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# Optimal Premium Subsidy and Its Impact on Individual Choice for Insurance Coverage

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**Abstract**

The purpose of this article is to analyze whether a government premium subsidy is desirable by using a game theoretic approach. From our analysis, the following main results are derived. When policyholder's effort for lowering accident probability is not considered, government conducts premium subsidy when the fraction of policyholders is small. In contrast, when policyholder's effort is considered, whether government conducts premium subsidy is ambiguous even if the fraction of policyholders is small.

**Keywords:** Government; Premium subsidy; Insurance demand

## Introduction

The importance of sharing risks via the insurance market has been addressed by many previous studies [1-3]. However, it is always difficult for an individual to get full insurance coverage at a reasonable cost due to the failure of private insurance market. In general, factors such as market imperfections and existence of informational asymmetries between an individual and insurer which generate problems such as moral hazard and/or adverse selection are responsible for market failure.

Insurer would prefer to provide an incomplete coverage or conduct some monitoring activities in order to avoid incurring possible losses caused by individual's opportunistic behavior [4-6]. In the latter case, a full insurance coverage would probably become more expensive due to increase in transaction cost resulted from monitoring activities in relation to policyholder's behavior. In some cases, an insurance coverage itself would become unaffordable or unavailable if asymmetric information problems are significant enough that complicated and specialized insurance contracts associated with high costs become indispensable [7].

Previous studies have also shown that an individual may favor a partial coverage or no coverage at all if she does not have sufficient knowledge and/or information regarding certain risks and/or insurance coverage [8-11]. Moreover, Anderson [12] and Kaplow [13] suggest that an ex post government relief program (e.g., grants, low-interest loans) against financial losses undermines an individual's willingness to pay to be fully insured, which is known as a problem of charity hazard [14-16]. Although government relief can be efficient if insurance markets suffer more inefficiency from market imperfections other than moral hazard [17].

Given the presence of market failures and, in some cases, the resulting absence of markets for insurance, the overall distribution of risks would presumably be sub-optimal and if the total cost of individual's risk-bearing is consequently significant, then government intervention may be desirable [18]. More specifically, government intervention in certain markets as a supplier of insurance (e.g., public health care) can be cost-effective because all uncertainty will be borne publicly and the total of the costs of risk-bearing goes to zero as the population of taxpayers becomes large [7,19].

Government can also intervene in insurance markets by providing a government-sponsored reinsurance program, which has been relatively effective in dealing with natural disaster hazards [20]. Government can intervene in insurance markets by means of a financial subsidy as well, which is more likely to be used in the agricultural and health service sectors by taking the form of premium subsidies or tax subsidies. Regarding catastrophe risks, government involves not only in the form of reinsurer, but also in the form of tax subsidies [21].

The cost efficiency of such government interventions, however, has been controversial because the intervention itself may generate inefficiencies due to new problems such moral hazard and/or adverse selection associated with the intervention [22]. For example, Nelson and Loehman [23], and Hazell [24] have pointed out that a public subsidy might be a costly solution to the market imperfections of agricultural insurance, although it is still preferred by many governments, especially in developing countries. Barnett and Skees [25] also suggested that participation rate of Federal Crop Insurance in the United States is not proportional to the increase in premium subsidies. Meanwhile, regarding the health service sector, Feldstein and Friedman [26] and Pauly [27] asserted that tax subsidies have caused large welfare losses, despite the fact that they contributed to the growth and development of health insurance in the United States.

On the other hand, Stiglitz [28] and Greenwald and Stiglitz [29] argued that government interventions (e.g., taxes and subsidies) in imperfect markets particularly those caused by the existence of imperfect and costly information, can be Pareto-improving and make everyone better off. Moreover, Akerlof [30] addressed that in the case of "trust" being considered an important element in market transactions, for example, as conducted in developing countries, the value of government intervention increases more than would otherwise be the case.

Given the aforesaid background of government intervention, this article focuses on the case in which government intervenes in a market with a low penetration rate by taking the form of premium subsidy.

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From our analysis, the following main results are derived. When policyholder's effort of lowering the probability of an accident is not considered in case the fraction of policyholders is small, premium subsidy conducted by government is desirable under which an individual chooses to purchase full coverage while the social welfare is maximized which consists of the welfare of policyholders, non-policyholders and insurance firm. In contrast, when policyholder's effort is considered, whether government should conduct premium subsidy is ambiguous even if the fraction of policyholders is small.

The remainder of this article is organized as follows. Section 2 builds a model and explains game structure of this model. Section 3 develops the model to derive the condition in which government conducts premium subsidy when policyholder does not conduct the effort. Section 4 provides a further analysis by introducing effort for lowering accident probability and investigates the effect of effort. The major findings of this article are summarized in Section 5.

## The Model

Suppose that there are weakly risk-averse identical (potential) individuals, a risk-neutral insurance firm, and the government. One type of individuals has two types of initial assets. The first type is liquid assets such as salary and bonuses, which is denoted by $w_L > 0$. The second type is fixed assets such as a house and vehicle, which is denoted by $w_F > 0$. In contrast, another type of individuals has only liquid assets. Assume that a fixed asset has the potential to incur damage, and the individual considers purchasing insurance for covering the damage. In contrast, it is assumed that there is no possibility of losing the amount of the liquid asset. After purchasing insurance, the policyholder chooses whether the effort of lowering the probability of an accident is conducted in "effort case" section. Because that effort is not observable by others, the policyholder chooses the effort only if it is profitable. $\pi_i$ represents the accident probability and $i \in \{0,1\}$ where "0" and "1" indicate the cases of no effort and effort, respectively. Thus, it is natural that $0 \le \pi_1 < \pi_0 \le 1/2$.

Effort can lower the accident probability, but the policyholder has to incur the cost involved. Effort cost is assumed to be constant and represented by $k > 0$. The following four-stage game is considered.

In the first stage, the government decides both the subsidy rate, which is denoted by $s_i \in [0,1]$, and the tax rate, which is denoted by $t_i \in [0,1]$. The government subsidizes a portion of the insurance premium from tax revenue. Thus, the policyholder actually pays the insurance premium. To apply the premium subsidy, the government imposes a tax on each liquid asset $w_L$ such as income tax. $\beta \in (0,1]$ denotes the fraction of policyholders involved. Then, the government chooses both the subsidy rate and the tax rate to satisfy the following equation which specifies that the government revenue and expenditure are equal:

$$t_i w_L = \beta s_i p_i \tag{1}$$

where $p_i > 0$ represents the insurance premium. Then, the government chooses the subsidy rate in accordance with the following equation:

$$s_i = \frac{t_i w_L}{\beta p_i} \tag{2}$$

In the second stage, the insurance firm chooses the insurance premium. For simplicity of the model, the amount of damage is assumed to be equal to $w_F$. Thus, when the policyholder purchases full insurance, the insurance money is equal to $w_F$. In the third stage, the policyholder chooses the insurance coverage rate, which is represented by $\alpha_i \in [0,1]$. In the fourth stage, the policyholder chooses whether to conduct the effort.

In this situation, the expected utility for the policyholder, which is denoted by $EU_i$, can be written as follows:

$$EU_1 = \pi_1 u\left(w_L + w_F - \alpha_1 p_1 - (1-\alpha_1) w_F\right) + (1-\pi_1) u\left(w_L + w_F - \alpha_1 p_1\right) - k \tag{3}$$

$$EU_0 = \pi_0 u\left(w_L + w_F - \alpha_0 p_0 - (1-\alpha_0) w_F\right) + (1-\pi_0) u\left(w_L + w_F - \alpha_0 p_0\right) \tag{4}$$

By using the computation in Asai and Okura [31], the certainty equivalent, which is denoted by $CE_i$, can be derived as follows:

$$CE_1 = (1-t_1) w_L - \alpha_1 (1-s_1) p_1 - \pi(1-\alpha_1) w_F - \frac{r}{2}\pi(1-\pi)\{(1-\alpha_1) w_F\}^2 - k \tag{5}$$

$$CE_0 = (1-t_0) w_L - \alpha_0 (1-s_0) p_0 - \pi(1-\alpha_0) w_F - \frac{r}{2}\pi(1-\pi)\{(1-\alpha_0) w_F\}^2 \tag{6}$$

where $r \ge 0$ represents the policyholder's degree of absolute risk aversion.

### No effort case

In this section, we consider the case in which policyholder's effort is excluded. To analyze this game, we temporarily remove the fourth stage from the original game and a three-stage game is considered by backward induction. Because policyholder does not conduct the effort, subscript of all variables in this section is surely zero.

We first investigate the third stage. The optimal insurance coverage rate has to satisfy the following first-order condition:

$$\frac{\partial CE_0}{\partial \alpha_0} = -(1-s_0) p_0 + \pi_0 w_F \left\{1 + (1-\pi_0)(1-\alpha_0^*) r w_F\right\} = 0 \tag{7}$$

where the asterisk represents the equilibrium value. From equation (7), we show

$$\alpha_0^* = \frac{\pi_0 w_F \{1 + (1-\pi_0) r w_F\} - (1-s_0) p_0}{\pi_0 (1-\pi_0) r w_F^2} \tag{8}$$

Further, consider the second stage. The expected profit of the insurance firm, denoted by $E\Pi_0$, is:

$$E\Pi_0 = \alpha_0^* (p_0 - \pi w_F) \tag{9}$$

Then, substituting equations (2) and (8) into equation (9), we have

$$E\Pi_0 = \frac{(p_0 - \pi_0 w_F)\left[t_0 w_L + \beta\left\{\pi_0 w_F \{1 + (1-\pi_0) r w_F\} - p_0\right\}\right]}{\pi_0 (1-\pi_0) r \beta w_F^2} \tag{10}$$

The optimal insurance premium has to satisfy the following first-order condition:

$$\frac{\partial E\Pi_0}{\partial p_0} = \frac{t_0 w_L + \pi_0 \beta w_F \{2 + (1-\pi_0) r w_F\} - 2\beta p_0^*}{\pi_0 (1-\pi_0) r \beta w_F^2} = 0 \tag{11}$$

From equation (11), the optimal insurance premium can be derived as follows:

$$p_0^* = \frac{1}{2\beta}\left[t_0 w_L + \pi_0 \beta w_F \{2 + (1-\pi_0) r w_F\}\right] \tag{12}$$

Also, substituting equation (12) into equation (8), the optimal insurance coverage rate can be rewritten as:

$$\alpha_0^* = \frac{1}{2} + \frac{t_0 w_L}{2\pi_0 (1-\pi_0) r \beta w_F^2} \tag{13}$$

From equation (13), we find the larger the tax rate (and the subsidy

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rate), the larger the optimal insurance coverage rate. However, there is an upper limit for the tax rate because $\alpha_0 \le 1$ has to be satisfied. Let $\overline{t_0}$ be the upper limit of the tax rate. The government can choose a tax rate beyond $\overline{t_0}$. However, even if such a tax rate is chosen, the policyholder will not change the insurance coverage rate. Thus, it is not desirable for the government to choose a tax rate beyond $\overline{t_0}$. Then, we have

$$\alpha_0^* = \frac{1}{2} + \frac{t_0 w_L}{2\pi_0(1-\pi_0) r w_F^2} = 1 \Rightarrow \overline{t_0} = \frac{\pi_0(1-\pi_0) r\beta w_F^2}{w_L} \tag{14}$$

In contrast, $\alpha_0^* = 1/2$ is realized when the tax rate (and the subsidy rate) is zero. Thus, the premium subsidy offered by the government always raises the optimal insurance coverage rate. Substituting equation (12) into equation (2), the subsidy rate is:

$$s_0 = \frac{2t_0 w_L}{t_0 w_L + \pi_0 \beta w_F \left\{2 + (1-\pi_0) r w_F\right\}} \tag{15}$$

$s_0 < 1$ is always satisfied if and only if $t_0 \le \overline{t_0}$ is satisfied.

Further, substituting equations (12), (13), and (15) into equations (6), and (10), the certainty equivalent of the policyholder and the expected profit of the insurance firm are derived as:

$$CE_0 = \frac{1}{8}\left[-\pi_0 w_F \left\{8 + 3(1-\pi_0) r w_F\right\} + \frac{2w_L\left\{t_0 + 4\beta(1-t_0)\right\}}{\beta} + \frac{t_0^2 w_L^2}{\pi_0(1-\pi_0) r\beta^2 w_F^2}\right] \tag{16}$$

$$E\Pi_0 = \frac{\left\{t_0 w_L + \pi_0(1-\pi_0) r\beta w_F^2\right\}^2}{4\pi_0(1-\pi_0) r\beta^2 w_F^2} \tag{17}$$

Lastly, we investigate the first stage. In this stage, the government actually chooses both the premium subsidy and the tax rates. However, both rates are related in equation (15), and the problem at this stage can be reduced to derive the optimal tax rate. It means that if government chooses strictly positive tax rate $t_0^* > 0$, government chooses strictly positive premium subsidy $s_0^* > 0$ and vice versa. It is assumed that the government chooses the tax rate for maximizing social welfare, which consists of the welfare of policyholders, non-policyholders, and the insurance firm. Then, the social welfare, denoted by $SW_i$, is shown as:

$$SW_i = \gamma\left\{\beta CE_i - (1-\beta) t_i w_L\right\} + (1-\gamma) E\Pi_i \tag{18}$$

where $\gamma \in [0,1]$ represents the weight of consumers' welfare used to calculate the social welfare.

Substituting equations (16) and (17) into equation (18), we obtain

$$SW_0 = \frac{1}{8\pi_0(1-\pi_0) r\beta^2 w_F^2}\Big[-\pi_0^2(1-\pi_0) r\beta^2 w_F^3 \left\{8\beta\gamma + (1-\pi_0) r\left\{(2+3\beta)\gamma - 2\right\} w_F\right\}$$

$$+2\pi_0(1-\pi_0) r\beta w_F^2 w_L \left\{-t_0\left\{(2+3\beta)\gamma - 2\right\} + 4\beta^2\gamma\right\} + t_0{}^2 w_L^2 \left\{2 - (2-\beta)\gamma\right\}\Big] \tag{19}$$

Equation (19) is the quadratic and convex functions of $t_0$, and so the value to minimize social welfare is uniquely determined. This value is denoted by $\hat{t}_0$, and the first-order condition can be shown as:

$$\frac{\partial SW_0}{\partial t_0} = -\frac{w_L}{4\beta^2}\left\{\beta\left\{(2+3\beta)\gamma - 2\right\} - \frac{\left\{2-(2-\beta)\gamma\right\}\hat{t}_0 w_L}{\pi_0(1-\pi_0) r w_F^2}\right\} = 0 \tag{20}$$

From equation (20), we have:

$$\hat{t}_0 = \frac{\pi_0(1-\pi_0) r\beta\left\{(2+3\beta)\gamma - 2\right\} w_F^2}{\left\{2-(2-\beta)\gamma\right\} w_L} \tag{21}$$

From equations (14) and (21), the following relationships are indicated:

$$\hat{t}_0 \ge 0 \Leftrightarrow \gamma \ge \frac{2}{2+3\beta} \tag{22}$$

$$\hat{t}_0 \ge \overline{t_0} \Leftrightarrow \gamma \ge \frac{2}{2+\beta} \tag{23}$$

From equations (22) and (23), the following three cases are possible.

*Case 1:* $\gamma \le 2/(2+3\beta)$

From equation (22), we find $\hat{t}_0 \le 0$. Then, the social welfare function in equation (19) is a monotone increasing function of $t_0$ in the range of $\left[0, \overline{t_0}\right]$. Thus, the government chooses $t_0^* = \overline{t_0}$ and full insurance is realized.

*Case 2:* $2/(2+3\beta) \le \gamma \le 2/(2+\beta)$

From equations (22) and (23), we find $0 \le \hat{t}_0 \le \overline{t_0}$. Then, social welfare is maximized in either $t_0$=0 or $t_0 = \overline{t_0}$ in the range of $\left[0, \overline{t_0}\right]$. To find the optimal tax rate that maximizes social welfare, two situations, $t_0 = 0$ and $t_0 = \overline{t_0}$ are compared. Let $SW_0^t$ and $SW_0^0$ be the social welfare in the case of $t_0 = \overline{t_0}$ and $t_0 = 0$, respectively. Then, social welfare in each tax rate can be computed as:

$$SW_0^t = \pi_0 w_F \left\{-\beta\gamma + (1-\pi_0) r w_F \left\{1 - \gamma(1+\beta)\right\}\right\} + \beta\gamma w_L \tag{24}$$

$$SW_0^0 = \frac{1}{8}\left[8\gamma\beta w_L - \pi_0 w_F \left\{8\beta\gamma + (1-\pi_0) r w_F \left\{(2+3\beta)\gamma - 2\right\}\right\}\right] \tag{25}$$

Also define $f_0 \equiv SW_0^t - SW_0^0$. Then, $f_0$ is calculated as:

$$f_0 = -\frac{1}{8}\pi_0(1-\pi_0)\left\{(6+5\beta)\gamma - 6\right\} r w_F^2 \tag{26}$$

From equation (26), the following relationship can be confirmed:

$$SW_0^t \ge SW_0^0 \Leftrightarrow \gamma \le \frac{6}{6+5\beta} \tag{27}$$

Because $2/(2+3\beta) < 6/(6+5\beta) < 2/(2+\beta)$, the value of γ that satisfies equation (27) surely exists. Then, we find:

If $\frac{2}{2+3\beta} \le \gamma \le \frac{6}{6+5\beta}$, then $t_0^* = \overline{t_0}$ and full insurance is realized.

If $\frac{6}{6+5\beta} \le \gamma \le \frac{2}{2+\beta}$, then $t_0^* = 0$ and partial insurance ($\alpha_0^* = 1/2$) is realized.

*Case 3:* $\gamma \ge 2/(2+\beta)$

From equation (23), we find $\overline{t_0} \le \hat{t}_0$. Then, the social welfare function in equation (19) is a monotone decreasing function of $t_0$ in the range of $\left[0, \overline{t_0}\right]$. Thus, the government chooses $t_0^* = 0$ and partial insurance ($\alpha_0^* = 1/2$) is realized.

By combining the above three cases, the following two possible results are derived.

If $0 \le \gamma \le \frac{6}{6+5\beta}$, then $t_0^* = \overline{t_0}$ and full insurance is realized.

If $\frac{6}{6+5\beta} \le \gamma \le 1$, then $t_0^* = 0$ and partial insurance ($\alpha_0^* = 1/2$) is realized.

The above results show that whether the premium subsidy is desirable depends on the weight of consumers' welfare $\gamma$ and the fraction of policyholders $\beta$. If $\gamma$ and/or $\beta$ are relatively small, then the government introduces a premium subsidy and full insurance is realized. In contrast, if $\gamma$ and/or $\beta$ are relatively large, then the government does not offer a premium subsidy and partial insurance is realized.

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**Effort case**

It is easy to verify that $CE_1 \geq CE_0$ is the condition in which policyholder chooses the effort in the fourth stage of the game. However, introducing policyholder's effort may change the condition whether government conducts premium subsidy. For example, the government may want to lower the optimal tax rate in the case of $0 \leq \gamma \leq 6/(6+5\beta)$ for lowering the optimal insurance coverage rate and conducting the effort. To investigate the effect of the effort, we re-examine two situations, $0 \leq \gamma \leq 6/(6+5\beta)$ and $6/(6+5\beta) \leq \gamma \leq 1$.

First, consider the case where $0 \leq \gamma \leq 6/(6+5\beta)$. In this situation, the policyholder never chooses to conduct the effort because full insurance is chosen. Thus, the optimal tax rate is surely $\overline{t_0}$. Then, the government may be able to increase the social welfare by lowering the tax rate, because this leads to lowering the optimal insurance coverage rate, and then the policyholder voluntarily conducts the effort. Let $\tilde{t}_1$ be the maximum tax rate at which the policyholder conducts the effort. Then, $\tilde{t}_1$ can be derived by solving $CE_1 = CE_0$. Of course, $\tilde{t}_1$ does not necessarily exist, because $\tilde{t}_1$ is never greater than $\overline{t_1} = \pi_1(1-\pi_1)r\beta w_F^2/w_L$ that is the upper limit of the tax rate when policyholder conducts the effort. In the latter analysis, it is assumed that $\tilde{t}_1$ always exists. Let $\tilde{\alpha}_1$ be the insurance coverage rate in the case of $\tilde{t}_1$. From same manner deriving equation (13), we find that $1/2 \leq \tilde{\alpha}_1 \leq 1$. In addition, $SW_1^t$ represents the social welfare when the tax rate is $\tilde{t}_1$. Then, the difference between the two social welfares, which is defined by $g \equiv SW_1^t - SW_0^t$, can be computed as:

$$g = \{-\gamma(1-\beta)\tilde{t}_1 w_L + (1-\gamma)E\Pi_1\} - \{-\gamma(1-\beta)\overline{t_0} w_L + (1-\gamma)E\Pi_0\} \quad (28)$$

From the same manner deriving equation (19), we have

$$E\Pi_1 = \frac{\{t_1 w_L + \pi_1(1-\pi_1)r\beta w_F^2\}^2}{4\pi_1(1-\pi_1)r\beta^2 w_F^2} \quad (29)$$

Then, if $g \geq 0$ is realized, the government chooses $\tilde{t}_1$ instead of $\overline{t_0}$. There are two kinds of conditions to realize $g \geq 0$, as shown below.

In the case that $E\Pi_1 - E\Pi_0 - (1-\beta)(\overline{t_0} - \tilde{t}_1)w_L \geq 0$:

$$\gamma \leq \frac{E\Pi_1 - E\Pi_0}{E\Pi_1 - E\Pi_0 - (\overline{t_0} - \tilde{t}_1)(1-\beta)w_L} \quad (30)$$

In the case that $E\Pi_1 - E\Pi_0 - (1-\beta)(\overline{t_0} - \tilde{t}_1)w_L \leq 0$:

$$\gamma \geq \frac{E\Pi_1 - E\Pi_0}{E\Pi_1 - E\Pi_0 - (\overline{t_0} - \tilde{t}_1)(1-\beta)w_L} \quad (31)$$

where $\overline{t_0} \geq \tilde{t}_1$ is always satisfied, because $\overline{t_0} \geq \overline{t_1}$. The denominator on the right-hand side of equations (30) and (31) represents the change in the expected profit for the insurance firm, represented by $E\Pi_1 - E\Pi_0$, and the welfare of non-policyholders, represented by $(\overline{t_0} - \tilde{t}_1)(1-\beta)w_L$, when the tax rate changes from $\overline{t_0}$ to $\tilde{t}_1$. From equations (30) and (31), we easily find that $SW_1^t \geq SW_0^t$ is always realized for all $\gamma \in [0, 6/(6+5\beta)]$ when $E\Pi_1 \geq E\Pi_0$. Thus, the government chooses $\tilde{t}_1$, while the policyholder chooses $\tilde{\alpha}_1 \in [1/2, 1]$ and conducts the effort. In this situation, the change from $\overline{t_0}$ to $\tilde{t}_1$ improves the social welfare of non-policyholders, because the tax rate becomes lower and the expected profit for the insurance firm is increased because $E\Pi_1 \geq E\Pi_0$, while the social welfare of policyholders is the same because $CE_1 = CE_0$. Consequently, it is desirable for all parties to choose the tax rate $\tilde{t}_1$.

In contrast, when $E\Pi_1 \leq E\Pi_0$, equation (31) is the unique condition because there exists no γ that satisfies equation (30), since $E\Pi_1 - E\Pi_0 - (1-\beta)(\overline{t_0} - \tilde{t}_1)w_L \leq 0$. However, we cannot know whether $\gamma$ satisfies equation (31) and so whether the government chooses $\overline{t_0}$ or $\tilde{t}_1$ is ambiguous.

Next, we consider the case where $6/(6+5\beta) \leq \gamma \leq 1$. In this situation, the policyholder chooses partial insurance $\alpha_i^* = 1/2$. Assume that the policyholder decides to conduct the effort in the case of $\alpha_i^* = 1/2$. Then, we compare two kinds of situations, $t_1 = 0$ and $t_1 = \tilde{t}_1$. Let $E\Pi_1^0$ be the expected profit of the insurance firm in the case of $t_1 = 0$ and $SW_1^0$ be the social welfare when the tax rate is zero and policyholder conducts the effort. If we define $h \equiv SW_1^t - SW_1^0$, we can show that

$$h = \{-\gamma(1-\beta)\tilde{t}_1 w_L + (1-\gamma)E\Pi_1\} - (1-\gamma)E\Pi_1^0 \quad (32)$$

Then, if $h \geq 0$ is realized, the government chooses $\tilde{t}_1$ instead of zero. From equation (32), the following condition for satisfying $h \geq 0$ is derived:

$$\gamma \leq \frac{E\Pi_1 - E\Pi_1^0}{E\Pi_1 - E\Pi_1^0 + \tilde{t}_1(1-\beta)w_L} \quad (33)$$

Because expected profit of the insurance firm is an increasing function of $t_i$ by equations (17) and (29), $E\Pi_1 \geq E\Pi_1$ is always satisfied. Thus, it is possible to realize $\tilde{t}_1$, but whether the government chooses zero or $\tilde{t}_1$ is ambiguous.

The above analysis shows that there are three kinds of optimal tax rates 0, $\tilde{t}_1$, and $\overline{t_0}$ and three insurance coverage rates, 1/2, $\tilde{\alpha}_1$, and 1. To know which optimal tax rate and insurance coverage rate are realized, we define the following two variables, which are the right-hand side of equations (31) and (33):

$$\gamma_1 \equiv \frac{E\Pi_1 - E\Pi_0}{E\Pi_1 - E\Pi_0 - (\overline{t_0} - \tilde{t}_1)(1-\beta)w_L} \quad (34)$$

$$\gamma_2 \equiv \frac{E\Pi_1 - E\Pi_1^0}{E\Pi_1 - E\Pi_1^0 + \tilde{t}_1(1-\beta)w_L} \quad (35)$$

To guarantee the above two variables, $0 \leq \gamma_1 \leq 6/(6+5\beta)$ and $6/(6+5\beta) \leq \gamma_2 \leq 1$ are assumed to be satisfied. First, consider the case of $E\Pi_1 \geq E\Pi_0$. From equation (33), the following results are derived.

If $\gamma \in [0, \gamma_2]$, then $t_i^* = \tilde{t}_1$ and $\alpha_i^* = \tilde{\alpha}_1$ are realized.

If $\gamma \in [\gamma_2, 1]$, then $t_i^* = 0$ and $\alpha_i^* = 1/2$ are realized.

Next, consider the case of $E\Pi_1 \leq E\Pi_0$. From equations (31) and (33), the following results are derived.

If $\gamma \in [0, \gamma_1]$, then $t_i^* = \overline{t_0}$ and $\alpha_i^* = 1$ are realized.

If $\gamma \in [\gamma_1, \gamma_2]$, then $t_i^* = \tilde{t}_1$ and $\alpha_i^* = \tilde{\alpha}_1$ are realized.

If $\gamma \in [\gamma_2, 1]$, then $t_i^* = 0$ and $\alpha_i^* = 1/2$ are realized.

From the results in this analysis, we derive the following implications. First, the smaller $\gamma$, the larger $t_i^*$ and $\alpha_i^*$. Second, unlike no effort case, whether government conducts premium subsidy is ambiguous even if $\beta$ is small. It is easy to verify that $\gamma_2$ becomes the critical value whether government conducts premium subsidy. However, the relationship between $\gamma_2$ and $\beta$ is unclear because $\tilde{t}_1$ is a function of $\beta$ and $\tilde{t}_1$ is neither monotone increasing nor decreasing function of $\beta$. This result shows whether premium subsidy conducted by government is surely desirable depends on whether policyholder's effort is considered when the fraction of policyholders is small.

## Concluding Remarks

The main findings of this article are summarized as follows. When policyholder's effort for lowering accident probability is not considered, and the fraction of policyholders is small, government conducts premium subsidy which stimulates an individual to choose full insurance coverage while maximizes social welfare which consists of policyholders, non-policyholders and insurance firm. In contrast, when policyholder's effort is considered, it becomes ambiguous whether premium subsidy is desirable even in the case of small fraction of policyholders.

This result suggests that, as a means of fostering the growth and development of insurance industry, a premium subsidy policy by government will probably be more effective when the targets are underdeveloped or in the rudimentary stage at least when policyholder's effort is not necessarily considered. Concretely, a government grant will facilitate the dissemination of knowledge and/or information regarding insurance and increase its penetration rate. Meanwhile, achieving sustainable growth in the insurance sector will ultimately lead to an improvement in social and economic welfare.

This finding is consistent with prior studies that assert government intervention can be Pareto-improving in a market associated with imperfect and/or costly information [28,29]. It also helps to explain why agricultural insurance programs in most developing countries would be assisted by a subsidy from the government. As a matter of fact, it has also been empirically supported by some recent studies on China's Cooperative Medical Scheme, a government-subsidized voluntary health insurance program in rural regions [32,33].

However, our study is only focused on a short-term contract. A further analysis based on a long-term contract and/or a repeated contract should be considered. Moreover, the problem of moral hazard between the insurance firm and the government also deserves special attention, because insurance firms may be reluctant to pursue sound practices such as risk classification and/or loss assessment when they know the government will eventually pay the bill.

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