How Do Cost and Regulation Change Loss Control Activities and Insurers’ Monitoring?

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Abstract: This study uses game theory to consider the impact of loss control (LC) and monitoring costs on insurers’ monitoring activities and investigate how the level of the insurance premium changes monitoring activities. The main results are as follows. First, a firm always undertakes LC when the LC cost is low. Second, when the insurer can spontaneously choose the level of the insurance premium, the insurer’s incentive to monitor the firm decreases and LC activities will not be promoted, because the cost of an accident can be directly reflected in the level of the insurance premium. In contrast, when the level of the insurance premium is exogenously decided, the insurer’s incentive to monitor the firm increases and LC activities will be promoted, because the cost of accidents cannot be directly reflected in the level of the insurance premium.

[Key words: loss control, monitoring, deregulation, game theory.]

INTRODUCTION

Underwriting insurance is the core business of insurers. If insurers succeed in reducing the cost of claims paid under a given insurance premium, then insurers will make larger profits. However, is it possible for insurers to reduce the accident rate of insured companies?

Insurers have vast amounts of information from the past payment of insurance claims. For example, insurers know how a ship’s cargo should be stowed so as not to damage the materials inside the crates. Furthermore, they know how companies can avoid gangs of bandits when transporting high-quality electronic sound equipment from a port to a destination on land. In practice, insurers will advise companies not to tell drivers the route

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to the destination in advance because drivers may be involved with gangs of bandits who may wait in ambush to steal the goods. Accordingly, insurers have proprietary know-how regarding loss control (hereafter “LC”) in the industries they cover, and their advice will reduce the accident rates of insured companies.

Insurers will start sharing LC skills after the insured signs the policy because they want to reduce the claims paid and make larger profits. Once insured companies acquire LC skills and follow the LC advice obtained from insurers, insurers can then reduce the claims paid. However, while LC activities in insured firms are effective for reducing claims paid and desirable for insurers, they do involve some costs to the insured (Harrington and Niehaus, 2003: Chapter 1). Therefore, the insured may be reluctant to conduct LC activities that involve a cost because they have already paid insurance premiums.

Because the insured have already paid insurance premiums, they will obtain claims payments if accidents occur. Moreover, purchasing insurance lowers the incentives to reduce risks that have LC costs, because this effort level is not observed by the insurer. This problem is inherent within the insurance industry and is known as the moral hazard problem. It has traditionally been one of the main topics in the economics and insurance fields. To handle the moral hazard problem, insurers have created devices to provide incentives to reduce accidents, such as deductible, coinsurance, and upper limits on coverage in the individual insurance market. While deductible, coinsurance, and upper limits on coverage reduce insurance premium payments, the basic purpose of them may be to reduce moral hazard in the individual insurance market.

Devices such as deductible are more frequently used in the corporate insurance market but the primary purpose of their use is to reduce the size of insurance premiums. For example, insurers do not cover petty claims under deductible so that the insured firm pays for small damages itself, meaning that such limited coverage allows lower insurance premiums. Therefore, deductible functions mainly as a tool for lowering insurance premiums, not as a monitoring device in the corporate insurance market. However, this does not necessarily mean that monitoring mechanisms do not exist in the corporate market, but rather that other monitoring mechanisms must be used.

In the corporate insurance market, the number of insured firms is usually small compared with the number of insured households. Hence, it is possible for insurers to monitor the corporate insured and accept monitoring costs because the level of the insurance premium for a firm is larger than that for a household. In fact, Shleifer and Vishny (1986) focused on the relationship between monitoring incentives and stakes. Thus,
monitoring can be an important device for alleviating the moral hazard problem in the corporate insurance market.

However, although previous studies (Chiappori and Salanié, 2000; Dionne et al., 2001; Saito, 2006) have focused on the relationship between the insurer and the individual insured, few studies, except Yamori (1999) and Kelly and Kleffner (2003), have focused on the relationship between the insurer and the corporate insured. Monitoring usually means the insurers monitor the insured so that they do not make a behavioral change after they purchase insurance. In this article, monitoring is defined as a series of activities in which insurers advise the insured in order to reduce the loss ratio and then require the insured to implement LC activities.

Furthermore, while several previous studies focused on the optimal level of LC in various situations (Ehrlich and Becker, 1972; Dionne and Eeckhoudt, 1985; Hiebert, 1989), how changes in the insurance market, such as deregulation, affect the level of LC in the insured firm has not yet been explored.

Recently, insurance industries around the world have undergone deregulation. For example, Saito (2006) analyzed the impact of deregulation on insurance premium in the Japanese insurance industry. Yamori and Kobayashi (2004) examined the impacts of deregulation and US–Japan insurance talks. Cummins and Rubio-Misas (2006) analyzed the impact of deregulation on the Spanish insurance industry and found that insurers experienced consolidation and improved efficiency after deregulation. Zweifel and Lehmann (2004), Zweifel (2006), and Zweifel et al. (2006) are studies that considered regulation. Despite the significance of the deregulation effect, there have been few theoretical studies investigating the effect of deregulation on the insurance industry.

This article considers the impact of LC and monitoring costs on insurers’ monitoring activities and investigates the relationship between LC, monitoring activities, and the level of the insurance premium. We introduce a theoretical model to analyze the situation in which a firm undertakes LC to lower its accident probability, and the insurer monitors the firm to see whether it actually engages in LC. The theoretical model also shows the impacts of insurance premiums in two cases: where the insurer can spontaneously choose the level of the insurance premium, and where the premium decision is exogenous to the firm.

This article is organized as follows. Section 2 surveys previous studies and applications of game theory in the insurance literature. Section 3 analyzes the basic model. Section 4 considers the optimal insurance coverage rate. Section 5 concludes with a discussion on the implications of the findings.
INSURANCE STUDIES AND GAME THEORY

Game theory has been traditionally applied to analysis of the insurance industry. For example, Williams and Dickerson (1966) used game theory to investigate a problem regarding insurance consumption. As the authors mentioned, game theory was a relatively new method of quantitative analysis at that time.

Miller (1972) tried to found optimal insurance contracts by using game theory with the zero-sum assumption. Kihlstrom and Roth (1982) showed that insurers prefer to bargain with the more risk averse of any two potential clients, because that client will agree to spend more than will a less risk averse client within a game-theoretic model. They also found that analysis with game theory leads to results that differ from those obtained in a competitive insurance market. In sum, game theory has been used to focus on general problems in the insurance industry and has widely contributed to the understanding of the characteristics of insurance, policyholders, and insurance contracts.

Recently, studies have focused on more specific problems in the insurance industry by using game theory. Posey (1998) focused on the decision of a claimant to obtain legal counsel, the timing of this decision, and the impact on the settlement amount an insurer can successfully offer. Mao and Ostaszewski (2007) formulated different pricing models for a participating deferred annuity based on customers’ preferences concerning benefits and risks by using game theory.

There are a few studies that focused on the relationship among insurers and between insurers and firms. For example, Okura (2007) examined how cooperation affects the level of investment in Japanese insurers by using game theory. Kelly and Kleffner (2003) is similar to this article, in that they examined the interaction between the premium rates set by an insurer and the incentives of an individual to purchase market insurance and undertake mitigation to reduce the size of a potential loss. However, their article differs from ours as their primary focus is not the impact of political changes such as deregulation on the insurance industry and insured firms, but rather loss mitigation to reduce expected losses from natural disasters. Furthermore, they focused only on the situation where insurers can set insurance premiums, while this article focuses on both situations in which insurers can and cannot set insurance premiums. Hence, we try to contribute to lines of studies on impacts of deregulation on the insurance industry and LC activities in the insured firm.

This article uses game theory to analyze the activities of insurers and individuals. Game theory can shed light on situations where firms and other organizations are faced with strategic interactions in which
individual action directly affects the payoff of others (Shy, 1995: Chapter 11). In the insurance industry, the number of insurers is limited, as Fuku-
yama and Weber (2001), Barros et al. (2005), and Nektarios and Barros (2010) indicated, suggesting that the market structure is often oligopolistic or not perfect competition. Furthermore, the relationship between the insurer and policyholders becomes repeating and often exclusive. Therefore, analysis under the perfect competition assumption may be inappropriate.

In our setting, the insurer considers the individual's actions when determining its own actions, because the utilities of both are closely related not only to its own decisions but also to those of others. For example, when an insurer chooses a higher insurance premium, an individual tends to choose a lower insurance coverage rate and vice versa.

Furthermore, game theory permits us to examine a complex situation by analyzing it in an analytical fashion. In the terminology of game theory, a situation that includes an individual's LC activities and an insurer's monitoring can be depicted as an extensive-form game. Such a game can be solved using backward induction, which means solving the optimal choice of the final stages in all possible situations and then working backward to compute the optimal choice (Fudenberg and Tirole, 1991: 68–69). Thus, we can analyze a situation stage by stage even if it is very complex. This makes game theory the appropriate tool for analyzing complex situations.

THE BASIC MODEL

Suppose that there is one firm that may undertake LC in order to lower its accident probability, and one insurer that sells insurance products to the firm.

In this context, we develop the following five-stage game. In the first stage, the level of the insurance premium, denoted by \( p > 0 \), is decided. If an accident occurs, fixed damage, denoted by \( D > p \), is realized. In our model, we consider two situations in relation to the level of the insurance premium: where the insurer can spontaneously choose the level of the insurance premium, and where it is exogenously decided by a regulator or market conditions such as competitive pressure.

In the second stage, the firm chooses the insurance coverage rate, denoted by \( \alpha \in [0,1] \), after observing the level of the insurance premium.

In the third stage, the firm chooses whether it undertakes LC. The LC cost is denoted by \( c_F > 0 \). \( \pi_N \) and \( \pi_L \) are the accident probabilities before and after LC, respectively. Furthermore, we assume that \( 0 < \pi_L < \pi_N < 1/2 \). The assumption \( \pi_L < 1/2 \) is derived from the condition that the expected utility
of the insurer is nonnegative, that is, \((1 - \pi_i) \alpha p - \pi_i aD \geq 0 \Rightarrow \pi_i \leq p/(p + D) < 1/2\).

In the fourth stage, the insurer chooses whether to monitor the firm. If the insurer chooses to monitor, it knows whether the firm undertook LC in the final stage. The monitoring cost is denoted by \(m > 0\). If the insurer monitors and knows the firm did not undertake LC in the final stage, the insurer can compel the firm to undertake LC in this stage. Although the effect of LC is the same, this LC cost is different and is denoted by \(c_j > c_f\). Thus, if the insurer monitors and the firm is aware of this, the firm always undertakes LC in the final stage.

In the fifth stage, nature chooses whether an accident occurs. If an accident occurs, the insurer pays an amount of insurance in proportion to the insurance coverage rate.

This game can be categorized as a dynamic game and can be solved by backward induction. Backward induction is a method that derives the equilibrium in the final stages given the decisions in the previous stages. Because the third and fourth stages involve simultaneous moves, and the fifth stage is the nature-decision stage, we first consider the final three stages given the outcomes in the first and second stages. After that, we derive the optimal insurance coverage rate in the second stage. Finally, we investigate the first stage and discuss the differences between the two situations in the first stage.

In order to analyze the final three stages, we first assume that the insurer is risk neutral and the firm is risk averse. \(u(\bullet)\) represents the utility function of the firm with \(u' > 0\) and \(u'' \leq 0\).

There are four possible outcomes in the final three stages. For simplicity of representation, we define \(u_t \equiv u(W - \alpha p - D + \alpha D)\) and \(u_0 \equiv (W - \alpha p)\), where \(W > 0\) represents the initial wealth of the firm. \(EU_{j,k}^{i}\) denotes the expected utility. \(j \in \{F,I\}\) indicates the firm (F) or insurer (I). \(k \in \{M,N\}\) indicates whether the firm undertakes LC (L) or not (N). \(l \in \{M,N\}\) indicates whether the insurer monitors (M) or not (N). Therefore, e.g., \(EU_{MN,F}^{i}\) represents the expected utility of the firm when the firm undertakes LC and the insurer does not monitor.

The four possible outcomes can be written as follows.

**Case 1:** The firm undertakes LC in the third stage and the insurer does not monitor.

\[
EU_{MN,F}^{i} = \pi_L u_1 + (1 - \pi_L) u_0 - c_F, 
\]

\[
EU_{MN,I}^{i} = \pi_L (\alpha p - \alpha D) + (1 - \pi_L)(\alpha p) = \alpha(p - \pi_L D). 
\]
Case 2: The firm undertakes LC in the third stage and the insurer monitors.

\[ EU_{MM}^F = \pi_L u_1 + (1 - \pi_L)u_0 - c_F, \]  

\[ EU_{MM}^I = \pi_L (\alpha p - \alpha D - m) + (1 - \pi_L)(\alpha p - m) = \alpha (p - \pi_L D) - m. \]  

Case 3: The firm does not undertake LC in the third stage and the insurer does not monitor.

\[ EU_{NN}^F = \pi_N u_1 + (1 - \pi_N)u_0, \]  

\[ EU_{NN}^I = \pi_N (\alpha p - \alpha D) + (1 - \pi_N)(\alpha p) = \alpha (p - \pi_N D). \]  

Case 4: The firm does not undertake LC in the third stage and the insurer monitors.

\[ EU_{NM}^F = \pi_L u_1 + (1 - \pi_L)u_0 - c_I, \]  

\[ EU_{NM}^I = \pi_L (\alpha p - \alpha D - m) + (1 - \pi_L)(\alpha p - m) = \alpha (p - \pi_L D) - m. \]  

These four possible outcomes are presented in Table 1.  

**Table 1. Possible outcomes of firm and insurer**

<table>
<thead>
<tr>
<th>Firm</th>
<th>Monitoring</th>
<th>Not monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>LC</td>
<td>( EU_{MM}^F, EU_{MM}^I )</td>
<td>( EU_{MN}^F, EU_{MN}^I )</td>
</tr>
<tr>
<td>Not LC</td>
<td>( EU_{NM}^F, EU_{NM}^I )</td>
<td>( EU_{NN}^F, EU_{NN}^I )</td>
</tr>
</tbody>
</table>

It is obvious that \( EU_{MM}^F > EU_{NN}^F \) and \( EU_{MM}^I > EU_{NN}^I \). Thus, the equilibrium of the table is decided by the two relationships between \( EU_{MN}^F \) and \( EU_{NM}^I \), and \( EU_{NN}^F \) and \( EU_{NN}^I \).

First, consider the situation in which \( EU_{MN}^F > EU_{NN}^F \), which means \( c_F \) is relatively low because this inequality is satisfied when \( c_F < (\pi_N - \pi_L)(u_0 - u_1) \). In this situation, the firm undertakes LC, because LC becomes the dominant strategy. Then, the insurer never monitors. Thus, Case 1 is realized in this situation.
Next, consider the situation in which \( EU_{NN}^{MM} < EU_{NN}^{NM} \), which means \( m \) is relatively high because this inequality is satisfied when \( m > \alpha D (\pi_N - \pi_I) \). In this situation, the insurer never monitors, because not monitoring becomes the dominant strategy. Then, the firm undertakes LC only if it has a voluntary incentive to do so, indicated by \( EU_{NN}^{MN} > EU_{NN}^{NN} \). Thus, Case 1 is realized when \( EU_{NN}^{MN} > EU_{NN}^{NN} \), and Case 3 is realized when \( EU_{NN}^{MN} < EU_{NN}^{NN} \).

Finally, consider the situation in which \( EU_{NN}^{MN} \leq EU_{NN}^{NN} \) and \( EU_{NN}^{NM} \geq EU_{NN}^{NN} \). In this situation, the firm does not have a voluntary incentive to undertake LC, but the insurer may monitor. Thus, the firm undertakes LC because of the possibility of monitoring by the insurer. It is easy to verify that there is no pure strategy Nash equilibrium in this situation. In other words, both the firm and the insurer randomly choose LC and the monitoring indicated by the mixed strategy Nash equilibrium. Let \( s_F \) and \( s_I \) be the probabilities that the firm undertakes LC and that the insurer monitors, respectively. Then, the mixed strategy Nash equilibrium can be computed as follows:

\[
\begin{align*}
    s_F^* EU_{NN}^{MM} + (1 - s_F^*) EU_{NN}^{NM} &= s_F^* EU_{NN}^{MN} + (1 - s_F^*) EU_{NN}^{NN} \\
    \Rightarrow s_F^* &= 1 - \frac{m}{\alpha D (\pi_N - \pi_I)}, \\
    s_I^* EU_{NN}^{MM} + (1 - s_I^*) EU_{NN}^{MN} &= s_I^* EU_{NN}^{MN} + (1 - s_I^*) EU_{NN}^{NN} \\
    \Rightarrow s_I^* &= 1 - \frac{c_I - c_F}{c_I - (\pi_N - \pi_L) (u_0 - u_1)},
\end{align*}
\]

(9)

(10)

where superscript “*” indicates the equilibrium value. Using equations (9) and (10), each expected utility can be written as:

\[
\begin{align*}
    EU_f &= s_F^* s_I^* EU_{MM}^F + s_F^* (1 - s_I^*) EU_{MN}^F + (1 - s_F^*) EU_{NN}^F + \\
    & (1 - s_F^*) (1 - s_I^*) EU_{NN}^F = \pi_I u_1 + (1 - \pi_I) u_0 - c_F, \\
    EU_i &= s_F^* s_I^* EU_{MM}^I + s_F^* (1 - s_I^*) EU_{MN}^I + (1 - s_F^*) s_I^* EU_{NN}^I + \\
    & (1 - s_F^*) (1 - s_I^*) EU_{NN}^I = \alpha (p - \pi_L D) - m.
\end{align*}
\]

(11)

(12)

Thus, we find that each expected utility is equal to that in Case 2, although both the firm and insurer randomly choose LC and monitoring. The results of the analysis in the final three stages can be summarized as follows.
Proposition 1:

There are the following three kinds of equilibrium in the last three stages. (1) When the LC cost is relatively low, the firm undertakes LC and the insurer does not monitor, regardless of the monitoring cost. (2) When both the LC and monitoring costs are relatively high, the firm does not undertake LC and the insurer does not monitor. (3) When the LC cost is relatively high and the monitoring cost is relatively low, both the firm and insurer randomly choose whether to undertake LC and monitor, respectively.

Furthermore, both expected utilities are equal to those in the case where the firm and insurer choose LC and monitoring. Table 2 summarizes the proposition.

Table 2. Equilibrium in high/low loss control and monitoring costs

<table>
<thead>
<tr>
<th>m</th>
<th>cF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Low</td>
<td>Case 1</td>
</tr>
<tr>
<td>High</td>
<td>Case 1</td>
</tr>
</tbody>
</table>

THE INSURANCE PREMIUM AND LOSS CONTROL

Next, consider the optimal insurance coverage rate in the second stage. As we discussed in the last section, Case 1, 2, or 3 may be realized. Thus, we have to consider the optimal insurance coverage rate in these three cases. For deriving the optimal insurance converge rate, we derive the following approximated certainty equivalent of the firm in the three cases, $CE_F^{MN}$, $CE_F^{MM}$, and $CE_F^{NN}$, as follows:

$$CE_F^{MN} = W - \alpha p - \pi_L(1-\alpha)D - \frac{r}{2}\pi_L(1-\pi_L)(1-\alpha)D^2 - c_F,$$  \hspace{1cm} (13)

$$CE_F^{NN} = W - \alpha p - \pi_N(1-\alpha)D - \frac{r}{2}\pi_N(1-\pi_N)(1-\alpha)D^2,$$  \hspace{1cm} (14)

where $r \geq 0$ is the degree of absolute risk aversion of the firm. Proofs of equations (13) and (14) appear in the appendix.

The firm chooses the insurance coverage rate to maximize its own expected utility given the level of the insurance premium. Suppose that $p_i$
and $\alpha_i$ are the level of insurance premium and insurance coverage rate when the insurer assumes that the firm undertakes LC ($i = L$) and does not undertake LC ($i = N$). Then, the first-order condition of both equations (13) and (14) can be written as:

$$-p_i + \pi_i D\{1 + (1 - \pi_i)(1 - \alpha_i)rD\} = 0.$$  

(15)

From equation (15), the optimal insurance coverage rate is:

$$
\alpha_i = \frac{\pi_i D\{1 + (1 - \pi_i)rD\} - p_i}{\pi_i(1 - \pi_i)rD^2}.
$$  

(16)

The possible level of the insurance premium ranges from $p_i^{\text{min}} = \pi_i D$ to $p_i^{\text{max}} = \pi_i D\{1 + (1 - \pi_i)rD\}$, because $\alpha_i^* \in [0,1]$, by definition. There is no possibility of realizing $p_i < p_i^{\text{min}}$, because $p_i^{\text{min}} = \pi_i D$ means an actuarially fair insurance premium. Furthermore, there is no possibility of realizing $p_i > p_i^{\text{max}}$, because the expected utility of the firm is equal to the reservation utility, which can be represented by the certainty equivalent in the case of $\alpha_i = 0$ when $p_i^{\text{max}} = \pi_i D\{1 + (1 - \pi_i)rD\}$.

Finally, we consider the level of the insurance premium in the first stage. First, we investigate the case in which the insurer can spontaneously choose the level of the insurance premium. Substituting equation (16) into the expected utility of the insurer (e.g., equation (2)), we get:

$$EUI_i = \frac{\pi_i D\{1 + (1 - \pi_i)rD\} - p_i}{\pi_i(1 - \pi_i)rD^2} (p_i - \pi_i D) - m.$$  

(17)

(If the insurer does not monitor, $m$ disappears.)

The first-order condition can be written as:

$$-2p_i + \pi_i D\{2 + (1 - \pi_i)rD\}
\frac{\pi_i(1 - \pi_i)rD^2}{\pi_i(1 - \pi_i)rD^2} = 0.$$  

(18)

Then, we show:

$$p_i^* = \pi_i D\left\{1 + \frac{1}{2}(1 - \pi_i)rD\right\}.$$  

(19)

This equilibrium insurance premium is feasible because $p_i^{\text{min}} < p_i^* < p_i^{\text{max}}$. Furthermore, equation (19) means $p_i^*$, which is the equilibrium insurance
premium when the insurer assumes that the firm undertakes LC, is lower than $P_{N}$, which is the equilibrium insurance premium when the insurer assumes that the firm does not undertake LC.

Substituting equation (19) into equation (16), we obtain:

$$
\alpha_i = \frac{1}{2}.
$$

(20)

Finally, from equations (17), (19), and (20), the equilibrium expected utility of the insurer becomes:

$$
EU_I = \frac{1}{4}\pi_i(1 - \pi_i)rD^2 - m.
$$

(21)

In this case, the following characteristic of the equilibrium expected utility of the insurer is very interesting:

$$
\frac{\partial EU_I}{\partial \pi_i} = \frac{1}{4}(1 - 2\pi_i)rD^2 > 0.
$$

(22)

Equation (22) means that the equilibrium expected utility of the insurer is an increasing function of the accident probability when the insurer can spontaneously choose the level of the insurance premium. The reason for this result can be explained by the advantages and disadvantages of the insurer when the accident probability rises. It is easy to intuit that the disadvantage is an increase in the expected amount of insurance. In contrast, the advantage is an increase in the income variance (uncertainty) of the firm. Increasing the income variance of the firm increases the risk premium, denoted by $(r/2)\pi_i(1 - \pi_i)(1 - \alpha)D^2$, including the expected utility. This means the insurer can set a higher insurance premium, because the reservation utility of the firm rises when the accident probability rises. Thus, when the insurer can choose spontaneously the level of the insurance premium, it receives higher expected utility when the accident probability is high. The results of this analysis can be summarized as follows.

**Proposition 2:**

*Suppose that the insurer can spontaneously choose the level of the insurance premium. Then, the insurer receives higher expected utility when the accident probability is high.*

Next, consider the case in which the level of the insurance premium is exogenously decided. As mentioned above, if the insurer spontaneously chooses the level of the insurance premium, it can set a higher insurance
premium in proportion to a higher accident probability, and it increases its expected utility. Thus, if the insurance premium is exogenously determined, the insurer cannot expect the higher accident probability associated with the firm through the higher insurance premium.

In order to investigate the change in the expected utility of the insurer when the accident probability changes, we differentiate its expected utility with respect to \( \pi_i \) to obtain:

\[
\frac{\partial EU_i}{\partial \pi_i} = -D + \frac{1}{D^2} \left\{ -\frac{(D - p_i)}{r(1 - \pi_i)^2} + \frac{p_i^2}{r} \right\}.
\]  

(23)

The sign of equation (23) is ambiguous. However, we find there is a unique \( p_i \) that satisfies \( \partial EU_i / \partial \pi_i = 0 \), which is denoted by \( p^* \), because:

\[
\frac{(\partial EU_i) / (\partial \pi_i)}{\partial p_i} = \frac{2\{(1 - 2\pi_i)p_i + \pi_i^2 D\}}{\pi_i^2 (1 - \pi_i)^2 r D^2} > 0,
\]  

(24)

\[
\left. \frac{\partial EU_i}{\partial \pi_i} \right|_{p = p_{\text{min}}} = -D < 0,
\]  

(25)

\[
\left. \frac{\partial EU_i}{\partial \pi_i} \right|_{p = p_{\text{max}}} = D\{1 + (1 - 2\pi_i)r D\} > 0.
\]  

(26)

When the exogenous insurance premium is \( p_i < p^* \), then \( \partial EU_i / \partial \pi_i < 0 \). In contrast, when the exogenous insurance premium is \( p_i > p^* \), then \( \partial EU_i / \partial \pi_i > 0 \). Thus, if the exogenous insurance premium is low, the insurer receives higher expected utility when the accident probability is low because the cost of the accident cannot be directly reflected in the level of the insurance premium. The results of this analysis can be summarized as follows.

**Proposition 3:**

Suppose that the level of the insurance premium is exogenously decided. If the exogenous insurance premium is low, the insurer receives higher expected utility when the accident probability is low. In contrast, if the exogenous insurance premium is high, the insurer receives higher expected utility when the accident probability is high.

“Exogenous insurance premium” has the following perspectives. It is easy to imagine that an exogenous insurance premium can be realized through insurance premium regulation. Actually, the insurance premium in Japan was strongly regulated and very high before the insurance busi-
ness law was amended in 1996. For example, a cartel-style insurance premium setting decision was permitted in the nonlife insurance market before 1996. The results of our analysis suggest that this regulation might promote the situation in which the expected utility of the insurer is an increasing function of the accident probability because the insurance premium decided by the regulator was expected to be high to satisfy $p_i > p_r$.

Another perspective can be obtained in terms of the effect of competitive pressure. An increase in the competitive pressure makes it more difficult for insurers to set desirable insurance premiums. However, deregulating the regulations for new entry into the insurance market promotes lower insurance premiums through competitive pressure. Thus, the results of our analysis suggest that deregulation might promote the situation in which the expected utility of the insurer is a decreasing function of the accident probability because the insurance premium decided by the market is expected to be low to satisfy $p_i < p_r$. In other words, deregulating the insurance market changes the effect of the accident probability on the expected utility of the insurer.

**CONCLUDING REMARKS**

This article provided a new perspective on the corporate insurance market and considered the impact of LC and monitoring costs on insurer’s monitoring activities. Furthermore, we investigated the relationship between LC and monitoring activities and setting the level of the insurance premium.

The main results of this article are as follows. First, a firm always undertakes LC when the LC cost is low. Thus, LC activities reduce accident probabilities in the firm. Second, when the insurer can spontaneously choose the level of the insurance premium, the insurer receives higher expected utility when the accident probability is high because the insurer can set a higher insurance premium. That is, the insurer can collect a higher insurance premium under a deregulated market, when the accident rate is high. In contrast, when the level of the insurance premium is exogenously decided, the insurer receives higher expected utility when the accident probability is low in the case of a lower exogenous insurance premium because the cost of the accident cannot be directly reflected in the level of the insurance premium. In other words, the insurer cannot collect a higher insurance premium under a regulated market or perfect competition, when the accident rate is high. Thus, the insurer’s incentive to engage in LC activities is high.
These results have the following implications for policy making. First, this article shows that insurers can choose the level of the insurance premium in a deregulated market but not in a highly competitive market. In a partially deregulated market, the cost of accidents can be directly reflected in the level of the insurance premium because insurers can set higher insurance premiums if the accident rate is high. That is, the insurer’s incentive to monitor the firm and LC activities will not be promoted. The situation in which insurers do not monitor the firm and the firm does not undertake LC is not socially preferable because the number of accidents in the firm will not be reduced, as Kelly and Kleffner (2003) mentioned. Hence, the implication from the analysis in this article is that partial deregulation (not heavily regulated but not perfect competition) is not desirable, and the financial authorities should immediately implement deregulation once they start moving from plan to action.

Second, these findings in our article can be tested empirically. Deregulation in the insurance industry is in process around the world but the deregulation process may differ across countries. For example, while insurance products began to be sold in Japanese banks in a step-by-step manner from 2001, with the process being completed in 2007, different measures may be undertaken in other countries. Therefore, differences in the deregulation process across countries may lead to different results in each country and it may be incorrect to make conclusions about the impacts of deregulation using evidence from a single country. Thus, more studies on the impacts of deregulation are necessary.

Third, this article indicated that insurers cannot choose the level of the insurance premium in a regulated market. In a similar way, insurers cannot choose the level of the insurance premium in a highly competitive market such as perfect competition. The most important point in this study is that insurers cannot choose the level of the insurance premium in both a regulated market and a competitive market. That is, insurers behave in the same way in both regulated and competitive markets in our model; however, the reason is quite different. Therefore, insurers start monitoring the firm and the firm undertakes LC, meaning that the accident probability in the firm will be reduced. Hence, although Cummins (2002) found that deregulation leads to lower productivity growth, the implication of our analysis is that regulation and perfect competition lead to increases in monitoring and LC activities in our model. In sum, perfect competition in the insurance industry is the most desirable in terms of productivity change and LC activities.

Fourth, the firm always undertakes LC activities when LC costs are low. As LC activities reduce the accident probabilities in the firm, permanently lower LC costs are desirable. Therefore, some measures and policies
should be taken to lower LC costs. For example, we can set up relevant associations that offer a platform for firms to exchange useful information with each other and/or reduce taxes for investments that lower LC costs.

Finally, as Harrington and Niehaus (2003: Chapter 1) described, LC activities are one of the most important tools for risk management. However, studies and/or practical information about LC activities within firms and monitoring activities by insurers have not been accumulated adequately by practitioners and researchers; therefore, we have only limited information on these activities. Thus, information on LC activities by firms and monitoring activities by insurers is required. Furthermore, while this article focused on firms’ LC activities, insurers’ monitoring activities, and regulation by using game theory, the number of theoretical and empirical studies on the relationship between an insurer and a firm is rather limited. Therefore, the relationship between an insurer and a firm is also a fruitful area for future research.

REFERENCES


APPENDIX

According to Pratt (1964), the approximated certainty equivalent of the firm in Case 1 (and Case 2) is:

\[ CE_F^{MN} = EP_F^{MN} - \frac{1}{2} Var(P_F^{MN}) - c_F, \]  

(A1)

where \( EP_F^{MN} \) represents the expected payoff, and \( P_F^{MN} \) represents the (variable) payoff. \( Var(\bullet) \) denotes the operator of the variance.

First, \( EP_F^{MN} \) can be computed as:

\[ EP_F^{MN} = W - \alpha p - \pi_R(1 - \alpha)D. \]  

(A2)

Second, \( Var(P_F^{MN}) \) can be computed as:

\[ Var(P_F^{MN}) = \pi_R \{(W - \alpha p - D + \alpha D) - EP_F^{MN}\}^2 + (1 - \pi_R)\{(W - \alpha p) - EP_F^{MN}\}^2 \]

\[ = \pi_R(1 - \pi_R)\{(1 - \alpha)D\}^2. \]  

(A3)

By substituting equations (A2) and (A3) into equation (A1), equation (13) can be derived. Furthermore, equation (14) can be derived in the same manner. \( Q. E. D. \)