Adverse selection and moral hazard in health insurance.

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Abstract

In this paper, we want to characterize the optimal health insurance contract with adverse selection and moral hazard. We assume that policyholders differ by the permanent health status loss and choose an unobservable preventive effort in order to reduce the probability of illness which is ex-ante identical. The difference in illness' after-effect modifies policyholders' preventive actions. By the way, they differ in probabilities of illness leading to a situation close to Rothschild and Stiglitz's model. In this case, we show that the optimal contract exhibits a deductible for the high health risk type since a higher aftereffect implies a higher preventive effort and then a lower probability of illness rather than for the low health risk type.

1 Introduction

In the context of insurance, moral hazard refers to the impact of insurance on incentives to reduce risk through preventive action. Shavell (1979) has shown that these actions are lower than the first best value when policyholders can choose complete coverage if the action is unobservable. This result is consistent with the introduction of irreplaceable good in the sense of Cook and Graham (1977). Health risk is closely related to such goods

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since health status modifies the utility provided by wealth. However, by introducing health risk, Bardey and Lesur (2005) argue that it may be the case that underinsurance is not a necessary condition to provide the right incentives to policyholders. With full coverage, they have an incentive to take preventive action in order to reduce the risk of being ill. This is due to the fact that illness permanently reduces health status (as after effects, permanent treatment).

In this paper, we focus on the implications of the introduction of adverse selection in this framework. We want to characterize the optimal health insurance contract. We argue that a deductible is a necessary condition in order to achieve separation between policyholder’s types. Indeed, even if policyholders have incentive to take preventive action with full coverage, the introduction of different types creates a problem of discrimination. Rothschild and Stiglitz (1976) had shown that second best contracts exhibit deductible for the risk type characterized by the lower probability. In our model, we suppose that insured differ by the health status loss. Thus, this difference in after effects modifies the policyholders’ preventive actions. By the way, they have different probability of illness leading to a situation close to Rothschild and Stiglitz’ one. In this case, we show that the optimal contract exhibits a deductible for the high health risk type since a higher after effect implies a higher preventive effort and then a lower probability of illness.

The first section presents the framework and the second section characterizes the optimal health insurance with moral hazard. The third section exhibits the effect of adverse selection and the fourth section concludes.

2 Framework

We consider an economy with a large number of consumer. Their preferences are described by an additively separable utility function:

$$U(W, H) = u(W) + H$$

This function is increasing and concave in wealth. As the debate on the sign of $u_{12}$ is still open (Rey, 2003), we assume that $u_{12} = 0$. So our assumption is very closed to Shavell (1979) and Bardey and Lesur (2005)’s analysis.

However, there exists two types of policyholders denoted by $i \in \{L, H\}$ for low and high health risk with $\partial h_H > \partial h_L$. We assume that they have
the same initial wealth \( w \) and health status \( h \). They face two states of nature: an illness state with a financial loss \( L \) and health loss \( \partial h i \). We suppose that policyholders face an malignant risk: \( \partial h > 0 \) which appears with a probability \( p \). The agent can decrease this probability taking preventive actions \( e \geq 0 \) with an unitary cost per unit of level effort. We assume that \( p = p(e) \) with \( p'(e) < 0 \) and \( p''(e) > 0 \). We consider a health risk non-deterministic in the sense that: \( p(0) < 1 \) and \( \lim_{e \to \infty} p(e) > 0 \). For the current problem, \( p'(0) = -\infty \) and convexity of \( p(e) \) are sufficient conditions for the second-order conditions on the problem of incentive compatibility constraint of insured. We can deduce that the preventive effort level depends on the health loss. If policyholders choose different preventive effort for a same indemnity, then they differ in illness probabilities. In this case, we show that deductible is necessary to achieve discrimination.

We consider a competitive market. When insurance firms cannot distinguish among different risk types, they may loose money by offering the set of full information contracts as shown by Rothschild and Stiglitz (1976). In this context, we assume that each insurer knows the proportion of good risks and bad risks but has no information on individual types. Our model considers that firm adopts a Nash equilibrium strategy. Then, a menu of contract at equilibrium is such that no contract makes negative expected profit and no other contract earns positive expected profit. Moreover, we assume that overinsurance is not allowed.

3 Optimal insurance contract with moral hazard

With ex ante moral hazard, the level of preventive effort \( (e_i) \) cannot be contracted for since it is unobservable to the insurer. The optimal contract maximizes expected utility subject to the zero profit constraint of the insurer and the incentive compatibility constraint of the insured. A contract \(^1\) denoted \( Ci \) is defined by a set of transfers contingent on the state of nature: a payment \( I_i \) when the insured fall ill and \( \theta_i \) is the premium by unit of coverage. Then, the optimal contract is solution of following program:

\(^1\) with no overinsurance
\begin{align*}
\max_{I_i, \theta_i, e_i} \{ (1 - p(e_i))[U(w - \theta_i I_i - e_i) + h] + p(e_i)[U(w + I_i - \theta_i I_i - L - e_i) + h - \delta h_i] \} \\
\text{s.t.} \quad \frac{\theta_i I_i - p(e_i)I_i}{U(w + I_i - \theta_i I_i - L - e_i) - \delta h_i} \\
\quad p'(e_i) \left[ U(w + I_i - \theta_i I_i - L - e_i) - U(w - \theta_i I_i - e_i) \right] \\
\quad - \left[ p(e_i)U_1(w + I_i - \theta_i I_i - L - e_i) \right] = 0
\end{align*}

with \( U_1 \) the first derivative and \( U_{11} \) the second derivative.

We denote \( \tilde{e}_i \) the optimal level effort choosen by the insured. Since interested in the optimum, we have \( \theta_i = p(e_i) \). After computations, the optimal coverage verifies the following condition:

\[
\frac{\delta EU(I_i)}{\partial I_i} = -\frac{d\tilde{e}_i}{dI_i} p' I_i \left[ (1 - p)U_1(w - p(e_i)I_i - e_i) \right] \\
\quad + pU_1(w + I_i - p(e_i)I_i - L - e_i) \\
\quad + (1 - p)U_1(w - p(e_i)I_i - e_i)
\]

(1)

For a full coverage \( (I_i = L) \), we obtain

\[
\frac{\delta EU(I_i)}{\partial I_i} \bigg|_{I_i = L} = -\frac{d\tilde{e}_i}{dI_i} p' L U_1(w - p(e_i^*)L - e_i^*)
\]

The sign of \( \frac{\delta EU(I_i)}{\partial I_i} \bigg|_{I_i = L} \) depends on the sign of \( \frac{d\tilde{e}_i}{dI_i} \bigg|_{I_i = L} \) and we have

\[
\frac{d\tilde{e}_i}{dI_i} \bigg|_{I_i = L} = \frac{pU_1(w - p(e_i^*)L - e_i^*) - pU_{11}(w - p(e_i^*)L - e_i^*)}{pL - U_{11}(w - p(e_i^*)L - e_i^*)}
\]

In the neighborhood of full coverage, preventive efforts are increasing with the indemnity level if the policyholders are sufficiently risk averse. Then we have \( -\frac{U_{11}(w - p(e_i^*)L - e_i^*)}{U_1(w - p(e_i^*)L - e_i^*)} \geq -\frac{p'}{p} \). If this inequality is verified then full coverage is optimal (Bardey and Lesur, 2005). In such a case, their level of effort has the following property.

**Lemma 1** With moral hazard, for a contract \( C_i(I_i, \theta_i) \) the preventive level effort is increasing with the severity of illness.

**Proof.** The objective of the policyholder is to maximise their expected utility. The derivative of the incentive compatibility constraint of the insured
with respect to the effort and the severity of illness yields:

\[
\frac{d\hat{c}_i}{d\delta h_i} = \frac{-p'(e_i)}{\frac{\delta^2 EU}{\delta e_i}}
\]

Assuming the existence of an interior solution implies that \(\frac{\delta^2 EU}{\delta e_i} < 0\). However, \(p'(e) < 0\) implies that \(\frac{d\hat{c}_i}{d\delta h_i} > 0\). ■

This property implies that optimal effort are positively correlated with the after effect.

**Corollary 2** With moral hazard, the preventive level effort of the high health risk type is higher than that of the low health risk type.

**Proposition 3** Proof. Since \(\delta h_H > \delta h_L\), from the above lemma, we know that \(\hat{c}_H > \hat{c}_L\). ■

The high health risk type have more incentive to internalize the benefit of their preventive action because the difference of the health status in the two states is higher than of the low risk types. Then as the probability of illness is decreasing with the level of effort, the high health risk type becomes the low risk for insurers. In fact, the expected damage of the high health risk type is lower than the low health risk type. Introducing adverse selection in this context, and following Rothschild and Stiglitz (1976), it may be the case that the high health risk type obtain less coverage than the low health risk type due to the fact that discrimination is based on the financial risk.

### 4 Optimal insurance contract with moral hazard and adverse selection

Combining adverse selection with hazard moral requires to eliminate either the moral hazard problem alone (Rubinstein and Yaari, 1983) or adverse selection alone (Dionne and Lasserre, 1985). Then, in a first step, we resolve the moral hazard problem. In a second step, following Fagart and Kambia-Chopin (2004), we verify if the moral hazard contract can be solution of a pure adverse selection model.

The existence of separating equilibrium in a context of adverse selection and moral hazard depends on the Spence-Mirless condition (Chassagnon and Chiappori, 1997; De Meza and Webb, 2001).
Lemma 4 For a contract $C_i(I_i, \theta_i)$, a sufficient condition in order to verify the single crossing condition is that policyholder’s preferences are non-increasing.

Proof. We have to prove that the absolute value of the slope of the low-risk indifference curve is lower than that of the high-risk indifference curve. For a contract $C_i(I_i, \theta_i)$, this slope is equal to

$$\frac{p(e_i)}{1-p(e_i)} \frac{U_1(w-\theta_i I_i-e_i)}{U_1(w+I_i - \theta_i I_i - L - e_i)}$$

Using the coralarly 2, we know that $e_H > e_L$. It implies that $\frac{p(e_H)}{1-p(e_H)} > \frac{p(e_L)}{1-p(e_L)}$. Since the single crossing condition is verified if $\frac{U_1(w-\theta_i I_i-e_H)}{U_1(w+I_i - \theta_i I_i - L - e_H)} \geq \frac{U_1(w-\theta_i I_i-e_L)}{U_1(w+I_i - \theta_i I_i - L - e_L)}$ a sufficient condition is that $\frac{U_1(w-\theta_i I_i-e_i)}{U_1(w+I_i - \theta_i I_i - L - e_i)}$ is decreasing with respect to $e_i$.

The derivative with respect to $e_i$ of this expression is negative iff

$$-\frac{U_{11}(w-\theta_i I_i-e_i)}{U_1(w-\theta_i I_i-e_i)} \leq -\frac{U_{11}(w+I_i - \theta_i I_i - L - e_i)}{U_1(w+I_i - \theta_i I_i - L - e_i)}$$

For $I_i \leq L$ this condition is verified if policyholder’s preferences exhibit non-increasing absolute risk aversion.

As we shown in the previous section, the unobservable level of preventive effort depends on the health risk type, then the two asymmetries can be combined in an adverse selection problem. The optimal contract maximizes expected utility subject to the zero profit constraint of the insurer, the incentive compatibility constraints and the low health risk self-selection constraint. The optimal contract is solution of following program:

$$\max_{I_i, \theta_i, e_i} \left\{ (1-p(e_i)) [U(w-\theta_i I_i - e_i) + h] + p(e_i) [U(w+I_i - \theta_i I_i - L - e_i) + h - \delta h_i] \right\}$$

s.t.\[ \theta_i I_i - p(e_i) I_i = 0 \]

$$\forall i \{ (1-p(e_i^*)) [U(w-\theta_i I_i - e_i^*) + h] + p(e_i^*) [U(w+I_i - \theta_i I_i - L - e_i^*) + h - \delta h_i] \geq \right\}$$

$$\{ (1-p(\tilde{e}_i)) [U(w-\theta_i I_i - \tilde{e}_i) + h] + p(\tilde{e}_i) [U(w+I_i - \theta_i I_i - L - \tilde{e}_i) + h - \delta h_i] \}$$

$$e_i^* \arg \max_{e_i} \{ (1-p(z)) [U(w-\theta_j I_j - z) + h] + p(z) [U(w+I_j - \theta_j I_j - L - z) + h - \delta h_i] \}$$

$$\tilde{e}_i \arg \max_{\tilde{e}_i} \{ (1-p(x)) [U(w-\theta_j I_j - x) + h] + p(x) [U(w+I_j - \theta_j I_j - L - x) + h - \delta h_i] \}$$

with $j \neq i$ and $i$ and $j \in \{L, H\}$

(3)
We denote $e_i^*$ the optimal level effort chosen by the insured when they take their own contract and $\tilde{e}_i$ the optimal level effort when the policyholder take other contract. Under the incentive compatibility constraint, we know that $\theta_i = p(e_i)$.

However as a pure adverse selection problem, the type of equilibrium depends on the self-selection constraint. The two self-selection constraints can not be simultaneously binding with the moral hazard contract.

**Lemma 5** The self-selection constraint of the low health risk type is binding alone.

**Proof.** The proposition 2 implies that for the hazard moral contracts the premium of the high health risk type contract is lower than that of the the low health risk type. So, both types will select the high health risk type. Each insurer will make losses since the average cost is greater than the premium of the high health risk type.

With the hazard moral contracts offering a full coverage, the self-selection constraint can be rewritten

$$U(w - \theta_iL - L - e_i^*) - p(e_i^*)\delta h_i \geq U(w - \theta_jL - \tilde{e}_i) - p(\tilde{e}_i)\delta h_i$$

with $e_i^* \arg \max_z U(w - \theta_iL - z) - p(z)\delta h_i$

with $\tilde{e}_i \arg \max_x U(w - \theta_jL - x) - p(x)\delta h_i$

with $j \neq i$ and $i$ and $j \in \{L, H\}$.

Firstly, with moral hazard contracts, the low health risk type never chooses the high health risk type contract. It is due to the fact that $e_i^*$ is an arg max and $\theta_L < \theta_H$. $e_i^*$ arg max implies that $U(w - \theta_LL - e_i^*) - p(e_i^*)\delta h_L > U(w - \theta_LL - \tilde{e}_L) - p(\tilde{e}_L)\delta h_L$. $\theta_L < \theta_H$ implies that $U(w - \theta_LL - \tilde{e}_L) - p(\tilde{e}_L)\delta h_L > U(w - \theta_HL - \tilde{e}_L) - p(\tilde{e}_L)\delta h_L$. We can deduce that $U(w - \theta_LL - e_i^*) - p(e_i^*)\delta h_L > U(w - \theta_HL - \tilde{e}_L) - p(\tilde{e}_L)\delta h_L$. So, the self-selection constraint of the high health risk type is never binding.

Secondly, with moral hazard contracts, the high health risk type prefers the low health risk type contract. It is easy to show that $U(w - \theta_HL - e_H^*) - p(e_H^*)\delta h_H > U(w - \theta_HL - e_H^*) - p(e_H^*)\delta h_H$ can be false. Fully derivativing the incentive constrainst for full coverage, we obtain that

$$\frac{de_H}{d\theta} = -\frac{U_{11}(w - \theta L - e_H)L}{U_{11}(w - \theta L - e_H) - p^\delta(e_H)\delta h_H} < 0$$
Assuming $\theta_L < \theta_H$ implies that $\bar{c}_h > e_H^*$. Assuming the damage is sufficiently high, i.e., the reduction of premium is higher than the increasing of cost of effort, we can deduce that $\theta_H L + e^*_H > \theta_L L + \bar{c}_h$. So we have $U(w - \theta_H L - e^*_H) < U(w - \theta_H L - e^*_H)$ and $p(e^*_H)\delta h_H > p(\bar{c}_H)\delta h_H$. With moral hazard contracts, we can conclude that the self-selection constraint of the low health risk is never true. Then, at equilibrium, this self-selection constraint is binding.

At equilibrium, the low health risk receive full insurance since the low-risk self-selection constraint is not binding. The solution of our program implies that the high health risk type receives less than full insurance. We can summarize the description of the separating equilibrium with the following proposition

**Proposition 6** In the presence of adverse selection and hazard moral, an optimal set of separating contract has the following characteristics

a) The low health risk type receives full coverage
b) The high health risk type receives partial coverage

Using lemma 4 the equilibrium separating is due to the fact that the single crossing is verified. Lemma 5 implies that full insurance can not be offered to the high health risk type and low health risk type obtains full coverage.

Only the low health risk type obtains the moral hazard contract whereas the high health risk type are restricted to partial insurance. This result seems to be in opposition to the Rothschild and Stiglitz’s analysis. They focus only on the financial risk. In our model, the high health risk type become the low financial risk type because the insurable health loss lead them to make most preventive effort.

5 Conclusion

We consider a model of health insurance. The health dimension is taken into account by considering a bivariated utility function. We assume that policyholders face not only a financial risk due to the cost of the treatment but also a risk on their health status since they suffer from a permanent health status loss in case of illness. Moreover we consider that there are different permanent health status loss i.e. different health risk type. They also may undertake an unobservable preventive effort in order to reduce the probability of illness. The difference in illness’ after-effect modifies policyholders’
preventive actions. By the way, they differ in probabilities of illness leading to a situation close to Rothschild and Stiglitz ’ model. In this case, we show that the optimal contract exhibits a deductible for the high health risk type since a higher after effect implies a higher preventive effort and then a lower probability of illness rather than for the low health risk type. Then high health risk are the low risk in term of expected loss and recieve undercover-age in case discrimination is allowed. They are not only the less wealthy in case of illness but also the less covered. This result gives a new argument to forbid discrimination in health insurance market.

References


