

# Controlling selection incentives when health insurance contracts are endogenous

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## Abstract

The paper examines the nature of health insurance contracts when insurance companies pool high- and low-risk individuals. In a spatial product differentiation model, the normal forces of competition induce quality provision, but selection incentives induce insurers to under-provide quality. To offset selection incentives, the government can reimburse some of the insurers' costs. However, such a subsidy can in some cases reduce quality further, as well as discourage production efficiency. In such cases the optimal reimbursement rate is negative. © 2001 Elsevier Science B.V. All rights reserved.

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## 1. Introduction

The issue of risk selection in health insurance markets, and the design of policies to control it, has received growing attention in recent years (see, for example, Newhouse, 1996; Glazer and McGuire, 1998). Recognizing that financial incentives are central to the analysis of this phenomenon a number of authors (Ma, 1994; Newhouse, 1996) have adopted techniques from the optimal regulation literature of Laffont and Tirole (1994) to the health insurance context to examine the implications for optimal reimbursement policies.<sup>1</sup> However, it is arguable that the mechanism of risk selection requires somewhat more specific modelling than is available in the standard literature.

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<sup>1</sup>See Ellis and McGuire (1986) and Ma and McGuire (1997) for related models in the health economics literature.

Insurance companies have incentives to select good risks ahead of bad risks because the latter are more expensive to cover. A major strand of the literature on selection control examines the use of risk-adjusters to offset these incentives. Exogenous characteristics correlated with expected health care utilization are used to predict costs, and correspondingly adjust premiums paid to health plans. Glazer and McGuire have recently investigated the design of such risk adjusters in the context of the model of insurance under adverse selection of Rothschild and Stiglitz (1976) and Wilson (1977).

An alternative natural way for the government to remove these incentives is for it to pay for some of the realized costs of coverage: indeed, by reimbursing all of the insurance claims paid, a government would cause insurers to be indifferent between covering either risk type. The problem with such a solution is, of course, that insurers would have no incentive to provide insurance efficiently, since the signal upon which transfers are based is no longer exogenous. This is an example of the multi-task agency problem identified by Hölmstrom and Milgrom (1991). By reducing incentives to select good risks, the government also waters down incentives for production efficiency.

In this paper selection is socially undesirable because it can lead to low quality insurance. There is a sense in which this occurs in the standard Rothschild–Stiglitz model. An equilibrium in that model (if one exists) is characterized by full insurance of high-risk individuals, but with low-risk individuals being under-insured. One might interpret this as under-provision of quality (of insurance bought by low risks) in order to deter high risks from purchasing the wrong contract. However, the ‘quality’ of insurance purchased by high risks is not distorted. In addition, competition eliminates the possibility of cross subsidization of high risks by low risks (firms earn zero profits on each contract they sell in equilibrium), so insurers have no particular incentive to alter the risk mix of their insurance pools.

It is arguable that this kind of model misses a fundamental issue in the analysis of selection incentives, namely, that such incentives derive from the benefits associated with better risk pools, and that they can lead to under-provision of quality for *all* consumers. To allow the possibility of positive profits I endow insurers with some market power, specifically by use of a spatial model of product differentiation. I also assume that consumers cannot be quantity constrained, or more generally, that insurers cannot offer non-linear screening contracts. This second assumption, which induces a kind of pooling, means that insurers must earn positive profits on at least some of their clients if they are to remain in the market.<sup>2</sup> Insurers may then have incentives to reduce the terms of insurance (i.e., its quality) in order to increase the share of profit-generating low risks they cover.

Whenever insurers have access to information about the risk-types they cover,

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<sup>2</sup>The adverse selection aspect of the model is thus closer to Akerlof’s (1970) lemons case than Rothschild and Stiglitz’s.

they will have incentives to sell to low risks – ‘cream-skimming,’ and deny coverage to high risks – ‘dumping’ (see Ellis, 1998). Government regulations often attempt to ban such activities, by requiring open enrollment periods and community rating. This paper assumes that such regulations are effective, so without loss of generality insurance companies have no private information about the characteristics of individuals (although they do know the distribution of risks in the population).

As Newhouse notes however, insurers have other subtle methods of inducing self-selection by good risks, including staffing policies and physician incentive contracts, which are difficult to regulate directly. To capture this idea, I will assume that although the insurance contract offered by firms is a very simple linear scheme, it is impossible for the government to impose its desired scheme on insurers. That is, consumers and insurers are fully aware of the terms of the contract, but these cannot be directly controlled by the government.

If under-provision of quality is to be corrected by subsidizing claims paid, then the effects on endogenous insurance company effort (production efficiency) need to be modelled. Ignoring the effects on effort, and possible feedback effects on quality, it is straightforward to interpret subsidization of expensive plans as a kind of risk adjustment (Cutler and Zeckhauser, 1997), with claims being used as a signal of the average risk of a firm’s enrollees. Appealing to the literature on optimal regulation under asymmetric information, it is natural to infer that, accounting for effort incentives, a positive but sub-unitary fraction of claims should be reimbursed. A contribution of this paper is to show that in fact, allowing feed-back effects from effort choice to quality, a negative subsidy may be optimal.

The simple intuition for this result is as follows. In the absence of subsidies, the effects of effort are fully internalized, so firms make socially efficient effort choices, but they may under-provide quality. Given the level of effort, a direct effect of a small proportional claims subsidy is to reduce the difference between the expected claims of high- and low-risks born by the insurer, and thus to *reduce* selection incentives. The subsidy also reduces effort, the direct social cost of which is second order. However, to the extent this effort reduction increases the cost differential between high- and low-risk individuals, it *increases* the incentive to select low risks, offsetting the direct effect of the subsidy on selection incentives. If this feedback effect is large enough, it is optimal (at least locally) to impose a negative subsidy.

Finally, let me compare the structure of this model with those of the regulation under asymmetric information literature. In that literature, firms have private information about their inherent efficiency (which is exogenous), and about the effort they supply. The realized cost of production (excluding the costs of effort borne directly by the firm), is observable by the government and is a function of these unobservable components. The optimal regulatory transfer takes a ‘cost-plus’ form. In this paper, an insurer’s ‘inherent efficiency’ corresponds to the average risk of the pool it covers, which is endogenous, and is a function of the quality of

insurance offered by all (in our model, both) firms, but not the effort they exert. Realized costs of production (net of effort costs) are again observable by the government.<sup>3</sup> However, the endogeneity of a firm's inherent efficiency means that the optimal regulatory transfer can be either a 'cost-plus,' or a 'cost-minus' contract.

The next section describes preferences, insurance provision, market structure, and welfare. Section 3 examines market equilibrium and the conditions under which selection incentives are operative. Section 4 introduces subsidies, and investigates their effect on effort and quality choices, and welfare. Section 5 offers some concluding comments.

## 2. The model

In this section I describe both sides of the insurance market (including preferences, costs of provision and market structure), and the measurement of social welfare.

### 2.1. Preferences

There are two possible states of nature, good and bad. Initially, I assume individuals have identical income endowments  $\omega = (\omega^G, \omega^B)$ , with  $\omega^G > \omega^B$ . They also possess identical state-independent utility indices over income,  $u(m)$ , and value state-contingent income vectors  $\mathbf{m} = (m^G, m^B)$  according to the expected utility generated,

$$v(\mathbf{m}) = (1 - \pi)u(m^G) + \pi u(m^B),$$

where  $\pi$  is the probability of the bad state occurring. The expected value of income is  $E(\mathbf{m}) = (1 - \pi)m^G + \pi m^B$ .

Individuals differ according to the probability of the bad state. Specifically, an individual of type  $K = L$  or  $H$  faces a probability  $\pi_K$  of being in the bad state, and a probability  $(1 - \pi_K)$  of being in the good state. Low risk individuals, who make up a proportion  $\phi_L$  of the population, have a lower probability of the bad state occurring,  $\pi_L < \pi_H$ . The proportion of high risks is  $\phi_H = 1 - \phi_L$ . Let  $v_K(\mathbf{m})$  denote the expected utility of a  $K$ -type individual.

### 2.2. Insurance provision

Insurance companies can offer insurance on linear terms. That is, a price  $\rho$  is set at which individuals can transfer income across states of nature, via the insurance company. I will refer to  $\rho$  as the terms of the insurance contract. This allows the

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<sup>3</sup>Clearly, the first-best optimum could be attained if the government could base transfers on each firm's average risk mix.

individual to trade one unit of consumption in the good state for  $\rho$  units in the bad state, inducing a budget line

$$\mathcal{B}(\rho) = \{(m^G, m^B) : (m^G, m^B) = (\omega^G - x, \omega^B + \rho x) \text{ for some } x\}.$$

It might be useful to think of  $x$  as the ‘quantity’ of insurance purchased:  $x$  (which need not be monotonic in  $\rho$ ) is the amount paid by the insured to the insurance company in the good state, in return for receiving  $\rho x$  in the bad state.

In many models of insurance, e.g. Rothschild and Stiglitz (1976), provision is costless – insurance companies facilitate trade between states of nature, but do not incur any real costs in doing so. In such models, questions about production efficiency cannot be addressed. To model the effects of insurance subsidies on effort incentives, we assume here that it is costly for the insurer to transfer income to an insured individual. This cost is reduced by effort,  $e \geq 0$ , exerted by the insurer. In particular, the cost of transferring a unit of income to an individual in the bad state is  $1 + \gamma(e)$ , where  $\gamma(e) > 0$  and

$$\gamma' < 0, \gamma'' > 0, \text{ and } \gamma(e) \xrightarrow{e \rightarrow \infty} 0.$$

As well as measuring the level of effort,  $e$  represents the direct cost per covered individual imposed on the insurer. The insurer’s expected costs of covering a  $K$ -type individual, including claims paid, are thus

$$\underbrace{\pi_K \rho x}_{\text{Claims paid}} + \underbrace{[\pi_K \gamma(e) \rho x + e]}_{\text{Resource costs}} = \underbrace{\pi_K (1 + \gamma(e)) \rho x}_{\text{Gross claims}} + e.$$

One way to interpret  $e$  is to think of the insurer as making in-kind transfers to individuals in the bad state through the provision and financing of medical care.  $e$  then captures the actions the insurer can take to more efficiently provide such transfers, say by inducing doctors to provide appropriate but inexpensive care, while not cheating on the patient. It might also measure the extent to which an insurer monitors the health needs of the insured. With these interpretations it makes sense that those individuals with higher expected claims would impose greater non-claim costs on insurers.

We do not allow  $\rho$  and  $e$  to depend on  $K$ , reflecting an assumption that insurers are unable to practice first- or third-degree price discrimination between consumers, either because it is too costly, or because such discrimination is illegal. Let us denote the expected resource costs associated with a  $K$ -type individual by  $I_K(\rho, e) = \pi_K \gamma(e) \rho x + e$ . Given terms  $\rho$ , a  $K$ -type individual chooses  $x$  to maximize expected utility, yielding an indirect utility function

$$\begin{aligned} V_K(\rho, \omega) &= \max_x v_K(\omega^G - x, \omega^B + \rho x) \\ &= v_K(\omega^G - x_K^*(\rho, \omega), \omega^B + \rho x_K^*(\rho, \omega)). \end{aligned}$$

Note that consumers do not care directly about insurance company effort –

everything that affects the value they place on insurance is captured in the terms of trade offered,  $\rho$ . We can think of  $\rho$  then as including various aspects of quality, such as timeliness of payment, courtesy of staff, quality of doctors whose services an insurer will finance, etc. We shall find it useful for expositional purposes to assume that there are no wealth effects. That is, if an individual's income in both states of nature is increased by a given amount, this has no effect on the quantity of insurance purchased.

**Assumption 1.**  $x_K^*(\rho, \omega) = x_K^*(\rho, \omega + \mathbf{1}w)$ , where  $\mathbf{1} = (1, 1)$ .

Under this assumption, we can write the insurance company's expected profit from a  $K$ -type individual, when the terms offered are  $\rho$ , as

$$\begin{aligned} \Xi_K(\rho, e) &= (1 - \pi_K)x_K^*(\rho) - [\pi_K(1 + \gamma(e))\rho x_K^*(\rho) + e] \\ &= \underbrace{[(1 - \pi_K)x_K^*(\rho) - \pi_K\rho x_K^*(\rho)]}_{\text{Net revenue from consumer}} - \underbrace{[\pi_K\gamma(e)\rho x_K^*(\rho) + e]}_{\text{Resource costs}} \\ &= R_K(\rho) - \Gamma_K(\rho, e). \end{aligned}$$

### 2.3. Market structure

I employ a simple spatial model of differentiated products to examine the incentives for insurance companies to alter their case loads by attracting low risks ahead of high risks. There are two insurance companies, labelled 0 and 1, that are located at the ends of a product space line of unit length. Insurers choose only the terms of insurance offered to individuals,  $\rho$ , and effort,  $e$ . They can not choose location.<sup>4</sup> Both high- and low-risk individuals are distributed uniformly along the unit interval, and incur travel costs  $td$  when travelling a distance  $d$  to purchase insurance. These travel costs can be interpreted literally, if individuals must visit an insurance company office to purchase a policy. More realistically, the travel costs represent the extent to which the kind of policy offered diverges from an individual's most preferred type, in some generic characteristic space.

The existence of travel costs means that the net income endowment of an individual at position  $d$  becomes contingent on if, and from whom, she purchases insurance. In particular,

$$\omega(d) = \begin{cases} \omega & \text{if she does not purchase} \\ \omega - \mathbf{1}td & \text{if she purchases from insurer 0} \\ \omega - \mathbf{1}t(1 - d) & \text{if she purchases from insurer 1.} \end{cases}$$

<sup>4</sup>This assumption can be supported by surmising that in the background we have a meta-model with  $n$  firms choosing location on a Salopian circle, and by assuming that an equilibrium of that model has firms equally spaced around the circle.

Let us write  $\omega - td = \omega_0(d)$ , and  $\omega - t(1 - d) = \omega_1(d)$ , as the net income endowments of an individual at position  $d$  when she purchases from insurer 0 and 1 respectively.

If insurer  $i$  offers terms  $\rho_i$ ,  $i = 0, 1$ , a  $K$ -type individual at position  $d$  compares the expected utility she enjoys from optimally purchasing insurance from each firm, and from not insuring at all. Thus she compares

$$V_{K,0}(\rho_0, d) \equiv \max_x v_K(\omega_0^G(d) - x, \omega_0^B(d) + \rho_0 x),$$

$$V_{K,1}(\rho_1, d) \equiv \max_x v_K(\omega_1^G(d) - x, \omega_1^B(d) + \rho_1 x),$$

and

$$\bar{V}_K = v_K(\omega),$$

where the numeric subscript denotes the insurer from whom insurance is purchased. This choice is illustrated in Fig. 1. We denote the interval in which individuals purchase from firm 0 as  $[0, d_{K,0}(\rho)]$ , and that in which individuals purchase from firm 1 as  $[d_{K,1}(\rho), 1]$ . Of course, it is possible that all individuals in  $[0, 1]$  purchase insurance, in which case  $d_{K,0}(\rho) = d_{K,1}(\rho)$ ; otherwise  $d_{K,0}(\rho) < d_{K,1}(\rho)$ .

#### 2.4. Welfare

Welfare is utilitarian, relative to the no-insurance situation. That is, without loss of generality, I do not include the expected utility of uninsured individuals in the welfare measure. Later I will have cause to introduce subsidies paid to firms, which will be financed through possibly distortionary taxes on consumers. The contribution to welfare of insurance provided by insurer  $i$  at terms  $\rho$  to a  $K$ -type individual at position  $d$ , is thus

$$W_{K,i}(\rho, d, e, \sigma) = V_{K,i}(\rho, d) + \bar{\Xi}_K(\rho, e, \sigma) - (1 + \lambda)T_K(\rho, e, \sigma) - \bar{V}_K$$

where  $\sigma$  is the subsidy parameter,  $1 + \lambda$  is the shadow cost of public funds, and  $T_K(\rho, e, \sigma)$  is the dollar value of the subsidy generated by sales to the individual,

$$\bar{\Xi}_K(\rho, e, \sigma) = R_K(\rho) - \Gamma_K(\rho, e) + T_K(\rho, e, \sigma).$$

As an aside, if we define the gross surplus associated with terms  $\rho$  as  $S_{K,i}(\rho, d) = V_{K,i}(\rho, d) + R_K(\rho)$ , then the contribution to welfare  $W_{K,i}$  can be written as

$$W_{K,i} = S_{K,i} - \Gamma_K - \lambda T_K - \bar{V}_K$$

This can be compared with the welfare criteria adopted in standard models of regulation under asymmetric information (see Laffont and Tirole, 1994). Social welfare is the sum, over those who purchase insurance, of these individual contributions.

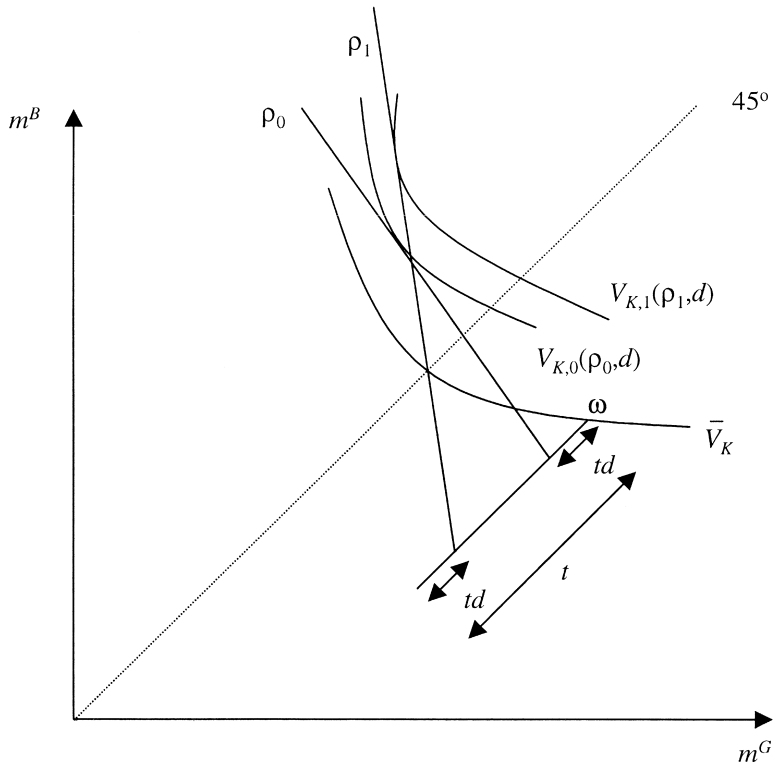


Fig. 1. Comparing insurance options. In this example an individual located at a distance  $d$  from insurer 0 will prefer to purchase a policy from insurer 1. Remaining uninsured is the least preferred option.

$$\begin{aligned}
 W(\boldsymbol{\rho}, \mathbf{e}, \sigma) = & \sum_{K=L,H} \phi_K \left[ \left( \int_0^{d_{K,0}(\boldsymbol{\rho})} W_{K,0}(\rho_0, d, e_0, \sigma) dd \right) \right. \\
 & \left. + \left( \int_{d_{K,1}(\boldsymbol{\rho})}^1 W_{K,1}(\rho_1, d, e_1, \sigma) dd \right) \right] \tag{1}
 \end{aligned}$$

### 3. Market equilibrium

In this section we first assume that the insurance companies operate in segmented markets with fixed clienteles, so there is no sense in which they compete with each other for customers. Demand is nonetheless elastic, as individuals can choose not to be insured. This will allow a convenient characteri-

zation of the positive effects, as well as the negative selection effects, that may be associated with competition, considered in the second part of this section.

### 3.1. Equilibrium without competition

Suppose that an individual located at  $d \leq 1/2$  can choose to purchase insurance only from firm 0, although she is not required to be insured. Similarly, individuals located at  $d > 1/2$  can only purchase from firm 1. Let us concentrate on the optimal choices of firm 0, and suppress firm-identifying subscripts. Starting from very low terms  $\rho$ , no-one will purchase insurance. As the terms are improved, at some  $\rho_H^{\min}$  a high-risk individual located at  $d = 0$  will be indifferent between insuring with insurer 0 and not.  $\rho_H^{\min}$  satisfies<sup>5</sup>

$$V_{H,0}(\rho^{\min}, 0) = \bar{V}_H.$$

Similarly, there exists  $\rho_H^{\max}$  which is large enough that even an  $H$ -type individual located at  $d = 1/2$  purchases some insurance from firm 0.  $\rho_H^{\max}$  satisfies

$$V_{H,0}(\rho^{\max}, \frac{1}{2}) = \bar{V}_H.$$

$\rho_H^{\min}$  and  $\rho_H^{\max}$  are illustrated in Fig. 2. Correspondingly define  $\rho_L^{\min}$  and  $\rho_L^{\max}$ . It is clear that  $\rho_H^{\min} < \rho_L^{\min}$  and  $\rho_H^{\max} < \rho_L^{\max}$ . That is, as the terms of insurance are improved, first high-risk individuals purchase and later low-risks enter the market. Depending on the relative probabilities, either  $\rho_L^{\min} < \rho_H^{\max}$ , in which case low risks start purchasing before all the high risks have entered the market, or  $\rho_H^{\max} < \rho_L^{\min}$ , in which case all high risks purchase insurance on terms at which no low risk would enter.

It is useful to note that per-person profits do not monotonically decrease as  $\rho$  increases. This is because the quantity of insurance purchased by an individual ( $x$ ) is variable, and as the terms improve this quantity first increases, then falls. This means that even if an insurer can not increase the number of individuals covered by improving the terms, it is possible that such an improvement may still increase profits. Note also that due to Assumption 1, per-person profits earned on those of a given risk type who purchase are independent of  $d$ .

There are five types of profit maximizing policies that firms, acting as local monopolies, might choose in this model. These types of outcomes are differentiated by the extent of coverage of the population, and the profits firms earn on the different risks.

**Outcome 1.** Universal coverage of both types;  $\Xi_L > 0$  and  $\Xi_H > 0$ . In this case the profit maximizing terms are greater than  $\rho_L^{\max}$ . The probability distributions of  $L$ -

<sup>5</sup>An alternative characterization of  $\rho_H^{\min}$  is that the  $H$ -type's indifference curve through  $\omega$  has slope  $-\rho_H^{\min}$ .

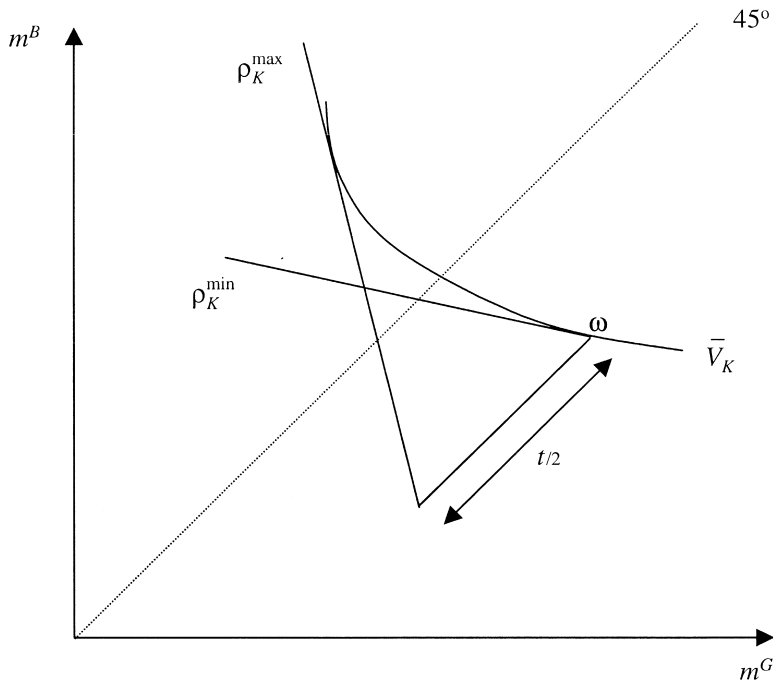


Fig. 2. For terms below  $\rho_K^{\min}$  no  $K$ -types buy insurance. For terms above  $\rho_K^{\max}$  all  $K$ -types buy insurance.

and  $H$ -types are similar enough, and travel costs are low enough, that profits earned on high-risks are positive.

**Outcome 2.** Universal coverage of both types;  $\Xi_L > 0$  and  $\Xi_H < 0$ . Again, profit maximizing terms are greater than  $\rho_L^{\max}$ . However, they are such that the firm earns negative profits on the high-risks.

**Outcome 3.** Universal coverage of high risks, but incomplete coverage of low risks;  $\Xi_L > 0$  and  $\Xi_H > 0$ . The profit maximizing terms are in the interval  $(\rho_H^{\max}, \rho_L^{\max})$ . Increasing  $\rho$  further would increase the number of low risks covered, but would reduce the per-person profits earned on high-risks by enough to offset the demand expansion effect.

**Outcome 4.** Universal coverage of high risks, but incomplete coverage of low risks;  $\Xi_L > 0$  and  $\Xi_H < 0$ . Again, profit maximizing terms are in the interval  $(\rho_H^{\max}, \rho_L^{\max})$ . If there are enough low-risks, profits per high-risk could be negative while coverage of low risks is incomplete.

**Outcome 5.** Partial coverage of high- and low-risks. Here the profit maximizing terms are less than  $\rho_H^{\max}$ . This includes the pathological case where all low-risks are deterred from entering the market.

The case of incomplete coverage of both risk types (Outcome 5) is likely to be of direct concern to policy-makers. However, I ignore this case here. In the more complete model of competition on a circle the number of firms can be increased (either by free entry or government licencing – decisions that are not modelled in this paper) to ensure universal coverage of high risks.<sup>6</sup> To focus on conditions under which incentives to off-load high-risks onto other insurers are operative, I will consider only Outcomes 1–4 above. In these cases, if the terms of insurance are reduced, the first consumers to leave the insurance pool are the low-risks. While reducing the terms can (but need not) increase profits on those who remain insured, the effect if any on the client mix is negative (i.e., the average risk increases as low-risks depart). Although the cost imposed on high-risk individuals by the reduction in terms is relatively high, the cost of having no insurance is sufficiently large to induce them to continue to purchase.

Formally, using a  $\sim$  to denote the segmented market case, for insurer 0 let us define

$$\tilde{d}_K(\rho_0) = \min\{\frac{1}{2}, d_K(\rho_0)\}$$

where  $d_K(\rho_0)$  satisfies

$$V_{K,0}(\rho_0, d_K(\rho_0)) = \bar{V}_K.$$

Insurer 0's profits are then

$$\tilde{\Xi}(\rho_0, e_0) = \phi_L \tilde{d}_L(\rho_0) \Xi_L(\rho_0, e_0) + \phi_H \tilde{d}_H(\rho_0) \Xi_H(\rho_0, e_0).$$

The first order conditions for the implied maximization problem are simply

$$\left( \phi_L \tilde{d}_L(\rho_0) \frac{\partial \Xi_L}{\partial \rho_0} + \phi_H \tilde{d}_H(\rho_0) \frac{\partial \Xi_H}{\partial \rho_0} \right) + \left( \phi_L \Xi_L(\rho_0, e_0) \frac{\partial \tilde{d}_L}{\partial \rho_0} + \phi_H \Xi_H(\rho_0, e_0) \frac{\partial \tilde{d}_H}{\partial \rho_0} \right) = 0 \tag{2}$$

(where  $\partial \tilde{d}_L / \partial \rho_0$  is interpreted as a right hand derivative when necessary) and

$$\phi_L \tilde{d}_L(\rho_0) \frac{\partial \Xi_L}{\partial e_0} + \phi_H \tilde{d}_H(\rho_0) \frac{\partial \Xi_H}{\partial e_0} = 0. \tag{3}$$

Denote the solution to the firm's maximization problem by  $(\tilde{\rho}_0, \tilde{e}_0)$ . If  $\tilde{\rho}_0 > \rho_L^{\max}$ , then we have Outcome 1 or 2, and (2) becomes

<sup>6</sup>That is, in a circle model with free entry, the equilibrium number of firms is such that all high risks purchase insurance.

$$\frac{1}{2} \left( \phi_L \frac{\partial \Xi_L}{\partial \rho_0} + \phi_H \frac{\partial \Xi_H}{\partial \rho_0} \right) = 0 \quad (4)$$

On the other hand, when  $\rho_L^{\max} > \tilde{\rho}_0 > \rho_H^{\max}$  we have Outcome 3 or 4. Of course, in either case firm 1 will make the same optimal choices as firm 0, so  $\tilde{\rho}_0 = \tilde{\rho}_1 \equiv \tilde{\rho}$  and  $\tilde{e}_0 = \tilde{e}_1 \equiv \tilde{e}$ . In cases 1 and 2,  $\tilde{d}_L = \tilde{d}_H = 1/2$  (and the second bracket in Eq. (2) is zero) and in cases 3 and 4  $\tilde{d}_L < \tilde{d}_H = 1/2$ .

For future comparison, we note that welfare is not maximized when firms operate in segmented markets. As its effects are internalized, effort is optimally supplied given the terms of insurance, as indicated in Eq. (3). However, the insurance terms that characterize a welfare maximum are in general different from those chosen by the firms acting as local monopolies. For example, using (1), under the assumption that universal coverage is optimal, ignoring non-negative profit constraints, the welfare maximizing terms satisfy

$$2 \left[ \sum_{K=L,H} \phi_K \left( \int_0^{\frac{1}{2}} \frac{\partial V_{K,0}(\rho, d)}{\partial \rho} dd \right) + \frac{1}{2} \left( \phi_L \frac{\partial \Xi_L}{\partial \rho_0} + \phi_H \frac{\partial \Xi_H}{\partial \rho_0} \right) \right] = 0.$$

As  $V_{K,i}$  is increasing in  $\rho$ , as long as aggregate profits are concave in  $\rho$  the profit maximizing terms chosen by local monopolies with segmented markets (according to (4)) are lower than those that characterize the welfare optimum.

### 3.2. Opening the market to competition

Now let us suppose that individuals are permitted to choose between the two insurance companies. Consider first the case in which, when individuals cannot choose between firms, it is optimal for the firms to provide universal coverage of both risk types – Outcomes 1 and 2 above. Holding the terms offered by insurer  $j$  fixed, a reduction in the terms offered by insurer  $i$  causes both high- and low-risks at the margin to switch provider. Indeed, proportionately more high-risks switch than low-risks. Although the cost imposed on high-risks by the reduced terms is the same as before, this is compared not with the cost of being uninsured, but with the cost of travelling a little further to the alternative provider. Since travel costs are the same for both types, relatively more high-risks switch to insurer  $j$ .

To formalize this intuition, let us denote the position of the marginal  $K$ -type consumer who purchases from insurer  $i$ , when insurer 0 offers terms  $\rho_0$  and insurer 1 offers terms  $\rho_1$ , as  $\hat{d}_{K,i}(\rho_0, \rho_1)$ . ( $A \wedge$  denotes the relevant variables in the model with unrestricted markets.) When  $\rho$  is such that coverage of  $K$ -types is complete, then  $\hat{d}_{K,0}(\rho_0, \rho_1) = \hat{d}_{K,1}(\rho_0, \rho_1) \equiv \hat{d}_K(\rho_0, \rho_1)$ , where  $V_{K,0}(\rho_0, \hat{d}_K) = V_{K,1}(\rho_1, \hat{d}_K)$ . Otherwise  $\hat{d}_{K,0}(\rho_0, \rho_1) < \hat{d}_{K,1}(\rho_0, \rho_1)$ . The following results are immediate:

**Proposition 1.** *If coverage of H- and L-types is universal at  $\rho = (\rho_0, \rho_1)$ , then:*

$$\hat{d}_H(\rho) < \hat{d}_L(\rho) < \frac{1}{2}, \quad \text{for } \rho_0 < \rho_1$$

and

$$\hat{d}_H(\rho) > \hat{d}_L(\rho) > \frac{1}{2} \quad \text{for } \rho_0 > \rho_1;$$

$$\left. \frac{\partial \hat{d}_K}{\partial \rho_0} \right|_{\rho} > 0 > \left. \frac{\partial \hat{d}_K}{\partial \rho_1} \right|_{\rho}; \quad \text{and}$$

if  $\rho_0 = \rho_1$ ,

$$\left. \frac{\partial \hat{d}_H}{\partial \rho_0} \right|_{\rho} > \left. \frac{\partial \hat{d}_L}{\partial \rho_0} \right|_{\rho} > 0. \tag{5}$$

The proof of these results is straightforward, and is omitted.

Firm 0's profits are now a function of the terms offered by both firms, and its own effort.

$$\hat{\Xi}_0(\rho_0, \rho_1, e_0) = \phi_L \hat{d}_L(\rho_0, \rho_1) \Xi_L(\rho_0, e_0) + \phi_H \hat{d}_H(\rho_0, \rho_1) \Xi_H(\rho_0, e_0).$$

To examine the impact of allowing consumers to choose between insurers, consider the marginal effect on firm 0's profits of a change in  $\rho_0$ , keeping  $\rho_1$  fixed at  $\tilde{\rho}$ , evaluated at  $(\tilde{\rho}, \tilde{\rho}, \tilde{e})$ .

$$\begin{aligned} \left. \frac{\partial \hat{\Xi}_0}{\partial \rho} \right|_{(\tilde{\rho}, \tilde{\rho}, \tilde{e})} &= \left( \phi_L \tilde{d}_L(\tilde{\rho}) \frac{\partial \Xi_L}{\partial \rho_0} + \phi_H \tilde{d}_H(\tilde{\rho}) \frac{\partial \Xi_H}{\partial \rho_0} \right) \\ &\quad + \phi_L \Xi_L(\tilde{\rho}, \tilde{e}) \frac{\partial \hat{d}_L}{\partial \rho_0} + \phi_H \Xi_H(\tilde{\rho}, \tilde{e}) \frac{\partial \hat{d}_H}{\partial \rho_0} \end{aligned} \tag{6}$$

When coverage is universal for both types at  $(\tilde{\rho}, \tilde{\rho})$ , this reduces to

$$\left. \frac{\partial \hat{\Xi}_0}{\partial \rho} \right|_{(\tilde{\rho}, \tilde{\rho}, \tilde{e})} = \phi_L \Xi_L(\tilde{\rho}, \tilde{e}) \frac{\partial \hat{d}_L}{\partial \rho_0} + \phi_H \Xi_H(\tilde{\rho}, \tilde{e}) \frac{\partial \hat{d}_H}{\partial \rho_0}. \tag{7}$$

In case 1, when consumers of both types contribute positively to the firm's profits, the firm has an unambiguous incentive to improve the terms of insurance,  $\partial \hat{\Xi}_0 / \partial \rho > 0$ . This is because, while per person profits are locally constant at  $(\tilde{\rho}, \tilde{e})$ , the firm is now able to increase its market share by increasing  $\rho$ . In this case, identifying the terms of insurance with quality, we might say that opening the market to competition induces a competitive quality improvement. Since effort

continues to be chosen efficiently, this improvement in ‘quality’ also represents a welfare improvement.<sup>7</sup>

On the other hand, in case 2, when the firm makes negative profits on high risk individuals, the incentive to improve the terms of insurance is not so strong. Indeed, writing  $\tilde{\Xi}_K = \Xi_K(\tilde{\rho}, \tilde{e})$  for  $K = L, H$  and using condition (5), as long as

$$\frac{\partial \hat{d}_H}{\partial \rho} / \frac{\partial \hat{d}_L}{\partial \rho} > - \phi_L \tilde{\Xi}_L / \phi_H \tilde{\Xi}_H$$

profits are decreasing in  $\rho$ , taking the other firm’s terms as fixed. In Eq. (7), the first term (which is positive) reflects the gains the firm makes by increasing the number of profit-generating low-risks that purchase insurance, while the second term measures the losses imposed by further enrollment of loss-generating high-risks. Here, competition leads to a selection-induced quality reduction, and a reduction in welfare. Indeed, at the market equilibrium,

$$\frac{\partial W}{\partial \rho} = 2 \sum_{K=L,H} \phi_K \int_0^{\frac{1}{2}} \left( \frac{\partial V_{K,0}}{\partial \rho_0} - \frac{\partial \tilde{\Xi}_K}{\partial \rho_0} \right) dd > 0. \tag{8}$$

When  $(\tilde{\rho}, \tilde{\rho})$  is such that coverage is universal for high risks, but incomplete for low risks, (6) reduces to

$$\frac{\partial \hat{\Xi}_0}{\partial \rho} \Big|_{(\tilde{\rho}, \tilde{\rho}, \tilde{e})} = \phi_H \tilde{\Xi}_H(\tilde{\rho}, \tilde{e}) \frac{\partial \hat{d}_H}{\partial \rho_0}.$$

Again, if  $\tilde{\Xi}_H > 0$  (case 3), competition leads to quality improvement. However, when high risks contribute negatively to profits at  $(\tilde{\rho}, \tilde{\rho}, \tilde{e})$  (case 4), competition provides an unambiguous incentive to reduce the terms at which insurance is offered.

These calculations identify the directions of the incentives to adjust the terms of insurance in the presence of competition, but they do not characterize the new equilibrium choices of the firms. To make definitive statements about the effect of competition on equilibrium choices, we must make assumptions about the slopes of the firms’ reaction functions. Let us therefore denote by  $\rho_i(\rho_j, e_i)$  firm  $i$ ’s optimal terms, given its effort level and the terms offered by firm  $j$ .

**Assumption 2.**  $0 < \partial \rho_i(\rho_j, e_i) / \partial \rho_j < 1$ . This assumption makes sense, since market size depends only on the  $\rho$ s. If firm  $i$ ’s competitor ( $j$ ) increases  $\rho_j$ ,  $i$  loses market share. Firm  $i$  can get this back by matching  $j$ ’s increase: the effect is that  $i$ ’s

<sup>7</sup>The full social optimum is not likely to be reached however, as the firms still enjoy some monopoly power. We are more interested however in the case when competition reduces welfare.

market share is unchanged, but  $i$  is now making less per person than before, so optimally will not match  $j$ 's increase fully.<sup>8</sup>

**Assumption 3.**  $\partial \rho_i(\rho_j, e_i) / \partial e_i > 0$ . This assumption is satisfied since the return to effort is increasing in  $\rho$ .

**Proposition 2.** *Suppose Assumptions 2 and 3 hold. In cases 1 and 3 competition leads to higher equilibrium insurance terms and greater equilibrium effort. In cases 2 and 4 competition leads to lower equilibrium insurance terms and smaller equilibrium effort.*

The effects of competition described in this proposition are illustrated in Fig. 3(i) and (ii), with  $\rho_1$  on the horizontal axis, and  $\rho_0$  on the vertical axis. In cases 1 and 3, the competitive quality improvement identified above means that firm 1's reaction curve passes through a point above  $(\tilde{\rho}, \tilde{\rho})$ . Assumption 2 ensures that, with effort of each firm held constant at  $\tilde{e}$ , the new equilibrium terms,  $\tilde{\rho}'$  will be greater than  $\tilde{\rho}$  (panel (i)). We know that each firm's optimal effort is increasing in its choice of  $\rho$ , and Assumption 3 ensures that such a change in effort will only enforce the tendency for the equilibrium terms to increase.

In cases 2 and 4, the opposite is true. Selection-induced quality reduction means firm 1's reaction curve passes through a point below  $(\tilde{\rho}, \tilde{\rho})$ , so holding effort fixed the equilibrium terms fall (panel (ii)). This reduction is supported by a concomitant reduction in effort.

#### 4. Subsidies

Let us now concentrate on those situations in which selection incentives will be operative – i.e., cases 2 and 4 above. Indeed, I focus on case 2, in which there is universal coverage of both types of individual. I will assume that, even though competition induces a reduction in the terms of insurance and effort, it remains

<sup>8</sup>Assumption 2 is equivalent to the assumption that

$$0 < - \frac{\left[ \frac{\partial^2}{\partial \rho_i^2} \hat{\Xi}_i \right]}{\left[ \frac{\partial^2}{\partial \rho_i \partial \rho_j} \hat{\Xi}_i \right]} < 1.$$

We assume the second order condition is satisfied, so the numerator is negative. The first inequality then requires that the denominator is positive, that is, that the marginal return to firm  $i$  offering better terms increases with the terms offered by firm  $j$ . Thus we require, in the terminology of Bulow et al. (1985), that  $\rho_0$  and  $\rho_1$  be strategic complements. The second inequality can be interpreted as a stability condition.

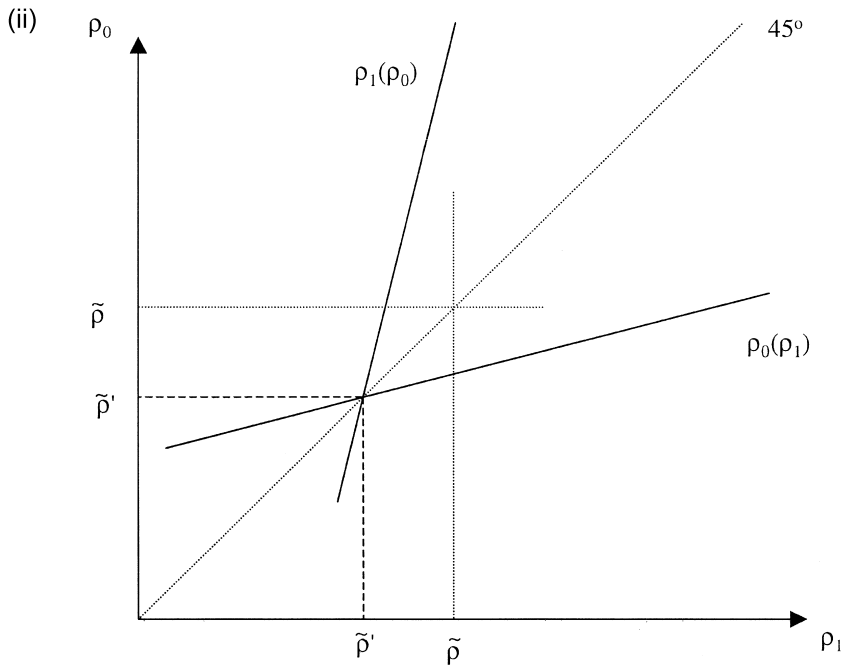
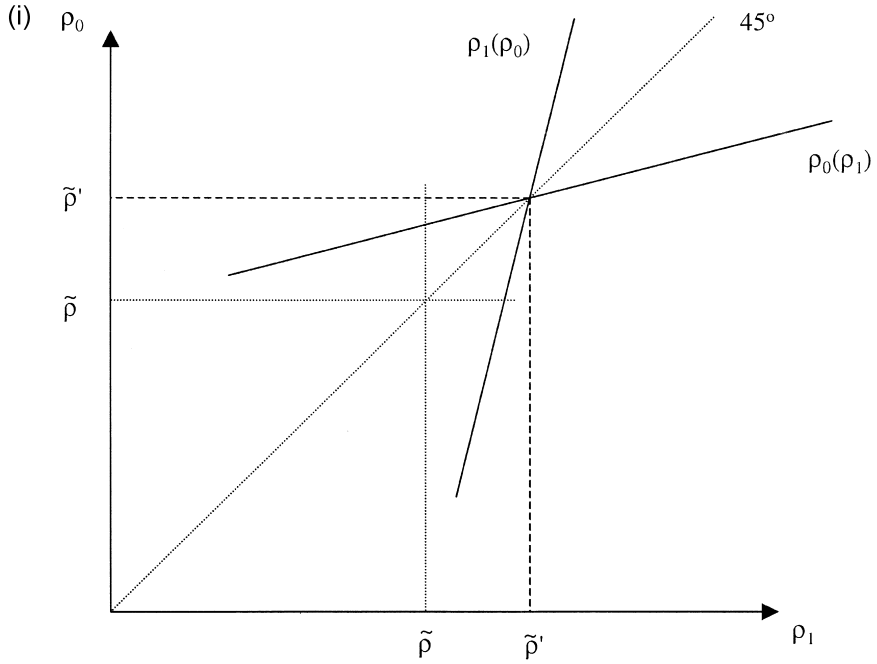


Fig. 3. (i) Selection-induced quality improvement; (ii) Selection-induced quality reduction.

true that in equilibrium coverage is universal. This makes welfare comparisons more straightforward.

I assume that the government cannot regulate the terms of insurance directly. There is some tension between this assumption and the fact that consumers are able to condition their insurance demands on the vector  $\rho$ . To justify this we appeal to the recent literature on incomplete contracts (e.g., Hart, 1995) and assume that while  $\rho$  is observable by the two groups of parties involved in the transactions (the consumers and the firms), it is not easily verifiable by an outsider such as a regulatory agency.<sup>9</sup>

The government may respond to the reduction in equilibrium terms and effort by attempting to reduce the incentive to select. This incentive derives from the difference in costs of insuring high- and low-risk individuals, both due to the larger probability of losses for members of the first group, and the larger quantity of insurance purchased by them. An apparently easy way for the government to reduce this incentive is to share in some of the costs of provision – that is, to provide a subsidy based on realized costs.

#### 4.1. Effects of subsidies on effort and terms

Suppose that firms receive a subsidy of  $\sigma$  times their realized costs, net of effort. That is, the profit of a firm exerting effort  $e$  and selling insurance at terms  $\rho$  to a  $K$ -type individual is

$$\begin{aligned} \Xi_K(\rho, e, \sigma) &= (1 - \pi_K)x_K^*(\rho) - \pi_K(1 + \gamma(e))\rho x_K^*(\rho)(1 - \sigma) - e \\ &= R_K(\rho) - I_K(\rho, e) + T_K(\rho, e, \sigma) \end{aligned} \tag{9}$$

where

$$T_K(\rho, e, \sigma) = \sigma\pi_K(1 + \gamma(e))\rho x_K^*(\rho)$$

is the value of the transfer from the government to the firm. This subsidy scheme is in the spirit of the regulation and procurement models of Laffont and Tirole (1994), who assume that government transfers can be based on realized costs of production, but that firms cannot be compensated directly for the cost of effort,  $e$ .

It is immediately apparent that a positive subsidy will reduce firms' incentives to engage in cost-reducing effort. Since a firm's market share is independent of effort, the first order condition for  $e$  in the presence of a subsidy is just

$$\frac{\partial \hat{\Xi}}{\partial e} = -[(1 - \sigma)\bar{b}(\rho)\gamma'(e) + 1] = 0 \tag{10}$$

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<sup>9</sup>Strictly speaking, if  $\rho$  is not verifiable, a contract between a consumer and a firm cannot be credibly written. I assume that reputation and repeated interaction, not modeled explicitly, sustain these contracts.

where  $\bar{b} = \sum_K \phi_K b_K(\rho)$  and  $b_K(\rho) = \pi_K \rho x_K^*(\rho)$  is the expected claims (benefits) received by a  $K$ -type individual. Thus, holding  $\rho$  fixed,  $\partial e / \partial \sigma = \gamma'(e) / [(1 - \sigma)\gamma''(e)] < 0$  for  $\sigma < 1$ . At  $\sigma = 0$ , this simplifies to  $\partial e / \partial \sigma = \gamma'(e) / \gamma''(e)$ .

What is less obvious is the effect that a subsidy will have on the terms at which insurance will be offered in equilibrium. There are two effects of the subsidy on the return a firm earns from increasing the terms on which it provides insurance. First, to the extent that better terms lead to an increase in gross claims paid, the subsidy reduces the associated cost, and we thus expect firms to offer improved terms. However, offsetting this effect is an indirect effect caused by the unambiguous reduction in effort. As effort is reduced, the cost difference between high- and low-cost individuals increases, as does the incentive to select. Since selection is effected by lowering the terms of insurance, firms have an incentive to reduce  $\rho$ . Which of these two effects dominates determines the change in the equilibrium terms and effort.

To state the result giving conditions under which each effect dominates, it is necessary to introduce a little notation. Thus, let  $\eta_K = \partial \hat{d}_K / \partial \rho_0 > 0$ , and let

$$z = \frac{1}{\bar{\eta} \bar{b}} \left( \frac{\partial \bar{b}}{\partial \rho_0} + \text{cov}(\eta, b) \right) > 0.$$

Finally, define

$$\varepsilon(e) = \frac{(1 + \gamma)\gamma''}{\gamma'^2} = \frac{(1 + \gamma)}{\gamma'} \frac{d\gamma'}{d(1 + \gamma)} > 0$$

as the elasticity of the marginal product of effort with respect to underlying unit costs, and let

$$\hat{\varepsilon} = \frac{1}{(1 + z)}.$$

**Proposition 3.** *If  $\varepsilon < \hat{\varepsilon}$ , then the effect of a small positive subsidy is to increase the incentive of firms to reduce the terms on which they provide insurance.*

The proof of this proposition can be found in Appendix A.

Under the conditions of Proposition 3, for *equilibrium* insurance terms to fall it is necessary that the subsidy also (weakly) increases the slope of each firm's reaction function. Such an effect makes intuitive sense, since the extent to which firm  $i$  will wish to respond to an increase in  $j$ 's terms in order to regain market share is limited by the higher costs such a response imposes on firm  $i$ . The subsidy reduces this cost, and therefore makes a more aggressive response optimal, and  $i$ 's reaction function is steeper.

**Assumption 4.**  $\partial/\partial\sigma[\partial\rho_i(\rho_j, e_i)/\partial\rho_j] > 0$ .

Thus we have

**Proposition 4.** *If  $\varepsilon < \hat{\varepsilon}$  and Assumption 4 holds, then equilibrium effort and insurance terms fall following the introduction of a small subsidy.*

Propositions 3 and 4 are illustrated in Fig. 4. Under the conditions of Proposition 3, firm 0's reaction function at  $\rho_1 = \tilde{\rho}$  shifts down as a result of the subsidy. Assumption 4 means that the reaction function through this point is steeper than in the absence of the subsidy, so equilibrium terms fall, to  $\tilde{\rho}'(\sigma)$ .

4.2. Effects of subsidies on welfare

The potentially negative effect of a subsidy on the terms at which insurance is offered suggests that such a subsidy may not be welfare improving. Let us briefly confirm this by continuing to assume that coverage is universal, and by assuming that optimal lump-sum taxes are available ( $\lambda = 0$ ). Welfare is then simply

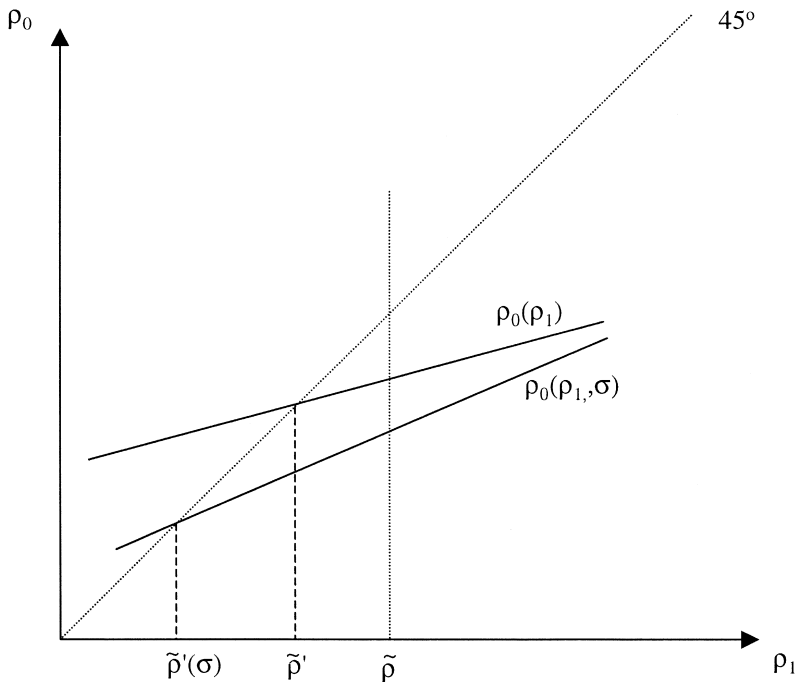


Fig. 4.

$$W = 2 \sum_{K=L,H} \left( \phi_K \int_0^{\frac{1}{2}} W_{K,0} dd \right) = 2 \sum_{K=L,H} \left( \phi_K \int_0^{\frac{1}{2}} (V_{K,0} + \Xi_K) dd \right) - \bar{k}$$

where  $\bar{k} = \sum_{K=L,H} \phi_K \bar{V}_K$  is a constant. The effect of the subsidy on welfare is thus

$$\left. \frac{\partial W}{\partial \sigma} \right|_{\sigma=0} = 2 \sum_{K=L,H} \phi_K \int_0^{\frac{1}{2}} \left[ \left( \frac{\partial V_{K,0}}{\partial \rho_0} + \frac{\partial \Xi_K}{\partial \rho_0} \right) \frac{\partial \rho_0}{\partial \sigma} \right]_{\sigma=0} + \left. \frac{\partial \Xi}{\partial e_0} \frac{\partial e_0}{\partial \sigma} \right|_{\sigma=0} dd.$$

Of course, the second term in the square brackets is zero, because when  $\sigma = 0$  effort is chosen efficiently. On the other hand, the bracketed part of the first term is positive, from (8), so welfare changes in the same direction as do the equilibrium terms of insurance. Thus we have,

**Proposition 5.** *If  $\varepsilon < \hat{\varepsilon}$  and Assumption 4 holds, then a small subsidy intended to reduce selection incentives is welfare-reducing. When  $\varepsilon > \hat{\varepsilon}$ , such a subsidy is welfare increasing.*

Notice that this result holds for  $\lambda = 0$ . When raising revenue to pay for a positive subsidy is costly, the welfare effects of such an intervention will be more negative (when  $\varepsilon < \hat{\varepsilon}$ ) or smaller (when  $\varepsilon > \hat{\varepsilon}$ ).

## 5. Conclusions

This paper has proposed a model for examining the mechanisms that might be used by insurance companies to indirectly select good risks, and the effects of possible government responses to these mechanisms. I have deliberately removed all avenues by which direct selection on the part of insurers, and direct regulation on the part of the government, could be effected. Thus, issues of ‘risk adjustment’, whereby insurance premiums are corrected for exogenously observable client characteristics (e.g., age), are ruled out, by assuming that there are no such characteristics to observe. This focus on indirect mechanisms of selection is meant to capture the idea that policymakers may be concerned about the quality of insurance offered, the supposition being that insurers might undersupply quality in order to deter consumers who value quality more (i.e., the high risks) from purchasing from them.

I have also not been directly concerned with incomplete coverage of certain categories of individuals. Indeed, to the extent that incomplete coverage is predicted by the model, it is the good risks that are more likely not to purchase than the bad risks, whereas policymakers are typically concerned with the opposite occurrence. Precisely because they value insurance more, high risks will always

buy insurance whenever low risks with similar endowments would. Negative correlations between risk and income could well reverse this qualitative feature of the model, but introducing two dimensions of heterogeneity would have led to significant complications.<sup>10</sup> Insurance companies cannot profitably deter more high risks than low risks from buying insurance, but an individual insurer can profitably induce relatively more high risks than low risks to *switch* to another insurance company. The greater elasticity of demand of high risks *vis à vis* low risks when switching is possible is the reason quality (identified with the terms of insurance) can sometimes be used as a selection mechanism.

As well as describing how selection might be effected, the model asks what government policies are likely to be welfare improving. To make the problem interesting, we assume that the government has even less information than insurers. It cannot observe the characteristics of individuals, and also it cannot observe, or at least regulate directly, the actual terms on which insurance is provided. (If it could, this could be directly regulated and the full social optimum attained, as long as there were no zero profit constraints on firms.) In order to reduce selection incentives the government subsidizes gross claims paid, in an attempt to reduce the difference between the costs of serving high- and low-risk individuals. The central result of the paper is that if effort is endogenous, then depending on the shape of the cost-reduction function and demand parameters, such a subsidy could lead to a further reduction in quality, and an unambiguous welfare decline. In this case, high claims should be taxed so as to induce more efficient effort supply. The intuition for this result is that a positive subsidy must reduce effort, and this can induce a feedback effect on selection incentives. The reduction in effort increases coverage costs, but also increases the *difference* between the costs of covering high- and low-risk individuals, and so increases selection incentives. If this feedback effect dominates the direct impact on quality, the subsidy can reduce welfare.

## Acknowledgements

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## Appendix A. Proof of Proposition 3

Consider the profit maximizing choices  $(\tilde{\rho}, \tilde{e})$  chosen when individuals cannot choose between insurers. Let us calculate the effect of a small subsidy on the

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<sup>10</sup>For a start on such a model, see Henriët and Rochet (1999), and Jack (1999).

incentive of firm 0 to change its insurance terms from  $\rho_0 = \tilde{\rho}$ . That is, we wish to calculate

$$\frac{\partial}{\partial \sigma} \left( \frac{\partial \Xi}{\partial \rho_0} \Big|_{(\tilde{\rho}, \tilde{\rho}, \tilde{e})} \right) \Big|_{\sigma=0}.$$

Using Eq. (6), this derivative can be calculated as the sum of two terms:

$$\delta_1 = \frac{\partial}{\partial \sigma} \left( \phi_L \tilde{d}_L(\tilde{\rho}) \frac{\partial \Xi_L}{\partial \rho_0} + \phi_H \tilde{d}_H(\tilde{\rho}) \frac{\partial \Xi_H}{\partial \rho_0} \right)$$

and

$$\delta_2 = \frac{\partial}{\partial \sigma} \left( \phi_L \Xi_L(\tilde{\rho}, \tilde{e}, \sigma) \frac{\partial \hat{d}_L}{\partial \rho_0} + \phi_H \Xi_H(\tilde{\rho}, \tilde{e}, \sigma) \frac{\partial \hat{d}_H}{\partial \rho_0} \right).$$

Using (9) and the definition of  $b_K$ ,

$$\frac{\partial}{\partial \sigma} \left( \frac{\partial \Xi_K}{\partial \rho_0} \right) = (1 + \gamma(e)) \frac{\partial b_K}{\partial \rho_0} - (1 - \sigma) \gamma'(e) \frac{\partial b_K}{\partial \rho_0} \frac{\partial e}{\partial \sigma}$$

which, at  $\sigma = 0$ , can be simplified to

$$\begin{aligned} \frac{\partial}{\partial \sigma} \left( \frac{\partial \Xi_K}{\partial \rho_0} \right) \Big|_{\sigma=0} &= - \frac{\gamma'(e)^2}{\gamma''(e)} \frac{\partial b_K}{\partial \rho_0} \left[ 1 - \frac{\gamma''(e)(1 + \gamma(e))}{\gamma'(e)^2} \right] \\ &= - \frac{\gamma'(e)^2}{\gamma''(e)} \frac{\partial b_K}{\partial \rho_0} (1 - \varepsilon(e)) \end{aligned}$$

where

$$\varepsilon(e) = \frac{(1 + \gamma)\gamma''}{\gamma'^2} = \frac{(1 + \gamma)}{\gamma'} \frac{d\gamma'}{d(1 + \gamma)} > 0$$

is, as defined in the text, the elasticity of the marginal product of effort with respect to underlying unit costs.

Under the assumption that coverage of both types is universal, we can write  $\delta_1$  as

$$\delta_1 = - \frac{\gamma'^2}{\gamma''} \frac{\partial \bar{b}}{\partial \rho_0} (1 - \varepsilon) \tag{A.1}$$

which is negative if and only if  $\varepsilon < 1$ .

To examine  $\delta_2$  we must calculate the effect of the subsidy on the relative profits earned on each type of consumer.<sup>11</sup> To this end, write

<sup>11</sup>Note that demand responsiveness,  $\partial \hat{d}_K / \partial \rho$ , is not affected by the subsidy.

$$\frac{\partial \Xi_K}{\partial \sigma} = (1 + \gamma(e))b_K - [1 + (1 - \sigma)\gamma'(e)b_K] \frac{\partial e}{\partial \sigma}.$$

Evaluating this at  $\sigma = 0$  yields

$$\begin{aligned} \left. \frac{\partial \Xi_K}{\partial \sigma} \right|_{\sigma=0} &= (1 + \gamma(e))b_K - [1 + \gamma'(e)b_K] \frac{\gamma'(e)}{\gamma''(e)} \\ &= - \frac{\gamma'(e)}{\gamma''(e)} [1 + b_K \gamma'(e)(1 - \varepsilon(e))] \end{aligned}$$

so

$$\begin{aligned} \delta_2 &= - \frac{\gamma'(e)}{\gamma''(e)} \left( \phi_L \frac{\partial \hat{d}_L}{\partial \rho_0} [1 + b_L \gamma'(e)(1 - \varepsilon(e))] \right. \\ &\quad \left. + \phi_H \frac{\partial \hat{d}_H}{\partial \rho_0} [1 + b_H \gamma'(e)(1 - \varepsilon(e))] \right). \end{aligned} \tag{A.2}$$

Defining  $\eta_K = \partial \hat{d}_K / \partial \rho_0 > 0$ , and suppressing all arguments, (A.2) can be written

$$\begin{aligned} \delta_2 &= - \frac{\gamma'}{\gamma''} [\bar{\eta} + \gamma'(1 - \varepsilon)\bar{\eta}b] \\ &= - \frac{\gamma'}{\gamma''b} [\bar{\eta}b - (1 - \varepsilon)\bar{\eta}b] \\ &= - \frac{\gamma'(1 - \varepsilon)}{\gamma''b} [\bar{\eta}b - \bar{\eta}b] - \frac{\gamma'\varepsilon}{\gamma''}\bar{\eta} \end{aligned} \tag{A.3}$$

using (10) in the second line. Combining (A.1) and (A.3) we have

$$\left. \frac{\partial}{\partial \sigma} \left( \frac{\partial \Xi}{\partial \rho_0} \right) \right|_{(\bar{\rho}, \bar{\rho}, \bar{\varepsilon})} \Big|_{\sigma=0} = - \frac{\gamma'}{\gamma''} \left[ - \frac{(1 - \varepsilon)}{b} \left( \frac{\partial \bar{b}}{\partial \rho_0} + \text{cov}(\eta, b) \right) + \varepsilon \bar{\eta} \right].$$

Under the assumption that  $\varepsilon < 1$ , this expression is negative if and only if

$$\varepsilon \bar{\eta} b < (1 - \varepsilon) \left( \frac{\partial \bar{b}}{\partial \rho_0} + \text{cov}(\eta, b) \right)$$

or

$$\frac{\varepsilon}{(1 - \varepsilon)} < \frac{1}{\bar{\eta}b} \left( \frac{\partial \bar{b}}{\partial \rho_0} + \text{cov}(\eta, b) \right) \tag{A.4}$$

where cov denotes covariance. Because the market share of high risks is more elastic with respect to  $\rho$  than is that of low risks, and because expected benefits are

higher for high risks, the covariance term is positive. Using the definition of  $z$  given in the text, we arrive at the result.

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