore, we derive the following proposition.

**Proposition 1.** When the market is not perfect and bad effort is costless, the shareholder offers a fixed compensation. That is, if  $\kappa = 0$  and  $\pi < 1$ , then the shareholder offers  $B = 0$ .

According to this proposition, when  $\kappa = 0$ , even if the market is almost perfect—that is,  $\pi = 1 - \phi$ , where  $\phi$  denotes a very small positive number—the shareholder cannot offer a compensation plan including flexible incentives. When  $\pi = 1$ , the market is very fragile and unstable, and the government may introduce a regulation, monitor the market system to ensure  $\kappa > 0$ . (It is highly unlikely to find a perfectly competitive market in the real world).

**When  $\kappa > 0$ .** The manager's expected utility in equation (2.10) is strictly concave for effort  $a$  and effort  $b$  of the manager. The first-order conditions with respect to effort  $a$  and effort  $b$  are given by:

$$a_{SB} = B_{SB}, \quad (2.12)$$

$$b_{SB} = \frac{(1 - \pi)B_{SB}}{\kappa}, \quad (2.13)$$

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<sup>9</sup> A linear compensation contract with a normal distribution and an exponential utility is very simple to analyze and derive robust results. See Holmström and Milgrom (1987).

where subscript  $SB$  denotes the second-best solution. The shareholder's profit maximization problem can then be expressed by substituting these optimal efforts (2.12) and (2.13) with  $a$  and  $b$  in (2.11) and the IR constraint. As aforementioned, the IR constraint is satisfied if the expected compensation is set equal to the sum of the cost of effort and the risk premium. These substitutions result in an unconstrained maximization problem in  $B$ . The reduced shareholder's maximization problem is thus:

$$\text{Maximize}_B B - \frac{1}{2}B^2 - \frac{(1-\pi)^2 B^2}{2\kappa} - \frac{r}{2}B^2\sigma_y^2. \quad (2.14)$$

This maximization problem is strictly concave for  $B$ , and the first-order condition with respect to  $B$  is necessary and sufficient to characterize optimal  $B_{SB}$  as follows:

$$a_{SB} = B_{SB} = \frac{\kappa}{(1-\pi)^2 + \kappa(1+r\sigma_y^2)}. \quad (2.15)$$

Furthermore, optimal  $b_{SB}$  can be computed as:

$$b_{SB} = \frac{1-\pi}{(1-\pi)^2 + \kappa(1+r\sigma_y^2)}. \quad (2.16)$$

It is also clear that:

$$E[y_{SB}] = \frac{\kappa + (1-\pi)^2}{(1-\pi)^2 + \kappa(1+r\sigma_y^2)}, \quad (2.17)$$

$$E[\Pi_{SB}] = \frac{1}{2} \left( \frac{\kappa}{(1-\pi)^2 + \kappa(1+r\sigma_y^2)} \right). \quad (2.18)$$

Comparing the first-best and second-best solutions, we confirm that  $a_{FB} > a_{SB}$ ,  $b_{FB} < b_{SB}$ ,  $E[y_{FB}] > E[y_{SB}]$ , and  $E[\Pi_{FB}] > E[\Pi_{SB}]$ . These relationships are satisfied even when the market is perfect. From equation (2.16), we then derive the following proposition.

**Proposition 2.** When the market is not perfect, the manager always makes bad effort. That is, if  $\pi < 1$ , then  $b_{SB} > 0$ .

In contrast, when the market is perfect, the manager never makes bad effort because  $\pi = 1$ . In order to verify the solutions extensively, we compute the results when  $\kappa \rightarrow \infty$  and  $\pi \rightarrow 1$  as follows.

**When  $\kappa \rightarrow \infty$ .**

$$a_{SB} = \frac{1}{1+r\sigma_y^2}, \quad (2.19)$$

$$b_{SB} = 0, \quad (2.20)$$



$$E[y_{SB}] = \frac{1}{1+r\sigma_y^2}, \quad (2.21)$$

$$E[\Pi_{SB}] = \frac{1}{2(1+r\sigma_y^2)}. \quad (2.22)$$

**When  $\pi \rightarrow 1$ .**

$$a_{SB} = \frac{1}{1+r\sigma_y^2}, \quad (2.23)$$

$$b_{SB} = 0, \quad (2.24)$$

$$E[y_{SB}] = \frac{1}{1+r\sigma_y^2}, \quad (2.25)$$

$$E[\Pi_{SB}] = \frac{1}{2(1+r\sigma_y^2)}. \quad (2.26)$$

From equations (2.19) to (2.26), we can establish the following proposition straightforward.

**Proposition 3.** The solutions for  $\kappa \rightarrow \infty$  and for  $\pi \rightarrow 1$  are always identical.

The policy implications of the above proposition are as follows. If the regulator cannot sufficiently improve market conditions, it can prevent managers' bad efforts by sufficiently increasing the cost of such bad efforts. Even if the regulator cannot sufficiently increase the cost, it can reduce managers' bad efforts by sufficiently imposing restrictions on accounting practices.

Moreover, we can analyze separately the effects of changes in exogenous variables by differentiating equations (2.15) and (2.18) with respect to  $\kappa$  and  $\pi$ , respectively, as follows:

$$\frac{\partial a_{SB}}{\partial \kappa} = \frac{(1-\pi)^2}{[(1-\pi)^2 + \kappa(1+r\sigma_y^2)]^2} \geq 0, \quad (2.27)$$

$$\frac{\partial b_{SB}}{\partial \kappa} = \frac{-(1-\pi)(1+r\sigma_y^2)}{[(1-\pi)^2 + \kappa(1+r\sigma_y^2)]^2} \leq 0, \quad (2.28)$$

$$\frac{\partial E[y_{SB}]}{\partial \kappa} = \frac{-(1-\pi)^2 r\sigma_y^2}{[(1-\pi)^2 + \kappa(1+r\sigma_y^2)]^2} \leq 0, \quad (2.29)$$

$$\frac{\partial E[\Pi_{SB}]}{\partial \kappa} = \frac{1}{2} \frac{\partial a_{SB}}{\partial \kappa} \geq 0, \quad (2.30)$$

$$\frac{\partial a_{SB}}{\partial \pi} = \frac{2\kappa(1-\pi)}{\left[(1-\pi)^2 + \kappa(1+r\sigma_y^2)\right]^2} \geq 0, \quad (2.31)$$

$$\frac{\partial b_{SB}}{\partial \pi} = \frac{(1-\pi)^2 - \kappa(1+r\sigma_y^2)}{\left[(1-\pi)^2 + \kappa(1+r\sigma_y^2)\right]^2}, \quad (2.32)$$

$$\frac{\partial E[y_{SB}]}{\partial \pi} = \frac{-2\kappa(1-\pi)r\sigma_y^2}{\left[(1-\pi)^2 + \kappa(1+r\sigma_y^2)\right]^2} \leq 0, \quad (2.33)$$

$$\frac{\partial E[\Pi_{SB}]}{\partial \pi} = \frac{1}{2} \frac{\partial a_{SB}}{\partial \pi} \geq 0. \quad (2.34)$$

Most of the above derivatives confirm the intuitive results, that an increase in  $\kappa$  decreases  $b_{SB}$ . However, some results are worth further discussion, based on the following proposition.

**Proposition 4.** (1) The effect of an increase in  $\pi$  on  $b_{SB}$  is not clear. (2) An increase in  $\kappa$  and/or  $\pi$  lowers  $E[y_{SB}]$ . (3) An increase in  $\kappa$  and/or  $\pi$  raises  $E[\Pi_{SB}]$ .

Several interesting facts can be derived from the above proposition. The first part of this proposition demonstrates that even when the market is close to perfect, bad effort may not decrease. That is because an increase in  $\pi$  has two opposing effects. First, from equation (2.13), an increase in  $\pi$  directly decreases bad effort (direct effect of  $\pi$ ). Second, from equation (2.15), an increase in  $\pi$  leads to an increase in the intensity of incentives and indirectly increases bad effort (indirect effect of  $\pi$ ). Thus, we cannot derive a unique result as we cannot compare the magnitudes of either effect.

The model under a perfect market shows that an increase in  $\kappa$  is not related to either the expected stock price or expected shareholder's profits because  $\pi = 1$ . In contrast, the model under an imperfect market demonstrates that an increase in  $\kappa$  decreases the expected stock price and increases expected shareholder's profits. An increase in  $\kappa$  and/or in  $\pi$  also has two effects. First, an increase in  $\kappa$ ,  $\pi$  or both results in an increase in the level of good effort. Consequently, both the expected stock price and expected shareholder's profits increase. Second, an increase in  $\kappa$ ,  $\pi$  or both lowers the level of bad effort. To this end, the expected stock price is lower, since the stock price is positively correlated to the level of bad effort. Because the first effect is always smaller than the second effect, we can derive the second part of Proposition 4. Meanwhile, the expected shareholder's profits are higher, since the manager's compensation is lower and the shareholder's profits are unchanged. Therefore, we can easily verify the third part of the proposition.

### III. Introduction of Insolvency Margin Ratio Regulation

Suppose the following solvency margin ratio regulation,  $R$ , is enforced:

$$R = a + b. \quad (3.1)$$

This definition shows that the manager can achieve a certain level of solvency margin ratio by making both good effort and bad effort.<sup>10</sup> Unlike shareholders and other investors of insurance companies, the regulator does not profit from discerning good effort from bad effort and do not have any incentives to do so as long as the company maintains the minimum ratio imposed by the regulation. Using this equation, we can discuss the case where the manager's combination of good effort and bad effort differs depending on the intensity of solvency margin ratio regulation in the market.<sup>11</sup>

For this, we define the lowest level of solvency margin ratio as follows:

$$R_{SB} \equiv a_{SB} + b_{SB} = \frac{\kappa + (1 - \pi)}{(1 - \pi)^2 + \kappa(1 + r\sigma_y^2)}. \quad (3.2)$$

With this equation, we can further limit our discussion to  $R \in (R_{SB}, \infty)$ . In this case, a manager faces the profit maximization problem presented as equation (2.11). When  $\kappa = 0$ , it is clear that:

$$a = B = 0 \text{ and } b = R. \quad (3.3)$$

When  $\kappa > 0$ , substituting  $R = a + b$  into equation (2.11) yields:

$$\text{Maximize}_a A + B(a + (1 - \pi)(R - a)) - \frac{1}{2}(a^2 + \kappa(R - a)^2) - \frac{r}{2}B^2\sigma_y^2. \quad (3.4)$$

The first-order condition is calculated as:

$$B(1 - (1 - \pi)) - \frac{1}{2}(2a - 2\kappa(R - a)) = 0. \quad (3.5)$$

Therefore, we can derive:

$$a_R = \frac{B\pi + \kappa R}{1 + \kappa}, \quad (3.6)$$

$$b_R = \frac{R - B\pi}{1 + \kappa}. \quad (3.7)$$

We can show the maximization problem for the shareholder as follows:

$$\text{Maximize}_B a - \frac{1}{2}(a^2 + \kappa b^2) - \frac{r}{2}B^2\sigma_y^2. \quad (3.8)$$

The first-order condition is calculated as:

<sup>10</sup> Equation (3.1) demonstrating capital regulation is in the same form as presented in Kojima (2003).

<sup>11</sup> Conversely, we only consider cases for  $a_{SB} + b_{SB} \leq R$  in a market without solvency margin ratio regulation. When  $a_{SB} + b_{SB} > R$ , solvency margin ratio regulation is ineffective, and the solution is exactly the same as that of the second-best case.

$$\frac{\partial a}{\partial B} - \frac{1}{2} \left( 2a \frac{\partial a}{\partial B} + 2\kappa b \frac{\partial b}{\partial B} \right) - rB\sigma_y^2 = 0. \quad (3.9)$$

Therefore, we can derive:

$$B_R = \frac{\pi}{\pi^2 + (1+\kappa)r\sigma_y^2}. \quad (3.10)$$

By using equation (3.10), we can define good effort and bad effort:

$$a_R = \frac{1}{1+\kappa} \left( \frac{\pi^2}{\pi^2 + (1+\kappa)r\sigma_y^2} + \kappa R \right), \quad (3.11)$$

$$b_R = \frac{1}{1+\kappa} \left( R - \frac{\pi^2}{\pi^2 + (1+\kappa)r\sigma_y^2} \right). \quad (3.12)$$

By using equations (3.10) to (3.12), we can further derive the expected stock price and the expected shareholder's profits:

$$E[y_R] = \frac{1}{1+\kappa} \left[ \frac{\pi^3}{\pi^2 + (1+\kappa)r\sigma_y^2} + R(\kappa + (1-\pi)) \right], \quad (3.13)$$

$$E[\Pi_R] = \frac{1}{2} \left( \frac{1}{1+\kappa} \right) \left[ \kappa(2R - R^2) + \frac{\pi^2}{\pi^2 + (1+\kappa)r\sigma_y^2} \right]. \quad (3.14)$$

Similarly to the way we did above, we compute the following results when  $\kappa \rightarrow \infty$  and  $\pi \rightarrow 1$ .

**When  $\kappa \rightarrow \infty$ .** We find the following:

$$a_R = R, \quad (3.15)$$

$$b_R = 0, \quad (3.16)$$

$$B_R = 0, \quad (3.17)$$

$$E[y_R] = R, \quad (3.18)$$

$$E[\Pi_R] = \frac{1}{2} (2R - R^2). \quad (3.19)$$

**When  $\pi \rightarrow 1$ .** We find the following:

$$a_R = \frac{1}{1+\kappa} \left( \frac{1}{1+(1+\kappa)r\sigma_y^2} + \kappa R \right), \quad (3.20)$$

$$b_R = \frac{1}{1+\kappa} \left( R - \frac{1}{1+(1+\kappa)r\sigma_y^2} \right), \quad (3.21)$$

$$B_R = \frac{1}{1+(1+\kappa)r\sigma_y^2}, \quad (3.22)$$

$$E[y_R] = \frac{1}{1+\kappa} \left( \frac{1}{1+(1+\kappa)r\sigma_y^2} \right), \quad (3.23)$$

$$E[\Pi_R] = \frac{1}{2} \left( \frac{1}{1+\kappa} \right) \left( \kappa(2R - R^2) + \frac{1}{1+(1+\kappa)r\sigma_y^2} \right) \quad (3.24)$$

These equations yield the following proposition.

**Proposition 5.** If solvency margin ratio regulation is incorporated, the solutions for  $\kappa \rightarrow \infty$  and for  $\pi \rightarrow 1$  are different.

Now consider the reason why the solutions for  $\kappa \rightarrow \infty$  and for  $\pi \rightarrow 1$  are different. When  $\kappa \rightarrow \infty$ , bad effort results in an approximately infinite cost to the manager. Therefore, the manager will not choose any level of bad effort. From equations (3.15) and (3.16), the manager attempts to meet the solvency margin ratio requirement only by good effort. From (3.21), it is clear that the manager would choose a strictly positive level of bad effort when  $\pi \rightarrow 1$ .<sup>12</sup> From equation (2.4), we find that the level of bad effort and the stock price are unrelated when  $\pi \rightarrow 1$  because bad effort cannot affect the stock price when the market can perfectly distinguish good effort from and bad effort. Increasing the level of bad effort does not increase the level of the manager's compensation. Thus, when capital regulation does not exist or is ineffective (that is,  $R < R_{SB}$ ), the manager will not make bad effort, and therefore the results are the same as for the case of  $\kappa \rightarrow \infty$ . However, if such regulation is effective, the manager may make bad effort because the increase in the level of good effort to meet the solvency margin ratio requirement has both benefits, such as an increase in compensation, and costs, such as additional costs to increase the level of good effort, for the manager.

As equation (2.2) demonstrates, the cost function of the manager's effort is convex, thus the incremental cost for the manager becoming higher as the level of effort increases. Meanwhile, the level of compensation will only increase linearly as the level of good effort increases. When the current level of good effort is higher than a certain threshold, an increment in the level of good effort is too costly, and the manager is better off by choosing a strictly positive level of bad effort, even if the bad effort will not increase compensation. Therefore, the manager chooses a strictly positive level of bad effort in the case of incorporating solvency margin ratio regulation, even when  $\pi \rightarrow 1$ . In other words, the manager adopts a level of bad effort that is just sufficient to meet the solvency margin ratio requirement.

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<sup>12</sup> When  $\pi \rightarrow 1$ ,  $R_{SB} = \kappa / \{ \kappa(1+r\sigma_y^2) \}$ , it is easy to check that  $R_{SB} > 1 / \{ 1+(1+\kappa)r\sigma_y^2 \}$ .

Let us consider the effect of solvency margin ratio regulation in terms of both effort levels and the expected stock price. First, consider how the regulation affects both efforts. Specifically, we analyze the possibility of the level of bad effort decreasing: that is,  $b_{SB} \geq b_R$ , when the regulation is introduced. For this, we derive the following proposition.

**Proposition 6.** There always exists a solvency margin ratio that realizes  $a_{SB} \leq a_R$  and  $b_{SB} \geq b_R$  when the following condition is met:

$$r\sigma_y^2 \leq \frac{\pi(1-\pi)}{\kappa}. \quad (3.25)$$

*Proof.* The above proposition is equivalent to proving the following equation:

$$b_{SB} - b_R = \frac{1}{1+\kappa} \left[ \frac{(1+\kappa)(1-\pi)}{(1-\pi)^2 + \kappa(1+r\sigma_y^2)} - \bar{R} + \frac{\pi^2}{\pi^2 + (1+\kappa)r\sigma_y^2} \right] \geq 0. \quad (3.26)$$

where  $\bar{R}$  is the solvency margin ratio derived by equation (3.26). In addition, we define  $\bar{R} = R_{SB} + \tilde{R}$ , thus yielding:

$$\frac{(1+\kappa)(1-\pi)}{(1-\pi)^2 + \kappa(1+r\sigma_y^2)} - R_{SB} - \tilde{R} + \frac{\pi^2}{\pi^2 + (1+\kappa)r\sigma_y^2} \geq 0. \quad (3.27)$$

Substituting equation (3.2) into (3.27), we obtain:

$$\frac{\pi^2}{\pi^2 + (1+\kappa)r\sigma_y^2} - \frac{\kappa\pi}{(1-\pi)^2 + \kappa(1+r\sigma_y^2)} \geq \tilde{R}. \quad (3.28)$$

In order to calculate the condition that satisfies  $b_{SB} \geq b_R$ , we need to demonstrate a condition wherein the equation is satisfied when  $\tilde{R} = 0$ . This means:

$$\frac{\pi^2}{\pi^2 + (1+\kappa)r\sigma_y^2} - \frac{\kappa\pi}{(1-\pi)^2 + \kappa(1+r\sigma_y^2)} \geq 0. \quad (3.29)$$

After rearranging equation (3.29), we obtain:

$$r\sigma_y^2 \leq \frac{\pi(1-\pi)}{\kappa}. \quad (3.25)$$

When equation (3.25) is satisfied and based also on  $b_{SB} \geq b_R$  and  $a_{SB} + b_{SB} = R_{SB} \leq \bar{R} = a_R + b_R$ , it is clear that  $a_{SB} \leq a_R$ .

Q.E.D.

This proposition can be interpreted as follows. When equation (3.25) is satisfied, introducing an effective solvency margin ratio regulation not only decreases bad effort but also increases good effort. It is also obvious from equation (3.25) that an imperfect market with

higher accounting flexibility (that is, lower  $\kappa$ ) induces a manager's good effort and discourages his or her bad effort.<sup>13</sup>

Under such circumstances, it becomes easier for Japanese insurance companies to maintain an adequate level of solvency margin ratio if they have unrealized gains from securities holdings. It is so because they could easily manipulate earnings by increasing the value of equity capital via liquidation of unrealized capital gains. Prior to the introduction of the Regulation of Accounting for Impairment of Assets, for example, Japanese insurance companies could time the realization of losses by impaired assets to manipulate their accounts, hence the solvency margin ratio requirement.

The International Accounting Standard Board (IASB) published in 2005 the new accounting standard "IFRS 4 Insurance Contracts" for life insurance business. The standard requires fair valuation of a variety of assets and insurance contracts of life insurance companies.<sup>14</sup> Our model demonstrates that changes as a result of implementation of the standard would decrease accounting flexibility (i.e., a higher  $\kappa$ ) and as a result, insurance company managers are likely to make more bad effort and less good effort.

It is worth noting that when  $\pi = 0$  and  $\pi = 1$ , the right-hand side of equation (3.25) becomes zero in both cases.<sup>15</sup> The result of  $\pi = 1$  is reasonable because the market can perfectly distinguish between good effort and bad effort. The result of  $\pi = 0$  is somewhat surprising. In order to better understand it, we partially differentiate equation (3.12) with respect to  $\pi$  such that:

$$\frac{\partial b_R}{\partial \pi} = -\frac{2\pi\sigma_y^2}{[\pi^2 + (1+\kappa)r\sigma_y^2]^2} < 0. \quad (3.30)$$

Unlike  $b_{SB}$ ,  $b_R$  in this equation is a monotonic decreasing function of  $\pi$  and the maximum value of  $b_R$  is realized when  $\pi = 0$ . In other words,  $b_{SB} \geq b_R$  is hardly satisfied when  $\pi$  is low. Thus, as explained earlier,  $b_R$  always has a larger direct effect of  $\pi$  than indirect effect of  $\pi$ .

Next we consider how solvency margin ratio regulation affects the stock price. Specifically, we analyze the possibility of the expected stock price increasing: that is,  $E[y_R] \geq E[y_{SB}]$ , in a market subject to solvency margin ratio regulation. To summarize, we derive the following proposition.

**Proposition 7.** If equation (3.25) is satisfied, the solvency margin ratio regulation always increases the expected stock price: that is,  $E[y_R] \geq E[y_{SB}]$ .

*Proof.* It is easy to calculate the following equation:

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<sup>13</sup> From equation (3.25), the introduction of solvency margin ratio regulation under a perfect market always increases the level of bad effort.

<sup>14</sup> See IAS Plus (<http://www.iasplus.com/standard/ifrs04.htm>) for further details. Ballotta et al. (2005) examined the effects of a fair-value-based accounting system on life insurance companies.

<sup>15</sup> The authors are indebted to an anonymous referee for this insight.

$$E[y_R] - E[y_{SB}] = (a_R - a_{SB}) - (1 - \pi)(b_{SB} - b_R). \quad (3.31)$$

From Proposition 6, we obtain  $0 \leq b_{SB} - b_R \leq a_R - a_{SB}$  when equation (3.25) is satisfied. Hence,  $E[y_R] - E[y_{SB}] \geq 0$ .

Q.E.D.

It is worth noting that when  $\pi = 0$  and  $\pi = 1$ , the right-hand side of equation (3.25) becomes zero in both cases.<sup>16</sup> Below, we consider the effects of  $\pi$  on the manager's effort and the expected stock price.

Changes in the level of  $\pi$  have two different effects. To illustrate these effects, we assume that there exists solvency margin ratio regulation and that  $\pi = 1$ . It is clear from equation (3.12) that the manager chooses a strictly positive bad effort. The reason can be stated as follows. With the regulation, the manager should realize a total effort equaling the level of  $R$ . Since the cost function of his effort is convex and the incremental cost of good effort is very high, it is very costly for the manager to implement additional good effort, although good effort only affects the stock price under  $\pi = 1$ . Thus, the manager adopts some level of bad effort, even though it does not affect the stock price, because the manager needs to achieve a certain level of  $R$  and the cost of implementing incremental bad effort is low. Meanwhile, it is clear from equation (2.16) that the level of bad effort is equal to zero when there is no such regulation. This is the reason why the level of bad effort increases under solvency margin ratio regulation when  $\pi$  is high.

A case exists, however, where the level of manager's bad effort decreases under solvency margin ratio regulation when  $\pi$  is high. To show this, we differentiate equation (3.2) with respect to  $\pi$ :

$$\frac{\partial R_{SB}}{\partial \pi} = \frac{(1 - \pi)^2 + \kappa(1 - 2\pi - r\sigma_y^2)}{[(1 - \pi)^2 + \kappa(1 + r\sigma_y^2)]^2}. \quad (3.32)$$

It is obvious from equation (3.32) that if  $\pi$  is high enough, the condition  $\partial R_{SB}/\partial \pi < 0$  is met.<sup>17</sup> In other words, when  $\pi$  is high enough, i.e., when the market is close to perfection in terms of information revelation and interpretation, a smaller solvency margin ratio is required to promote good effort while discouraging bad effort.

In this regard, solvency margin ratio regulation is desirable only when equation (3.25) is satisfied. Besides, from the above two propositions, we can obtain the following lemma.

**Lemma.** If the manager is risk neutral, there always exists a solvency margin ratio that satisfies  $a_{SB} \leq a_R$  and  $b_{SB} \geq b_R$  and increases the expected stock price without needing any conditions.

<sup>16</sup> The authors are indebted to an anonymous referee for this insight.

<sup>17</sup> When  $\pi > 1 + \kappa - \sqrt{\kappa} \sqrt{1 + \kappa + r\sigma_y^2}$ , then  $\partial R_{SB}/\partial \pi < 0$  is satisfied.



#### **IV. Conclusions**

This study evaluates solvency regulation and its effects on the insurance manager's compensation and allocation of effort as well as shareholders' profits in a market subject to the problem of information asymmetry. The policy implication drawn from this analysis is that regulators may consider using both solvency margin ratio regulation and accounting regulation to decrease bad effort and increase good effort by managers. In a real-world setting, the importance of such regulations in preventing agency problems are revealed to be more critical in our model than in those analyzed in previous studies (e.g., Kojima 2003). The primary findings in this study can be summarized as follows.

First, we conclude that when the market is not perfect and bad effort is costless, the shareholder provides a fixed compensation. That is, if  $\kappa = 0$  and  $\pi < 1$ , then the shareholder offers  $B = 0$ . Under these conditions, there will be no incentive-based compensation plan. Second, when the market is not perfect, we find that the manager always makes bad effort. That is, if  $\pi < 1$ , then  $b_{SB} > 0$ . Third, the regulator can prevent a manager's bad effort by enforcing stringent accounting regulation, since the solutions for  $\kappa \rightarrow \infty$  and for  $\pi \rightarrow 1$  are identical. Fourth, when the levels of accounting regulation and/or stock market perfection increase, the stock price decreases: conversely, when this level decreases, the shareholder's profits increase. We also find that in a market subject to solvency margin ratio regulation, our solutions for  $\kappa \rightarrow \infty$  and for  $\pi \rightarrow 1$  are different, unlike the results without such regulation. Therefore, there always exists a solvency margin ratio that induces a manager's good effort and decreases his or her bad effort: that is,  $a_{SB} \leq a_R$  and  $b_{SB} \geq b_R$ , when certain conditions are met. Also, we demonstrate that an introduction of solvency margin ratio regulation always increases the expected stock price under certain conditions. Finally, we find that there always exists a solvency margin ratio that satisfies  $a_{SB} \leq a_R$  and  $b_{SB} \geq b_R$  and increases the expected stock prices without any conditions when the manager is risk neutral.

Our study has certain limitations. Although we find that solvency margin ratio regulation always increases the expected stock price in our model, this occurs only under certain conditions. We have not analyzed the possibility that the manager, when his or her compensation is tied to the stock price, can hedge the compensation in the capital market, such as buying the company's shares from the market to keep the stock price high.

Future research could extend the model by incorporating other financial (e.g., earnings ratio) and nonfinancial (e.g., balanced scorecard) measures to draw up the manager's compensation contract.<sup>18</sup> Future research may also investigate an optimal compensation scheme for inducing a manager's effort to meet the solvency margin ratio and maximize shareholders' profits.

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<sup>18</sup> Feltham and Xie (1994) and Banker and Thevaranjan (1997) among others have analyzed accounting earnings-based compensation contracts on managers' effort allocation.

Table A1: Solvency Margin Regulation – Government Actions

| Category   | Solvency Margin Ratio  | FSA Action   |
|------------|------------------------|--|
| None       | 200% and over          | No action shall be taken.  |
| Category 1 | 100% to less than 200% | The FSA shall issue a business improvement administrative order to the insurance company in question. The company submits a business improvement plan that the FSA considers appropriate to ensure sound management of the company. Then the FSA will order the implementation of the plan.  |
| Category 2 | 0% to less than 100%   | <p>The FSA shall order measures it deems appropriate from among the following.</p> <ol style="list-style-type: none"> <li>1. Submission of plans considered as appropriate to increase the capability of paying claims etc., and the implementation of these plans.</li> <li>2. Prohibition of payment of stock dividends or directors' bonuses, or constraints on these amounts.</li> <li>3. Prohibition of distribution of dividends or surpluses to policyholders, or constraints on these amounts. (*)</li> <li>4. Alteration of calculation method (including coefficients that form the basis of the calculation) of premium rates concerning new insurance contracts.</li> <li>5. Restraint on operating expenses.</li> <li>6. Prohibition of certain methods of asset investment, or constraint on the amount.</li> <li>7. Reduction of business operations of part of the branch or office.</li> <li>8. Closure of some of the branches or offices, excluding the main office.</li> <li>9. Reduction of business operations at subsidiaries etc.</li> <li>10. Disposal of stock or equities of subsidiaries etc. (*)</li> <li>11. Reduction of existing businesses or prohibition of new businesses, such as businesses ancillary to life or nonlife insurance business, businesses relating to specific securities transactions stipulated in the Securities and Exchange Law, and businesses allowed under other laws.</li> <li>12. Other measures that the supervisory authority considers necessary.</li> </ol> <p>(*) This item is not applicable to foreign insurers operating through branches and agents.</p> |
| Category 3 | Less than 0%           | The FSA shall order partial or total suspension of business operations for a specified period.   |

### Appendix: Solvency Margin Ratio Regulation in Japan

Solvency margin ratio regulation, introduced in Japan in April 1996, identifies the need for early remedial action by the regulated insurance company to achieve a good risk profile.<sup>19</sup>

<sup>19</sup> The description in this section is based on the compilation of information available from the Japanese Financial Services Agency and *General Insurance in Japan: Fact Book 2003–2004*.

With this regulation, the FSA reviews the solvency margin ratios of all insurance companies to monitor their financial stability. This index is calculated as follows.

$$\text{Solvency Margin Ratio (\%)} = \frac{\text{Solvency Margin}}{\text{Risk Amount} \times 1/2} \times 100 .$$

The numerator of the above equation is the total amount required to cover risks that exceed usual estimates. This includes total equities, reserves for fluctuation in value of investments, reserves for catastrophic risk, and so forth. The denominator of the above equation is calculated as follows.

$$\text{Risk Amount} = \sqrt{A^2 + (B + C)^2} + D + E ,$$

where *A* stands for general insurance risk, *B* for assumed interest rate risk, *C* for asset management risk, *D* for business administration risk, and *E* for catastrophe risk.

General insurance risk is the risk of occurrence of claims that exceed the underwriting reserve. Assumed interest rate risk is the risk of not being able to secure the assumed interest rate, which forms the basis of the calculation of the underwriting reserve. Asset management risk includes risk of fluctuation in value, credit risk, risk arising in a subsidiary company, derivative transactions risk, and reinsurance risk. Business administration risk is the risk of occurrence of loss beyond that anticipated. Catastrophe risk is the risk of loss caused by natural catastrophes.

This index enables judgments about whether insurance companies are financially stable. If the ratio is less than 200%, the FSA urges insurance companies to take action to improve their financial stability in order to protect policyholders. The actions stipulated by the Japanese regulator since April 1999 are divided into three categories according to the solvency margin ratio, as shown in Table A1.<sup>20</sup>

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<sup>20</sup> See *General Insurance in Japan: Fact Book 2003–2004*, p. 71.

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