Claim Cost Information Constraint and Solvency Regulation in Property-Liability Insurance Industry

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摘要

本文之主要目的在於探討損失成本資訊限制對於產險清償法規之影響。傳統上保險費率之附加費率採用淨費率之一固定百分比，保險人容易高估損失成本以提高費率，對於消費者並不公平。而近日開放彈性費率，其目的原在於促進保險人之經營效率，卻造成保險人之殺價競爭，導致清償能力不足之現象，危及被保人之損失保障。因此監理機關必須謹慎設計彈性費率模型，以減少保險人失去清償能力之機會。

由於產險理賠過程之延長，實際損失成本無法在當年度完全確定，而必須以準備金方式作爲理賠成本之估計，因此實務上損失準備金往往容易受到保險人之操縱，以配合其本身之財務目標。根據先前文獻之研究，失去清償能力之主因在於準備金提存不足，因此本文藉由代理理論 (agency theory)，提出一具有誘因作用之附加費率模式，說明監理機關如何借助彈性附加費率誘導保險人確實提列準備金。

根據研究結果，本文認爲監理機關可採用二階段策略，以減少保險人無力清償之危險。首先是在期初之費率規章上重新設計，對於保險產品之附加費率除費用與基本利潤外，尚應包含一額外利潤或罰款，以誘導保險人誠實提列損失準備金。但是期初無法觀察準備金之造假程度，因此監理機關可於期末財務檢查時，對於準備金提列不足之保險人予以罰款。在此種誘因設計 (incentive scheme) 下，保險人將重新評估其預期利潤，並且發現造假並未能增加利潤，因而不再低報損失準備金。

本文建議監理機關可藉由異常之投資利潤以計算誘因比例，因爲低報準備金之主要目的多爲追求投資利潤。最後，並建議可將此罰款視爲資本額之應增加額度，以反應失去清償能力之潛在風險，此結論與近日所倡導之危險基礎資本額度(risk-based capital, RBC) 觀念一致，但可提供較完整之理論基礎，改善 RBC 在實務應用上之限制。

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Abstract

The primary purpose of this paper is to develop a theoretical analysis for insurance solvency regulation with an incentive issue under asymmetric information structure. In this paper "information" is emphasized on loss reserves which are the most critical factor for insolvency risk in property-liability insurance industry. Based on the agency theory for regulatory economics, this paper discusses the information costraint of claim cost to the regulator and analyzes the incentive scheme in profit loading allowance for inducing the adequate loss reserves.

According to the finding of this study, we suggest that the regulator may adopt a two-step approach to achieve this objective. First, induce the true reporting of claim cost estimation by redesigning the profit loading allowance with an incentive scheme at the beginning of year. Second, penalize the deficiency of loss reserves by requesting an increase in capital contribution at the end of year. The results show that the incentive rate in pricing formula and the request of capital increase are related to the manipulation level of loss reserves. There is no advantage for manipulation and underpricing when the solvency regulation is developed based on such incentive scheme, which helps to reduce the risk of insolvency.

I. Introduction

The characteristic of insurance products is that the insured pays premiums in advance and collects the loss payments thereafter in case the claims incurred. Therefore the value of insurance policy highly depends on the solvency of insurer. Solvency is defined as a positive surplus (equity) level, i.e., the asset is greater than the liability.[1] When the asset is not sufficient to pay the liability, the insurer becomes insolvent. In order to protect the policyholders, the financial performance of an insurance company is strictly monitored by the government. Some detective and early warning systems have been developed and all insurance companies are examined periodically by the regulatory authorities. Therefore, solvency surveillance can be the most important task of insurance regulators.

Even if there exist serious regulatory concern for the financial condition of the insurers, the number of insolvency cases for property-liability insurance industry has dramatically increased from the mid-1980's. This phenomenon calls attention on the cause of insolvency and provokes to modify the regulatioin of solvency.

In addition to the economic factors(e.g., the downside of investment market), one of the fundamental reasons for the insolvency of insurance companies is the inadequate incentive scheme inside the solvency regulation. That is, the solvency regulation does not take into account the differences of risk level among the insurers. Some recent reforms of insurance regulation began to concern this problem and proposed new models with risk differences of insurers. For example, the concept of risk-based capital (RBC) has been adopted by the insurance commissioner as a requirement for the insurers, and it will be effective for property-liability insurance industry from 1994 (see Cummins, Harrington and Niehaus,1993).

Once an insurer becomes insolvent, not only the policyholders but also the general taxpayers may incur additional cost. Although there are guaranty funds to compensate the policyholders for part of the unpaid claims, the inadequacy of incentive scheme also exists inside the insurance guaranty funds. The assessment approach of graranty funds in fact creates the incentive of insolvency for the irresponsible insurers because the cost of unpaid claims has been shifted to other parties. Therefore, the guaranty funds do not solve the problem of insolvency, but transfer the cost of insolvency to the surviving insurers, policyholders and taxpayers due to the improper incentive scheme. Barrese and Nelson (1994) have shown the significant impact of guaranty funds on those parties. It becomes necessary to redesign the solvency regulation system with a consistent incentive scheme. A theoretical model of risk-based premiums for guaranty funds has been suggested by Cummins (1988), which may help to solve the problem of conflicts incentives.

In theory, the RBC requirement or risk-based premiums for guaranty funds (RBP) can solve the incentive conflicts and help to reduce insolvency once the risk level is determined. In practice, the remaining question is how the regulators decides the true risk levels of the insurers. Numerous studies have contributed to develop the analytical methodoloty and test of predication accuracy to distinguish the financial strength of insurers, for example, Munch and Smallwood (1982), and Cummins, Harrington, and Klein (1995). These methods all are based on the data of financial statements of the insurers. Therefore, the truth of the reported accounting data becomes the critical point when applying these prediction methods to the solvency monitoring system.

A major deterrent for monitoring the financial condition of an insurance company is the asymmetric information between the regulator and the insurer. In fact, most of the regulated industries encounter the same problem that the regulator does not have full information about the firm and can examine the performance only based on the accounting reports, as indicated in the study by Laffont and Tirole (1986). To reduce the risk of default, the solvency regulation must be designed with an incentive scheme to induce truthful reportng so that the regulator can find the potential problems of the insurer. To sum up, the requirement of RBC or RBP becomes meaningful only if the truthful financial reports are available.

Provided the truthful reporting and correct evaluation of risk are given, the next step of solvency regulation is to request the insurer to maintain sufficient surplus level because capital adequacy remains the fundamental method to provide protection against the risk of insolvency and failure for an insurance company. The function of capital is to absorb unanticipated losses with enough margin to inspire confidence and enable a financial institute to continue the business (Saunders, 1994). Capital provides a source of funds in addition to premiums written to protect the policyholders, the insurer, and the regulator against the risk of insolvency. Therefore, this paper considers that one of the most important requirement of solvency regulation for the insurer is to keep the adequate surplus level. Once the regulator finds the insurer with higher underwriting risk, he should ask the insurer to contribute additional capital.

Hartmann-Wendels (1993) suggests that the problem of designing optimal incentive schemes arises once the information asymmetry exists between the parties in a contract relationship. The theories of regulatory policy with incentive scheme have been extensively studies in other industries (see Laffont and Tirole, 1993), but the theories specific to insurance industry are few. Thus the primary purpose of this paper is to develop a theoretical analysis for the solvency regulation wth incentive issue under asymmetric information structure.

In this paper, the content of "information" emphasizes on loss reserves even though other information may be also relevant to insolvency. The loss reserves account for more than 65% of liabilities for an insurance company.[2] They are the most important liabilities and the most crucial factor for insolvency. Because of the loss settlement process in property-liability insurance industry, a large amount of unfinished losses must be estimated at the end of accounting year. These estimation procedures involve many actuarial assumptions and thus open much space for the insurer to manipulate the cost of incurred losses.

The accuracy of loss reserves is crucial to evaluate the financial performance of an insurance company. For example, the study by the A.M. Best Company (1991) has showed that deficiency of loss reserves was the primary factor for the insolvent companies during 1969-90. Some of the previous studies, e.g., Smith (1980) and Weiss (1985), suggest that the loss reserves may be manipulated by the management of insurance companies. Therefore this paper develops an analysis with an emphasis on the information constraint and manipulation of loss reserves.

Based on the agency theory for regulatory economics, this paper discusses the optimal incentive scheme for solvency regulation in property-liability insurance industry. We suggest that the regulator can adopt a two-step aproach to reduce the risk of insolvency. First, induce the true reporting of claim cost estimation be redesigning the profit loading allowance with an incentive scheme at the beginning of years. Second, penalize the deficiency of loss reserves by requesting an increase in capital contribution at the end of year.

The structure of this paper is organized as follows. Section II presents the background of claim cost and manipulation problem in property-liability insurance industry. Section III introduces the design of profit loading allowance with an incentive scheme. The analysis of the optimal solvency regulatory policy with incentive scheme is provided in section IV. Then the concluding remarks are provided in section V.

II. Insurance Claim Cost and the Manipulation Problem

To understand the underlying reason for deficient loss reserves and the incentive of an insurer for untruthful reporting, we must start the story from the cost structure and pricing procedure of an insurance product. The total cost function of an insurance policy is given as follows.

$$C = L + k \tag{1}$$

In equation (1), C is the total cost, L is the claim cost, and k is the expense of an insurance policy. Expense is quite stable for an insurance company and is usually assumed to be a nonnegative fixed cost. On the other hand, actual claim cost L is a random variable since the losses are uncertain each year. L is assumed following some conditional distribution functioin $G(L|\alpha)$, and the higher value of α results in stochastically higher claim cost L in the sense of the first-order stochastic dominance. $G(L|\alpha)$ is commonly known to both the regulator and the insurer.[3] However, the value of parameter α is known only to the insurer but not the regulator. Parameter α represents the mean of claim cost L of the specific insurer, which is a private information. That is, there exists information asymmetry between the regulator and the insurer.

The insurance price is subject to prior-approval rate ragulation in most of the states. The regulator allows the insurer to modify the premium rate based on the loss experience of the previous year, either through loss ratio method or pure premium method (see Brown, 1993). Due to the loss settlement delays, the loss experience of an insurer must be indicated by the "incurred losses" on the annual financial statement instead of actual losses because the ultimate claim cost is not realized yet at the moment of pricing. The incurred losses are composed of loss payments and loss reserves for the unsettled claims. If the insurer overstates the loss reserves and thus larger amount of incurred losses are reported, then the premium rate for next year may be adjusted to a higher level. On the other hand, the understatement of loss reserves may result in lower price.

In addition to the adjustment of premium rates, the manipulation of incurred losses also has an impact on the liquidity and surplus level because the insurer must keep sound financial ratios to satisfy the NAIC requirements. For example, the NAIC liquidity test requires that the ratio of liabilities to liquid assets must be less than 105%; besides, the reserve test requires that the ratio of one-year and two-year reserve development to surplus must be less than 25% (Troxel and Bouchie, 1990). Therefore, the insurer may understate the loss reserves when there are not enough liquidity assets or surplus, which is a primary factor for insolvency.

Due to certain financial purposes, the insurer usually makes several estimates for the loss reserves. The insurer may submit one estimate to the commissioner but apply another one for his internal business operation. This business practice may delay the timing for the commissioner to monitor the risky insurer, which may result in insolvency in the near future.

Suppose the estimate of claim cost (incurred losses) projected by the insurer for his internal operation is denoted by $\bar{L}$, and the best estimate of actual cost L under rational expectations is the mean of claim cost α. Let's define "manipulation" in this paper as the action the insurer does not maintain the rational estimate α of incurred losses. If the insurer intends to default, his business will be operated based on a subjective estimate $\bar{L}$ which is less that α. Let's denote the manipulated amount as θ, $\theta = \alpha - \bar{L}$. Provided the insurer maintains the adequate incurred losses without manipulation (i.e., without intention to default), then $\bar{L}=\alpha$. The relationship between $\bar{L}, L$, and α can be summarized as follows.

$$\bar{L}=\begin{cases} \int L dG(L|\alpha-\theta) = \alpha-\theta, & \text{if with manipulation} \quad (2) \\ \int L dG(L|\alpha) = \alpha, & \text{if without manipulation} \quad (2') \end{cases}$$

On the other hand, at the beginning of the year the insurer must submit a cost estimate X to the commissioner to apply the approval of premium rates. Due to some financial purposes, the insurer is not necessarily to report the rational estimate α or his internal estimate $\bar{L}$ of incurred losses to the comissioner, but submits another estimate of incurred losses X. This incurred losses estimate X can be considered as a combination of internal estimate $\bar{L}$ and a "misreported" amount ξ. That is.

$$X=\bar{L}+\xi \qquad (3)$$

The ξ is the dollar amount of misreported loss reserves, which is part of the "loss reserve error" as indicated in the study by Weiss (1985). ξ is positive if over reserved, negative if under reserved, and equal to zero if there is no misreporting.

Because the insurance market is very competitive, any increase in price may result in losing business to other competitors. Consequently the irresponsible insurers may lower down the premium rates in order to attract the consumers even though the rate regulation requires that rate must be adequate. Furthermore, in insurance practice there is a tendency that the insurers consider to compensate underwriting loss through investment incomes. Because premiums written are the source of funds for investment, the insurer may lower down underwriting standards and premium rates to increase business when the investment market is profitable. This may be a potential reason for underwriting cycles (Doherty and Kang, 1988) and a possible cause for the insolvency of insurers when the investment performance does not come out as expected. In fact this is what had happened during 1980's.

As indicated in the study by A.M. Best Co. (1991), 28% of P/L insolvency cases are attributed to deficient loss reserves and 21% resulted from rapid growth, both of them related to underpricing. Since the underreserving is more critical for insolvency than overreserving, the definition of "untruthful reporting" in this paper emphasizes on the understatement of loss reserves (incurred losses) although the overstatement may also be regarded as misreporting. Besides, this paper restricts the manipulation of incurred losses to the case of under reserves. The purpose of untruthfully reporting and manipulation by the insurer is to increase the volume of business and total profit which includes investment profit as well as underwriting profit.

We consider there are two situations of deficient loss reserves: intentional and unintentional default. The intentional insolvency is that the insurer not only misreports but also manipulates the incurred losses, that is, $X=\bar{L}-\xi$ and $\bar{L}=\alpha-\theta$. While the unintentional insolvency involves only misreporting $X=\bar{L}-\xi$, but the insurer still maintain the adequate level of loss reserves internally, i.e., $\bar{L}=\alpha$. Since both conduct misreporting, the regulator cannot distinguish the difference at the beginning of year due to information asymmetry. Therefore, we suggest that the regulator can adopt a two-step approach to reduce the chance of insolvency. First, induce the true reporting of claim cost estimation by redesigning the profit loading allowance at the beginning of year. Second, penalize the deficiency of loss reserves through auditing at the end of year.

The model of solvency regulatory policy considered in this paper is one-period. At the beginning of year t the insurer subjectively maintains an estimated claim cost as $\bar{L}$, but submits a financial report with cost estimate X to the commissioner to apply the approval of premium rates. Because of information constraint, the commissioner does not know the true parameter α and can only apply the reported accounting data X to adjust the premium rates for the insurer at the beginning of year t. Thus the ojbective of the regulator is to induce the insurer to report X truthfully as his internal estimate $\bar{L}$. For those insurers without manipulation, this step is enough since the $\bar{L}$ is equal to α. But for those insurers with manipulation, $\bar{L}$ is less than α. Thus the commissioner needs a further step to induce the insurer to maintain adequate $\bar{L}$ equal to α.

Since the manipulation is not observable ex ante at the moment of rating, the regulator usually has the authority to audit and penalize the insurer for manipulation ex post in order to monitor the solvency of an insurance company. Thus the regulator periodically conducts the on-site financial examination for the insurer. At the end of year t when more loss payments are made for the previous unsettled claims, the regulator is able to observe the manipulation level θ by referring to the actual losses L.[4] If the regulator considers the reported incurred losses are significantly deviated from a reasonable level of cost estimation, he will penalize the insurer. It is assumed that the regulator is able to commit himself to actually conducting the audit and imposing the penalth, i.e., there is no collusion between the regulator and the insurer.[5]

The insurance commissioner is assumed to have the authority to impose a penalty(adjustment) $N(L,\theta)$ on the insurer. The penalty is a function of realized claim cost L and the manipulation level θ. Since the insurer has the incentive to understate the loss reserves, the regulator will impose a penalty when the estimated incurred losses are comparatively low and there is evidence of a high manipulation level. The means of penalization could be a request of increase in capital level of the insurance company or a contribution to guaranty funds in order to raise additional funds for the risky operation. This approach is consistent with the concepts of RBC and RBP developed in the recent years.

Since in practice the penalty is always subject to a maximum amount, it is assumed $N(L,\theta)$ cannot be unlimited (Barron and Besanko, 1984). Besides, the actual losses may be accidental and the deviation may be not completely from manipulation. For example, the losses from natural disasters or macroeconomic factors as suggested by Winkler, Flanigan, and Johnson (1994). When the deviation of actual loss payments from estimated cost does not result from manipulation by the insurer, the regulator in general will not enforce the penalty. Therefore, the contingent capital is limited to a maximum amount. However, there is no subsidy if the insurer overstates the loss experience. This implies the penalty or $N(L,\theta)$ will be constrained to be nonnegative.

III. The Design of Profit Loading Allowance with An Incentive Scheme

As described in the previous section, the risk of insolvency primarily related to underpricing due to market competitioin. Since in most states the premium rates must be approved before they are introduced to the market, the commissioner may develop the incentive scheme to induce true reporting from the insurance price and profit loading allowance.

The basic assumptions are that the insurer is risk neutral and the objective of his pricing decision is to maximize the expected total profit, including underwriting profit and other profit such as investment profit. The purpose of underpricing is to compete business and increase total profit, which does not necessarily conflict with the rationality of solvency. The unintentional-default insurer still hope to maintain the adequate reserves level and continue the business, however, he considers to apply the extra investment income to cover the claim cost instead of using premium income directly. In fact we have seen that many insurers suffer from underwritng losses but still maintain positive total profit in the market. However, in the view of sound operation, the commissioner does not welcome such business strategy because the investment market is highly fluctuated and the outcome of performance may be not as anticipated. Therefore the insurer is required to set up an adequate premium rate.

In insurance market the premium rate is equal to the total cost plus a proft loading, ω. The profit loading is usually a function of claim cost. Thus the insurance pricing formula may simply indicated as the following equation.

$$P=L+k+\omega(L) \tag{4}$$

Traditionally the profit loading is set as a fixed percentage of claim cost such as

5%. Suppose the actual claim cost L is full informed, this pricing formula may be reasonable. However, the actual claim cost in fact is unknown at the moment of pricing and must be replaced with the reported incurred losses. If the regulator adopts a fixed-percentage profit loading, there is no incentive for the insurer to truthfully reoprt the internal estimate of claim cost $\bar{L}$ because the insurer may have other financial gains from misreporting the incurred losses. Therefore, the commissioner must redesign the profit loading with an incentive scheme in order to induce true reporting.

The profit allowance with an incentive scheme for other procurement contracts usually in the form of linear combination of target profit and an extra penalty for the overrun of target cost because the contractors intend to over report the cost (Reichelstein, 1992). In insurance market, the situation is reverse. The insurer prefers to understate the claim cost which may increase the insolvency risk. The regulator will impose an extra penalty for underreserves. Therefore, the model must be modified for the insurance market. The profit loading with incentive scheme for true reporting in insurance market can be described as equation (5).

$$\omega(X, L) = \mathrm{a}(X)+\mathrm{b}(X)(X-L) \tag{5}$$

Equation (5) presents that the profit loading allowance is related to the actual cost level and the reported estimate. The a(X) in the above equation is the target profit allowance and b(X) is the incentive rate of extra penalty to discourage misreportng. a(X) and b(X) are functions of reported cost, instead of a fixed percentage. Depending on the amount of reported cost X, the commissioner offers different levels of profit loading allowance. Therefore, the profit loading allowance under asymmetric information will be related to the truthfulness of claim cost reporting, which is supposed to be more effective to elicit the true information than a fixed percentage.

Due to the characteristic of insurance contract, the profit loadng is determined at the moment of rating, i.e., the beginning of the year. Thus the insurer does not have realized cost L on hand at the moment of rating, and must evaluate the potential profit based on his own estimate $\bar{L}$. That is, the expected profit loading is $\omega(X, \bar{L}) = \mathrm{a}(X) + \mathrm{b}(X)(X-\bar{L})$.

In order to derive the optimal incentive scheme for insurance profit loading, we must require that a(X) is a convex increasing function and $\mathrm{b}(X)=-\mathrm{a}'(X)$. Thus the incentive rate b(X) is negative.[6] These requirements guarantee that the expected profit loading allowance of true reporting will be not less than that of misreporting, that is $\mathrm{a}(\bar{L}) \geqq \mathrm{a}(X) + \mathrm{b}(X)(X-\bar{L})$ for all X. The mathematical proof and an example are provided in appendix 1.

As indicated in the previous section the insurer may sacrifice underwriting profit and pursue investment profit to create a higher amount of total profit. The understatement of incurred losses will reduce the price and increase the business, therefore the insurer may collect more premium written for investment. The expected total profit is equal to expected underwriting profit ω plus expected investment profit γ. The expected total profit for the insurer at the moment of rating is shown as equation (6).

$$\pi(X, \bar{L}) = a(X) + b(X)(X - \bar{L}) + \gamma(X) \tag{6}$$

According to the revelation principle (Mayerson, 1979), an incentive-compatible regulatory policy is optimal if under which the insurer has no incentive to misreport its cost parameter. That is, an optimal solvency regulation must avoid the insurer to report the claim cost estimate untruthfully. This principle is important for the commissioner. As indicate in the previous section, the insurer may submit one estimate to the commissioner but apply another one for his business operation, which may result in insolvency in the near future.

Therefore, the expected total profit without misreported incurred losses, $\pi(\bar{L}) \equiv \pi(\bar{L}, \bar{L})$, must be greater than the expected total profit with misreporting, $\pi(X, \bar{L})$. Under such incentive scheme, the insurer has no incentive to misreport the information and will always report $X=\bar{L}$. The incentive-compatibility constraint can be described by equation (7).

$$\pi(\bar{L}) \equiv \pi(\bar{L}, \bar{L}) \geqq \pi(X, \bar{L}) \tag{7}$$

Therefore,

$$\pi(\bar{L}) \geqq a(X) + b(X)(X - \bar{L}) + \gamma(X) \tag{8}$$

Besides, it is assumed that the insurer is rational and does not intend to have negative expected total profit. Therefore, he will not issue insurance policies if the given regulatory policy would result in a negative profit. This assumption is realistic as we saw the phenomenon of "insurance crisis" in the 1980's when the liability insurance was not available. This implies the solvency regulation must also satisfy the "individual-rationality conditoin" as equation (9).

$$\pi(\bar{L}) \geqq 0 \tag{9}$$

IV. The Optimal Solvency Regulatory Policy with Incentive Scheme

Based on the above discussion, we can infer that the insurer will always report $X=\bar{L}$ when the profit loading is set up with an incentive formula, and his expected total profit is $\pi(\bar{L})=\pi(\alpha)$. Now we turn to analyze the solvency regulatory policy with incentive scheme. If the insurer is just underreporting the loss reserves but still keep adequate level of reserves internally, that is, the additional investment income is prepared to pay the claim cost, the insurer will not be insolvent. On the other hand, the insurer may launch into risky operation and make deficient loss reserves. Under such case the insurer is doing business with an under estimated claim cost $\bar{L} = \alpha - \theta$.

The expected total profit with manipulation is equal to expected underwriting profit ω plus expected investment income γ with $\bar{L}$ =α-θ, that is,

$$\pi(X,\bar{L}) = \pi(\bar{L}) = \pi(\alpha-\theta)$$
$$= \alpha(\alpha-\theta) + b(\alpha-\theta)[(\alpha-\theta)-(\alpha-\theta)] + \gamma(\alpha-\theta) \qquad (10)$$

Let's further distinguish the investment profit into the normal level of profit η(α) without manipulation, and extra profit due to manipulation ε(θ), that is, γ(α-θ)=η(α)+ε(θ).[7] The extra benefit ε results from the manipulation of loss reserve, thus it is assumed to be a concave increasing function of θ with nonnegative third derivative. Let θ(α) denote the manipulation level that maximizes the expected total profit for the insurer when the mean of loss experience is α. The optimal level of manipulatioin θ(α) will depend on the insurer's belief of mean claim cost α and the macroeconomic factors for investment which are out of control of the insurer. Thus, the expected total profit of the insurer can be rewritten as equation (11).

$$\pi(\alpha,\theta(\alpha)) = a(\alpha-\theta(\alpha)) + \eta(\alpha) + \varepsilon(\theta(\alpha)) \qquad (11)$$

Based on equaton (11), we can derive the optimal solvency regulatory polcy. First, let's stand on the point of the insurer, the strategy in reporting the incurred losses is to select an optimal level of $\theta^*(\alpha)$ which maximizes the expected total profit. Therefore we take the first order condition of equation (11) with respect to θ, and obtain the following condition.

$$-a'(\alpha-\theta(\alpha)) + \varepsilon'(\theta(\alpha)) = 0 \qquad (12)$$

By replacing -a' with b according to the result in the previous section, we have:

$$b(\alpha-\theta(\alpha)) = -\varepsilon'(\theta(\alpha)) \qquad (13)$$

Equation (12) shows that under the optimal incentive scheme the marginal underwriting profit reduced by the manipulation of incurred losses is equal to the marginal extra benefit earned through investment profit. Therefore, under a well-designed incentive scheme there is no advantage to manipulate the incurred losses since the expected total profit for the insurer is always the same (see appendix 2 for illustratioin).

Based on the result of equatoin (13), we can infer that the optimal solvency regulatory policy to induce the sufficient reserves is to design a profit loading formula with an incentive rate equal to the negative of marginal extra benefit instead of applying a fixed percentage. The incentive scheme can response the insolvency risk of underreserves.

For the previous insurers with misreporting but without manipulation, the profit loading formula $a(X)+b(X)(X-\bar{L})$ is sufficient to prevent misreporting once $a(X)$ is a convex increasing function and $b(X)=-a'(X)$. However, for those insurers with manipulation, the regulator must offer the profit allowance with carefully designed incentive rate $b(\alpha-\theta)=-a(\alpha-\theta)=-\varepsilon'(\theta)$. In order to derive the incentive rate function, the regulator must take into consideration of the investment environment and the manipulation level. This result is consistent with the argument that insurance premium rate must incorporate the investment profit as suggested by Fairley (1979).

The information of investment factors such as interest rate or stock return usually are publicly available. However, the manipulation level is not observable by the commissioner since the commissioner does not know the meam cost α and is unable to observe the manipulation level $\theta(\alpha)$ at the moment of rating. Therefore, the regulator may adopt a two-step approach to achieve ths objective. First, induce the true reporting of claim cost estimation by designing the profit loading allowance at the beginning of year with the regulator's prior belief of the mean claim cost. Second, charge a penalty retrospectively at the end of year to make up the prior biased estimation of mean cost.

The regulator may project a reasonable range of manipulation level based on his prior belief of α although he lacks of the full information of α. It is assumed that the prior probability distribution function of α is $F(\alpha)$ which satisfy the monotone-increasing property.[8] Based on this prior belief of α and the reported claim cost, the commissioner could approve a premium rate $P_1=X+k+\omega(X,X)$ at the beginning of year.

At the end of year, the information of actual claim cost L is realized. Then the regulator adjusts the profit allowance by charging a penalty (adjustment) retrospectively. According to the study by Chen and Li (1996), the retrospective rating is an optimal pricing scheme when the control effort is not observable. Therefore, the second step of solvency regulatory policy is to consider the imposition of a penalty $N(L,\theta)$ at the end of year through auditing.

Since the premium rate which the insurer should have charged is $P_2=L+k+\omega(X,L)$ according to equations (4) and (5), while the price really charged by the insurer is $P_1=X+k+\omega(X,X)$. As the consumer surplus is the primary concern of the regulator (Bower, 1981), the difference between the price allowed and the price actually charged must be adjusted. Therefore the adjustment $N(L,\theta)$ is equal to the difference between P_1 and P_2 as shown by the following equation.

$$\begin{aligned} N(L,\theta) &= P_2-P_1 \\ &= \{L+k+\omega(X,L)\}-\{X+k+\omega(X,X)\} \\ &= (L-X)+b(\alpha-\theta(\alpha))[(\alpha-\theta(\alpha))-L] \end{aligned} \qquad (14)$$

Equation (14) presents that the penalty charged retrospectively is equal to the amount underpriced, which is the sum of the understated loss reserves and the incentive charge for profit loading. In most of the regulated public-utility industries and procurement contracts, the regulator usually requests an adjustment in price due to overpricing. However, different from other procurement contracts, it is uncommon to assess the premiums ex post in property-liability insurance industry. In fact the insurer has already underpriced, it is not logically to return the adjustment as a compensation to the consumers.

To increase the consumer's surplus, we suggest that the commissioner charges the penalty by way of requesting an increase in capital to enhance the solvency and protection to policyholders because solvency is the most important concern for insurance buyers. The commissioner may request an increase in insurer's surplus (capital) by an amount as the sum of deficient loss reserves and the incentive charges. Since the incentive charge reflects the manipulation level by the insurer, it is related to the insolvency risk of the insurer. Therefore, this adjustment is a risk-based capital which may help to prevent the insolvency risk and increase the consumer's surplus. An alternative way to handle the penalty is to request a contribution to the guaranty funds.

V. The Concluding Remarks

The problem of asymmetric information in designing an optimal regulatory policy is unavoidable because the inherent characteristics of insurance industry. The uncertainty of claim cost and settlement process in property-liability insurance industry offer a good opportunity for the isurer to manipulate the loss reserves. In the traditional pricing method, the profit loading is a fixed percentage of the claim cost which provides no incentive for the insurer to reduce the manipulation of loss reserves. Since deficient loss reserves are the most important factor for insolvency risk, the regulator must consider to reform the solvency regulation and the pricing formula.

The model developed in this paper suggests that the profit loading in price formula must be redesigned with an incentive scheme to discourage the misreporting of incurred losses. We first distinguish the understatement of loss reserves into two cases: (1) misreporting on the financial statement but not manipulating internally, and (2) misreporting and manipulation. The first case is trivial because it will not result in insolvency if profit loading allowance includes an incentive scheme. For this case, a profit loading formula with incentive scheme, $a(X)+b(X)(X-\bar{L})$, is sufficient to prevent misreporting as long as $a(X)$ is a convex increasing function and $b(X)=-a'(X)$.

However, for the insurer with manipulation which causes deficient loss reserves and insolvency, the regulator must offer the above profit loading formula with careful design of incentive scheme, that is, the incentive rate $b(X)$ must be equal to the negative of marginal extra benefit $-\varepsilon'(\theta)$ earned with manipulation level of θ. The regulator may adopt a two-step approach to achieve this objective because the manipulation level is not observable ex ante and thus $b(\alpha-\theta)$ is not available at the moment of rating. First, induce the true reporting of claim cost estimation by designing the profit loading allowance at the beginning of year with the regulator's prior belief of the mean claim cost. Second, charge a penalty retrospectively at the end of year to make up the prior biased estimation of incentive rate. The retrospectively charged penalty is equal to the amount underpriced which is the sum of the understated loss reserves and the incentive charge for profit loading. Therefore, there is no advantage to manipulation and underpricing.

This study can provide a modification for current the risk-based capital (RBC) requirement in the recent solvency regulation reforms. Since 50% the current RBC related to loss reserves (Cummins, et al, 1995), the true reporting of loss reserves is critical for the success of RBC reform. Otherwise, underreserves which result in lower RBC will cause adverse selection effect in the insurance market. According to the analysis of this paper, the insurer must be responsible and keep adequate capital against the his own potential risk of insolvency due to manipulation on the loss reserves. The commissioner may request an increase in surplus level (capital) by the amount underpriced retrospectively which includes an incentive charge. Thus, it is a risk-based capital.

To maintain adequate level of loss reserves is the ultimate goal for the reform of solvency regulation, while to induce the true reporting is the first step for the reform. The truthful reporting of loss reserves contributes in fact not only to the solvency regulation but also the rate regulation because the ratemaking decision largely depends on the data of incurred losses. This paper is a primitive study of agency relationship between the insurer and the regulator under asymmetric information setting. The primary purpose is to signify the information effect on the insurance solvency regulation, which follows the recent innovation of research in regulatory economics during the past decays (see Laffont, 1994).

The finding suggests that by way of designing the profit loading allowance with an incentive scheme, the regulator can induce adequate loss reserves and reduce insolvency risk. If the functional forms of the extra investment benefit and the probability distribution of the mean cost are specified, the incentive rate can be determined. The future study can extend research on this point.

Note:

1.The difference between asset and liability is usually called "equity" in accounting, while it is called "surplus" in insurance. Insolvency means that the asset is not enough to pay liability, which implies a negative equity or surplus level.

2.The number is based on the data of Best's Aggregates and Averages, 1994.

3.For example, G may be a gamma distribution or distribution (see Hogg and Klugman, 1984). In practice, distribution functions of losses have been well studied by the actuaries and become familiar to most of the insurance people. Therefore, this assumption will not be too artificial.

4.In this paper we assume the insurance claims of year t-1 will be settled at the end of year t. i.e, loss settlement delays only for one year. Thus the regulator can observe claim cost L at the end of year t even though he can not know α at the beginning of year t. The regulator may refer the information of L to audit the insurer since the loss distribution function $G(L|\alpha)$ is commonly known to the regulator. If there is significant deviation between X and L, then the regulator may consider the insurer manipulated the incurred losses and charges a penalty. In practice, the loss settlement delays may involve several years instead of one year, however, the same reasoning can be applied to those cases.

5. Usually this assumption is acceptable since legislation does not allow such collusion. The case of collusion between the auditor and the firm has been studied by Kofman and Lawarree (1993).

6. In most of procurement contracts, the $a(X)$ is a convex decreasing function and $b=-a'$ to prevent the overrun of cost. However, the insurance profit loading must be designed to avoid understatement of incurred losses. Therefore, $a(X)$ is required to be a convex increasing function and consequently b is negative in our case.

7. Because the insurer collects the premiums in advance and pays claims thereafter, the insurer always earns certain investment profit due to the time lag between premium collection and loss payments even if there is no manipulation of incurred losses.

8. The monotone-increasing property states that $d[F(\alpha)/f(\alpha)]/d\alpha \geqq 0$, which are satisfied by most common probability distributions (Laffont and Tirole, 1993, p66).

Appendix 1.

According to the text, the profit loading formula is $\omega(X,\bar{L})=a(X)+b(X)(X-\bar{L})$. To find the maximum value of ω, we take the first order condition of ω with respect to X. That is,

$$a'(X)+b'(X)(X-\bar{L})+b(X)=0 \tag{A1}$$

Since true reporting implies $X=\bar{L}$, the second term of equation (A1) is equal to zero when true reporting. Therefore, $a'(X)+b(X)=0$, i.e., $b(X)=-a'(X)$. Because $a(X)$ is a convex increasing function, the incentive rate $b(X)=-a'(X)$ will be negative. By replacing $b(X)$ with $-a'(X)$ in the equation of ω, we have

$$a(X)+b(X)(X-\bar{L})=a(X)-a'(X)(X-\bar{L}) \tag{A2}$$

Then $a(\bar{L}) \geqq a(X)+b(X)(X-\bar{L})$ for $\forall\ X$ because $a(X)$ is a convex increasing function. Table 1 provides and illustration for the incentive scheme.

Table 1.

An example of profit loading allowance with incentive scheme, assumed $\bar{L}$ = \$1000.

X	a(X)	b(X)	ω(X)
500	45	-0.01	50
600	46	-0.02	54
700	48	-0.03	57
800	51	-0.04	59
900	55	-0.05	60*
1000	60	-0.06	60*
1100	66	-0.07	59
1200	73	-0.08	57
1300	81	-0.09	54
1400	90	-0.10	50
1500	100	-0.11	45

*The equal values of ω's are due to discrete X in this example. We will have a unique maximum value of ω at X=1000 in case X is continuous.

Appendix 2.

Based on the result in the text, we know that $a'(\alpha-\theta(\alpha))=\varepsilon'(\theta(\alpha))$, $a(\alpha-\theta(\alpha))$ is convex increasing function and $\varepsilon(\theta)$ is a concave increasing function. Their relationship can be illustrated by figure 1.

figure 1.

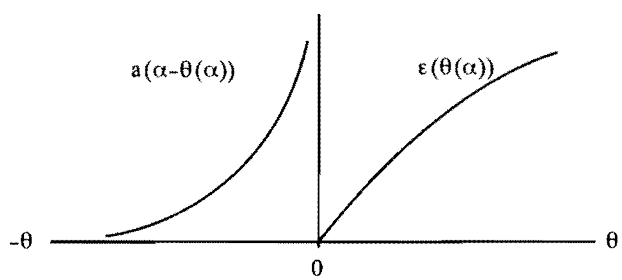
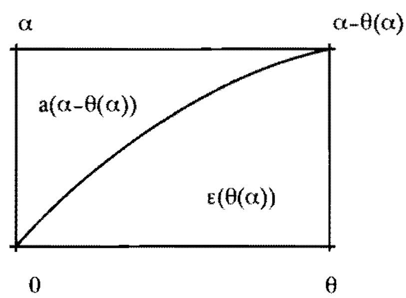


Figure 1 can be rearranged as figure 2.

figure 2.



Based on figure 2, we can see that the sum of $a(\alpha-(\theta(\alpha))$ and $\varepsilon(\theta)$ is all the same as the height of the box no matter what value of θ. Thus for a given α there is no advantage to manipulated the incurred losses since the expected total profit $\pi(\alpha,\theta(\alpha)) = a(\alpha-\theta(\alpha)) + \eta(\alpha) + \varepsilon(\theta(\alpha))$ for any θ.

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