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## To commit or not to commit: A health insurance monopoly with variable quality and uncertain types of individuals

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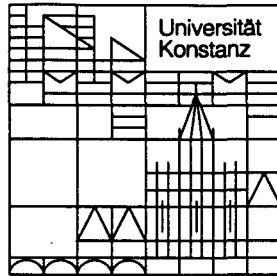
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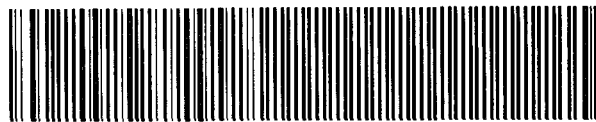
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**Mathias Kifmann** 786618

**Serie I - Nr. 288**

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To commit or not to commit:  
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Mathias Kifmann<sup>†</sup>

September 1997

**Abstract**

This paper examines the trade-off between risk allocation and quality supply for an insurance monopolist when individuals face two kinds of risk related to health. First, they may suffer an ordinary monetary loss. Second, they are subject to uncertain premiums because their type may change. We assume that neither quality of insurance service nor the individual type is verifiable in front of a court. We show that no-commitment is a necessary condition for the efficient supply of unverifiable quality while the insurance of premium risk requires commitment. Profit-maximizing contracts may involve full, partial or no-commitment. Risk allocation or quality supply is inefficient.

**JEL-classification:** D80, I10.

**Keywords:** Health insurance, premium risk, unverifiable quality, commitment.

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## Contents

<b>1</b>	<b>Introduction</b>	<b>1</b>
<b>2</b>	<b>An insurance monopoly with variable quality</b>	<b>4</b>
2.1	The model . . . . .	4
2.2	The one-period game . . . . .	5
2.2.1	Verifiable quality . . . . .	5
2.2.2	Unverifiable quality . . . . .	7
2.3	Repeated Games . . . . .	7
<b>3</b>	<b>Uncertain types and insurance contracts</b>	<b>9</b>
3.1	Uncertainty about types . . . . .	9
3.2	The optimal degree of commitment . . . . .	11
3.2.1	Expected utility in absence of long-term insurance . .	11
3.2.2	Contracts and switching . . . . .	11
3.2.3	The trade-off between risk allocation and quality . . .	15
3.2.4	Profit-maximizing contracts . . . . .	17
<b>4</b>	<b>Conclusion</b>	<b>20</b>
<b>5</b>	<b>Appendix</b>	<b>22</b>
<b>6</b>	<b>References</b>	<b>26</b>

# 1 Introduction

The analysis of health insurance is often restricted to the case in which individuals face a loss with a given probability. There is, however, a second risk related to health that has received less attention. Individuals' types, i.e. their loss probability, may change over time. For instance, the immune system of a person might permanently be weakened by a severe illness. With risk-based contracts individuals will face the risk of uncertain premiums when signing future contracts. This premium risk would not be an issue in a world with complete information and no restrictions on contract design. Insurers could be expected to cover both risks. However, an insurance market for premium risk might not work because it can be impossible or very costly to measure the type. Still, there is another possibility to cover premium risk. Before types may change, individuals could commit to a health insurer and form a risk pool. As some types turn out to be high risks and others low risks, there could be ex post cross-subsidization in the pool. There would be no need to determine types. Still, commitment may not be desirable because consumers do not like to be locked into a contract for the rest of their lives. Thus a trade-off emerges. Commitment may achieve a superior risk allocation but lead to consumer dissatisfaction due to lock-in. This trade-off is the topic of our paper.

Premium risk and lock-in are major problems in countries with private health insurance. In the United States the main issue is the lack of long-term health insurance at a guaranteed price in the individual and small group markets.<sup>1</sup> Consumers are exposed to premium risk after their short-run contracts end or when their long-run contracts are being renewed. One of the main explanations advanced for this lack of insurance against premium risk is the problem that consumers cannot be held to long-term contracts.<sup>2</sup> Consumers who turn out to be healthier than average have an incentive to switch to another insurer. The original insurer is left with high risks. Therefore protection against premium risk will not be offered as the low risks cannot be obliged to cross-subsidize the high risks in later periods. However, this argument is not very convincing as individuals are free to sign long-term contracts with premium guarantees in exchange for the promise to pay these premiums for the duration of the contract. A more consistent justification for the lack of long-term contracts is that consumers do not want these contracts as they prefer to bear premium risk to being at the mercy of one insurer for multiple periods.<sup>3</sup>

In Germany the discussion on premium risk has focused on a different problem. The 6.9 million consumers who are completely covered by private health

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<sup>1</sup>See Diamond (1992), p. 1238.

<sup>2</sup>See Cochrane (1995), p. 447; and Dowd and Feldman (1992), pp. 148-149.

<sup>3</sup>See Cochrane (1995), p. 447; Dowd and Feldman (1992), p. 151; and Pauly et al. (1995) p. 153.

insurance are faced with a lock-in situation. By law insurers are required to save part of the premium income for health expenditure in old age. As these savings are not transferable to other insurers, there is a strong disincentive to switch. While this stabilizes risk pools, there are complaints that insurers exploit this lock-in situation by raising premiums uniformly for all insured.<sup>4</sup> The theoretical literature on premium risk in health insurance so far has taken two approaches. Meyer (1992) and Cochrane (1995) assume that types are observable and verifiable. They take the position that separate insurance against premium risk is possible. For the United States Cochrane has suggested a system of medical savings accounts. If an individual becomes a higher risk type than average, a payment flows in this account to compensate for her higher premiums. Correspondingly money is withdrawn from the account of an individual who turns out to be a lower risk type than average. For Germany Meyer has proposed that savings should be made transferable when a privately insured switches to another insurer. Because a transfer of savings independent of type obviously would destabilize the health insurance market, he wants transfers to depend on type. Low risk types should receive less than high risk types.

The main criticism of both proposals is the strong assumption about type verifiability. If types were verifiable in front of courts, there seems to be no reason why separate insurance against premium risk should not already be observed. In particular such insurance should exist in the United States where the health insurance market is not as highly regulated as in Germany. Type unverifiability would explain this phenomenon. To see that type unverifiability makes separate insurance against premium risk impossible consider a high risk individual who cannot prove that he is a high risk type and hence cannot expect an adequate payment by the insurer. Anticipating this opportunistic behavior, a rational individual would not sign a contract against premium risk. Still, one could argue that types are verifiable because there already exist criteria upon which insurers base their premiums. However, there is a difference between internal criteria of a firm which are not subject to outside scrutiny and criteria which are recognized by courts. The demands for the latter are much stricter and it is doubtful whether an enforceable list of criteria that would solve the premium risk problem can be established.

The second approach in the literature can be found in Pauly et al. (1995). They do not require verifiability of types and relies on a premium schedule involving prepayments. Such a premium schedule can make it rational for all types to remain in the contract because prepayments allow premiums in

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<sup>4</sup>This problem has to be seen in connection with the German regulatory system. Health insurers can increase their premiums when their insured's health expenditure has risen. Thus the commitment situation lessens incentives for cost control. For a more detailed description of the German private health insurance market, see Finsinger and Kraft (1984) and Lenel (1994).

future periods to be so low such that even the best type cannot get a cheaper new contract. Cross-subsidization between types is possible and there is no premium risk. Since the insured can be certain that they can prolong their contracts at predetermined prices, Pauly et al. label this concept guaranteed renewability. The main problem of this solution is that individuals face a complete lock-in situation.

This paper is in the spirit of the approach of Pauly et al.. We explicitly assume that types are unverifiable and introduce two new elements. First, while these authors examine a full commitment contract that leaves all possible types within the contract, we allow partial commitment solutions. These make it rational for high risk types to stay while low risk types may opt out. The mechanism we examine is analogous to the idea of prepayments: Consumers have to pay a uniform fee when they opt out of the insurance contract. Secondly, we explicitly model the negative lock-in effect. We start from the premise that the insurance company will interpret the terms of the health insurance contract as favorably for itself as possible when it knows that the consumer must stay in her contract. Of course, if the contract can be designed in a way as to take account of all contingencies and if every aspect of the contract is verifiable, i.e. enforceable by a third-party, there will be no problem. But if some parts of the contracts are impossible or too costly to specify or if parts of the contracts are not verifiable, a contract enforcement problem can appear. As has been shown by Klein and Leffler (1981), the market can solve this problem when there are repeat purchases. Firms have an incentive to supply unverifiable characteristics of a good because otherwise they risk future sales. In short-run health insurance contracts this mechanism can be expected to work. In long-run contracts, however, this mechanism is put out of action. We will regard this special property of long-run contracts as the source of lock-in.

There are two plausible candidates for unverifiable aspects of health insurance contracts. On the one hand, the insurance company might be ungenerous by denying payment in case of a loss when it is not certain that the particular case falls under the terms of contract or by honoring claims as slowly as possible. On the other hand, the insurer might supply as little quality of service as possible. This effect is of particular importance in health insurance as health insurers frequently organize and supply health services. As quality of health care is impossible or very costly to measure in front of a court, an individual may not be able to enforce adequate quality.<sup>5</sup> In fact, the journal *Health Affairs* recently devoted a special issue to quality because lack of quality is a key concern in the debate about managed care.<sup>6</sup> In our model we therefore label the unverifiable part of the health insurance

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<sup>5</sup>In the terms of Nelson (1970) health care is an experience good, which can only be judged by the consumer after it has been received. For an excellent discussion of the supply of such goods, see Tirole (1988), Section 2.3.

<sup>6</sup>see *Health Affairs* (1997), Vol. 16 (3), pp. 6 - 56.



contract as quality.

Before we present the model, we find it useful to point out the difference between our approach and the literature on multi-period adverse selection models in insurance economics (for a survey, see Dionne and Doherty (1992)). Firstly, in our model there are no informational asymmetries. Types of individuals and quality are observable to all parties. All deviations from a first-best situation are due to unverifiability. Secondly, while the question of commitment is crucial in the adverse selection literature as well, the degree of commitment of both parties in these models is given exogenously. We only assume that the insurer fully commits himself. The degree of commitment of the insured, however, is determined endogenously. We think that devices like prepayments that make the degree of commitment a choice variable justify this new approach to the issue of commitment.

The paper is organized as follows. In Section 2 we concentrate on the lock-in effect and develop a model of an insurance monopoly with unverifiable quality. We show that only under no-commitment efficient supply of unverifiable quality can be achieved. In Section 3 we introduce premium risk and describe contracts that allow varying degrees of commitment. The trade-off between risk allocation and quality supply is characterized and sufficient conditions for full and no commitment are given. We illustrate our results by a numerical example. Section 4 concludes and discusses possible implications for health insurance markets.

## 2 An insurance monopoly with variable quality

The insurance market we examine is monopolistic. This avoids the problem of modeling competition in the presence of unverifiable quality. As Stiglitz (1989) points out, an effective mechanism that leads to the efficient supply of unverifiable quality implies that price must exceed marginal costs. Although this can be reconciled with a zero-profit equilibrium by introductory offers or advertising, we work with a monopoly model to focus on the topic of the paper.

### 2.1 The model

We consider a model with many identical risk-averse individuals, one risk-neutral insurance company and two states of the world. The representative individual has gross income  $y$  in both states and faces a loss of  $l$  with probability  $\pi$ . Her net income with no insurance is therefore  $y_1 = y$  in state 1 and  $y_2 = y - l$  in state 2. In state 1 the individual's utility depends only on income, in state 2 it is also a function of quality  $q$  which can be interpreted as the service which is provided by the insurance company in case of a loss. We specify the utility function as  $u_1(y_1) = u(y_1)$  and  $u_2(y_2, q) = u(y_2 + \theta q)$ ,

$\theta > 0$ , where  $u(\cdot)$  is strictly concave and has the property of constant absolute risk aversion (CARA).  $\theta$  is the constant monetary value per unit of quality.

The insurance company offers the consumer a transfer of income from state 1 into state 2. In addition, it may provide a service  $q$  for which the company incurs a per-unit cost of  $c$  with  $c > 0$ . This quality can take the values 0 or 1. We assume that the company also has a monopoly in supplying this quality. Contracts take the form  $(\alpha_q, \beta_q)$  with  $q \in \{0; 1\}$  where  $\alpha_q$  is the premium the insurance company receives in state 1 and  $\beta_q$  the net monetary coverage for the consumer in state 2. Therefore, expected profits if  $q = 0$ ,  $p_0$ , are

$$p_0 = (1 - \pi)\alpha_0 - \pi\beta_0. \quad (1)$$

With  $q = 1$  we get

$$p_1 = (1 - \pi)\alpha_1 - \pi(\beta_1 + c). \quad (2)$$

The game between the insurance company and the individual is characterized by complete information and structured as follows. First, the insurance company offers a contract which the individual accepts if her participation constraint is fulfilled. She then pays  $\alpha_q$ . Next the state of nature is revealed. If there is a loss, the insurance company pays out  $\beta_q$  and supplies quality 0 or 1. Then the game ends. We start by examining the case in which this game is only played once. Then we extend the analysis to repeated games.

## 2.2 The one-period game

### 2.2.1 Verifiable quality

When quality is verifiable, the insurance company will supply high quality when it promised to. Thus, the monopoly has to decide whether it wants to produce no quality or positive quality. First, we examine the case where  $q = 0$ . We define  $y_c(\pi)$ , the certainty equivalent of income without insurance, by

$$u(y_c(\pi)) = (1 - \pi)u(y) + \pi u(y - l). \quad (3)$$

Note that  $y_c(\pi)$  is a decreasing function of  $\pi$ :

$$y'_c(\pi) = -\frac{u(y) - u(y - l)}{u'(y_c(\pi))} < 0 \quad \text{for } \pi \in [0, 1]. \quad (4)$$

We maximize equation (1) subject to the following reservation constraint:

$$(1 - \pi)u(y - \alpha_0) + \pi u(y - l + \beta_0) \geq u(y_c(\pi)). \quad (5)$$

At the optimum, constraint (5) is binding and all risk is borne by the insurer. We must have  $u(y_c(\pi)) = u(y - \alpha_0^*(\pi)) = u(y - l + \beta_0^*(\pi))$  and hence

$$\alpha_0^*(\pi) = y - y_c(\pi) \quad \text{and} \quad \beta_0^*(\pi) = y_c(\pi) - y + l. \quad (6)$$

Maximized profits are

$$p_0^*(\pi) = y - y_c(\pi) - \pi l. \quad (7)$$

To obtain the maximum expected profits for  $q = 1$ , we maximize equation (2) subject to

$$(1 - \pi)u(y - \alpha_1) + \pi u(y - l + \beta_1 + \theta) \geq u(y_c(\pi)). \quad (8)$$

Here the optimal contract for the monopolist consists of

$$\alpha_1^*(\pi) = y - y_c(\pi) \quad \text{and} \quad \beta_1^*(\pi) = y_c(\pi) - y + l - \theta. \quad (9)$$

Maximum expected profits are

$$p_1^*(\pi) = y - y_c(\pi) - \pi l + \pi(\theta - c). \quad (10)$$

Note that both contracts have the same premium while monetary coverage is lower in the high quality contract for  $\theta > 0$ . This is due to the specification of utility. Compared to the no-loss-state marginal utility is lower in the loss-state for  $q > 0$  for all levels of income. Therefore only partial coverage in terms of money is optimal when quality is present. This result can be supported by the intuition that in health insurance individuals are usually less concerned with a payment in case of a loss but with good and prompt service and treatment.

Optimal contracts and profits depend on type  $\pi$ . In the next section this will prove to be crucial. In this section, however, we ignore this dependence as the type is given and concentrate on the supply of quality. Comparing equations (7) and (10) we obtain

$$p_1^* > p_0^* \iff \theta > c.$$

High quality yields higher profits for the insurance company if and only if the monetary value of quality for the consumer is higher than the cost of quality. From now on we will suppose that this condition is fulfilled. In a first-best solution the monopolist will then offer the contract  $(\alpha_1^*, \beta_1^*)$  and will supply  $q = 1$ . This outcome is also efficient.

### 2.2.2 Unverifiable quality

When quality is not verifiable, a time-consistency problem arises in the supply of insurance. The monopolist does not have the incentive to supply high quality in case of a loss in a one-shot game. By supplying high quality the insurance company will only incur costs. Hence quality will never be supplied. Since the consumer anticipates this, she will not accept the contract  $(\alpha_1^*, \beta_1^*)$  as  $\alpha_0^* = \alpha_1^*$  and  $\beta_0^* > \beta_1^*$ . Since both contracts would now supply the same quality, the contract promising  $q = 1$  must be worse. Hence in the unique Nash equilibrium of the one-shot game contract  $(\alpha_0^*, \beta_0^*)$  will be sold. With  $\theta > c$  its outcome is inefficient.

### 2.3 Repeated Games

Although quality is unverifiable, there may nevertheless exist private devices that assure performance of high-quality contracts. As has been shown by Klein and Leffler (1981), repeat purchases can give firms an incentive to honor contracts which are not enforceable by the government or any other third party. This mechanism relies on the loss of future profits when the firm deviates. We will apply this idea to our model and examine an infinitely repeated game with the one-shot game as the stage game. Because the number of periods consumers live is uncertain we can interpret the infinitely repeated game as a repeated game that ends after a random number of periods.<sup>7</sup> To show that high quality can be supplied in this setting we assume that the individual plays the following trigger strategy where  $q(i)$  and  $y(i)$  stand for the values of  $q$  and  $y$  in period  $i$ .

$$\begin{aligned} \text{For } t = 0 & : \quad \text{Buy } (\alpha_1^*, \beta_1^*) \\ \text{For } t > 0 & : \quad \begin{cases} \text{Buy } (\alpha_1^*, \beta_1^*) \text{ if } q(i) = 1 \text{ for all } i < t \text{ where } y(i) = y - l \\ \text{Buy } (\alpha_0^*, \beta_0^*) \text{ otherwise} \end{cases} \end{aligned} \quad (11)$$

The individual will thus accept the contract promising high quality in the first period. She will continue do so only if high quality has been supplied to her in all cases when a loss was experienced.<sup>8</sup> Otherwise, the individual buys only no-quality contracts.

To see whether the insurance company has an incentive to supply high quality given this strategy, we consider a period in which a loss happened. By supplying  $q = 1$  it has to spend  $c$  but keeps expected profits of  $p_1^*$  in all

<sup>7</sup>See e.g. Gibbons (1992), p.90.

<sup>8</sup>We assume that the individual only cares about the quality she receives. She is not affected if someone else does not receive the promised high quality.

future periods. Producing no quality means no expenditure this period but implies expected profits of  $p_0^*$  in all following periods. Therefore, we have

$$q = 1 \iff \frac{\delta}{1-\delta}p_1^* - c \geq \frac{\delta}{1-\delta}p_0^*$$

where  $\delta$  denotes the insurance company's discount factor. Substituting from equations (7) and (10) we obtain the equivalent condition

$$\theta \geq \left(\frac{1}{\delta\pi} - \frac{1}{\pi} + 1\right)c. \quad (12)$$

Assuming that this condition is fulfilled, the strategies (11) by the consumer and "Always produce high quality" by the insurance company constitute a subgame-perfect Nash equilibrium. If (12) holds, we can therefore conclude that in the infinitely repeated game the first-best solution can be achieved in a subgame-perfect Nash equilibrium. Note that (12) is more restrictive than the condition for the efficiency of high quality which is  $\theta \geq c$ .<sup>9</sup> It is more likely to hold the larger  $\delta$  and  $\pi$ . A larger discount factor makes deviation less attractive as the loss of higher future profits is valued higher in the present period. For  $\pi$  we must have

$$\pi \geq \frac{(1-\delta)}{\delta} \frac{c}{(\theta-c)} \equiv \tilde{\pi}. \quad (13)$$

Only if  $\pi$  is at least as high as the critical value  $\tilde{\pi}$  the first-best can be achieved. For  $\delta < 1$  this implies that the repeat-purchase mechanism will not work for some low risk individuals. This is due to the fact that extra expected profits due to high quality  $p_1^* - p_0^* = \pi(\theta - c)$  depend on  $\pi$ . The lower  $\pi$ , the less demand there is for high quality and the smaller the loss of future profits by disappointing the consumer. While it is well known that in an infinitely repeated game the existence of a subgame-perfect Nash equilibrium which is pareto-superior to the Nash equilibrium of the stage game depends on the discount factor,<sup>10</sup> the application to insurance yields this additional dependence. With this insight we can sum up our results in

**Proposition 1:** *In a one-period game unverifiable quality will not be produced. If the game is repeated infinitely, unverifiable quality can be supplied when the discount factor of the insurance company and the loss probability of the consumer are sufficiently high.*

The driving force behind the supply of unverifiable quality is the repeat-purchase mechanism. An important property of this mechanism is that the individual does *not* commit herself to a particular insurance contract.

<sup>9</sup>E.g. with  $\delta = 0.9$  and  $\pi = 0.5$  we must have  $\theta \geq 1.22c$ .

<sup>10</sup>See Friedman (1971).

By playing a trigger strategy she keeps the option of refusing a contract promising high quality and can thus punish the insurance company for a disappointment. Commitment to a high quality contract forever would deprive her of this means. Like in the one-shot game, there would be no incentive to supply high quality and the outcome would remain inefficient. Hence, we can conclude that no-commitment is a necessary condition for efficient high quality. As we have shown that there is indeed a possibility of achieving high quality by no-commitment, we will in the following section work with the hypothesis that no-commitment is also a sufficient condition for high quality.

### 3 Uncertain types and insurance contracts

#### 3.1 Uncertainty about types

In this section we extend the analysis and introduce a reason for commitment by considering that the type of the individual, i.e. her loss probability  $\pi$ , is uncertain. Individuals are then subject to premium risk because  $\alpha_q^{*'}(\pi) = y - y'_c(\pi) > 0$ . We assume that types are observable but not verifiable in front of a court. This implies that the only way to receive insurance against premium risk is via committing to a long-run contract before the type is revealed. The premium to be paid each period is then invariant of the realized type. Risk allocation would be efficient. However, we work with the hypothesis that commitment implies a quality of 0 while no-commitment leads to a quality of  $q = 1$  when  $\pi \geq \tilde{\pi}$ . Thus, commitment implies inefficient quality supply. We explore this trade-off by examining contracts that allow varying degrees of commitment. This is made possible by introducing a payment  $S$  which has to be paid upon opting-out of the long-run contract. The larger  $S$ , the higher the degree of commitment as it is more costly to leave the contract. Consistent with our assumption about the unverifiability of types,  $S$  is independent of type.<sup>11</sup> We do not consider the case in which the monopolist may give types who would like to remain in the long-run contract voluntary payments if they switch to short-run contracts. To simplify the analysis, we allow the type to change only at one point in time. Before the type is determined, the distribution of  $\pi$  is common knowledge and is described by the continuous and strictly positive density function  $\phi(\pi)$  where  $\pi \in [0, 1]$ . Let  $\Phi(\pi)$  be the respective distribution function. The sequence of events is structured as follows:

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<sup>11</sup>When types are verifiable, insurance against premium risk could be achieved by letting  $S$  depend on type. High risks would have to pay less than low risks.

- (i) At the beginning of the first period the type of the individual is uncertain. The individual may sign a contract of the form  $(\alpha_s, \beta_s, S)$ . If the contract is signed, she pays  $\alpha_s$ .
- (ii) The type is revealed.
- (iii) The individual can leave the contract  $(\alpha_s, \beta_s, S)$  by paying  $S$ . She will get  $\alpha_s$  refunded.
- (iv) If the consumer has left contract  $(\alpha_s, \beta_s, S)$ , the monopolist offers her the one-period contract  $(\alpha_0^*(\pi), \beta_0^*(\pi))$  if  $\pi < \bar{\pi}$  or the one-period contract  $(\alpha_1^*(\pi), \beta_1^*(\pi))$  if  $\pi \geq \bar{\pi}$ . These contracts are risk-based and depend on the actual loss probability of the individual.<sup>12</sup> They will be accepted because they satisfy the participation constraint of consumers.
- (v) A loss may occur. If the individual remained in the contract at stage (iii) or bought a one-period contract  $(\alpha_0^*(\pi), \beta_0^*(\pi))$  at stage (iv), no quality is supplied and she receives  $\beta_s$  or  $\beta_0^*(\pi)$  respectively. If the individual has signed a one-period contract  $(\alpha_1^*(\pi), \beta_1^*(\pi))$ , high quality is delivered.
- (vi) In all future periods types remain unchanged. Consumers who committed by not leaving at stage (iii) pay  $\alpha_s$  each period. If they are subject to a loss, they receive  $\beta_s$  and no quality is supplied. Individuals who left the contract pay  $S$  and sign contracts  $(\alpha_0^*(\pi), \beta_0^*(\pi))$  or  $(\alpha_1^*(\pi), \beta_1^*(\pi))$  each period.<sup>13</sup> Types with  $\pi \geq \bar{\pi}$  receive high quality in case of a loss.

To sum up, contracts of the form  $(\alpha_s, \beta_s, S)$  allow partial insurance against premium risk while allowing some gains from trade of quality if types with  $\pi \geq \bar{\pi}$  opt out of the long-run contract.

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<sup>12</sup>This assumption does not contradict the unverifiability of types. A contract is a voluntary agreement between two parties. Hence, discrimination is allowed.

<sup>13</sup>Here we assume that the insurance company can enforce that consumers who left the long-run contract pay  $S$  ad infinitum. This assumption is not as strong as it appears because prepayments are an equivalent device and enforceable in practice. In particular, the insurance company could require the consumer to deposit an amount equal to the present value of the infinite stream of payments  $S$ . If the insurance company guarantees that the deposit and its returns are used exclusively for a premium reduction  $S$  each period and if the consumer agrees ex ante to give up his claims on the deposit and its return upon leaving the contract, then we have the same effect as the payments  $S$  while the contract is enforceable. We decided to use the equivalent contract with infinite payments instead because we want to focus on the switching decision without examining how the consumer would finance a possible prepayment.

## 3.2 The optimal degree of commitment

To determine the optimal degree of commitment we proceed in four steps. Firstly, we determine the individual's expected utility at stage (i) in absence of long-term insurance. Secondly, we analyze the switching decision at stage (iii) and determine expected utility at stage (i) of a contract  $(\alpha_s, \beta_s, S)$ . We show that these contracts can be regarded as a means of the monopolist to choose a probability  $\hat{\pi}$  such that types with  $\pi \leq \hat{\pi}$  switch to one-period contracts while types with  $\pi > \hat{\pi}$  remain in the long-run contracts. Thirdly, we point out the trade-off between risk allocation and quality supply. Finally, we characterize optimal contracts. We restrict the analysis to one period. As is shown in Appendix A, maximizing one-period expected profits is equivalent to maximizing the present value of expected profits.

### 3.2.1 Expected utility in absence of long-term insurance

In the absence of long-term insurance, the individual would sign contract  $(\alpha_0^*(\pi), \beta_0^*(\pi))$  or  $(\alpha_1^*(\pi), \beta_1^*(\pi))$  at stage (iii). Therefore, if she turns out to have loss probability  $\pi$  her expected utility at stage (iii) is

$$E_{(iii)}(u) = u(y - \alpha_0^*(\pi)) = u(y - \alpha_1^*(\pi)) = u(y_c(\pi))$$

by equations (6) and (9). Expected utility at stage (i) in the absence of insurance can be expressed as

$$E_{(i)}(u) = \int_0^1 u(y_c(\pi))\phi(\pi)d\pi.$$

Since  $u(y_c(\pi)) = (1 - \pi)u(y) + \pi u(y - l)$  we can simplify to

$$E_{(i)}(u) = (1 - \bar{\pi})u(y) - \bar{\pi}u(y - l) = u(y_c(\bar{\pi})) \quad (14)$$

where  $\bar{\pi} = \int_0^1 \pi\phi(\pi)d\pi$  is the average loss probability.

### 3.2.2 Contracts and switching

The switching decision of a consumer is determined by the comparison of expected utility of staying in contract  $(\alpha_s, \beta_s, S)$  and switching. Given the proportion of consumers who opt out of the long-run contract, it will always be optimal for the insurer to assume all risk of individuals who stay in the long-run contract. Thus income will be state-independent for these consumers, i.e.  $y - \alpha_s = y - l + \beta_s$ . Hence

$$\beta_s = l - \alpha_s. \quad (15)$$



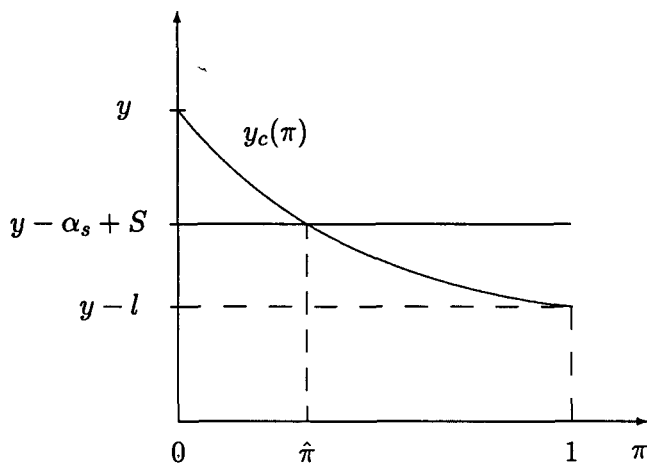


Figure 1

Therefore expected utility of an individual who stays can be written as  $u(y - \alpha_s)$ . If she switches her expected utility without insurance at stage (iii) is

$$E_{(iii),S} = (1 - \pi)u(y - S) + \pi u(y - S - l).$$

We define the certainty equivalent after switching,  $y_c(\pi, S)$ , by

$$u(y_c(\pi, S)) = (1 - \pi)u(y - S) + \pi u(y - S - l).$$

In Section 2 we established that the individual will only receive her reservation utility when signing a contract with the monopolist. Assuming that agents switch when indifferent between remaining in the contract or switching, we obtain the switching condition

$$y_c(\pi, S) \geq y - \alpha_s. \quad (16)$$

CARA implies that

$$y_c(\pi, S) = y_c(\pi) - S.$$

Therefore, the switching condition (16) translates into

$$y_c(\pi) \geq y - \alpha_s + S. \quad (17)$$

Figure 1 shows the right-hand and left-hand side of this inequality as a function of  $\pi$ . Because  $y'_c(\pi) < 0$ , it is only profitable for low risks to switch. In fact,  $\alpha_s$  and  $S$  determine the probability  $\hat{\pi}(\alpha_s, S)$  such that all types with  $\pi \leq \hat{\pi}$  will switch at stage (iii) while types with  $\pi > \hat{\pi}$

stay in contract  $(\alpha_s, \beta_s, S)$ . Taking  $\alpha_s$  as given, the monopolist's choice of  $S$  therefore amounts to choosing  $\hat{\pi}$  where a higher  $S$  leads to a lower  $\hat{\pi}$ . Assuming that the monopolist sets  $S = \alpha_s$  when he wants nobody to switch, we can regard the switching threshold  $\hat{\pi}$  as the choice variable of the monopoly and treat  $S$  as a function of  $\hat{\pi}$ .<sup>14</sup> For  $S(\hat{\pi}, \alpha_s)$  we obtain from (17)

$$S(\hat{\pi}, \alpha_s) = \alpha_s + y_c(\hat{\pi}) - y. \quad (18)$$

Under contract  $(\alpha_s, \beta_s, S(\hat{\pi}, \alpha_s))$  an individual will therefore face an income of  $y_c(\pi, S) = y_c(\pi) - S(\hat{\pi}, \alpha_s) = y_c(\pi) - \alpha_s - y_c(\hat{\pi}) + y$  when her type is  $\pi \leq \hat{\pi}$  and of  $y - \alpha_s$  when she turns out to be  $\pi > \hat{\pi}$ . Expected utility at stage (i) therefore is

$$E_{(i)}(u) = \int_0^{\hat{\pi}} u(y - \alpha_s + y_c(\pi) - y_c(\hat{\pi}))\phi(\pi)d\pi + u(y - \alpha_s)(1 - \Phi(\hat{\pi})). \quad (19)$$

Given  $\hat{\pi}$  it is always profit-maximizing for the monopolist to choose  $\alpha_s$  as to satisfy the individual participation constraint with equality where reservation utility is given by equation (14). Therefore the optimal  $\alpha_s^*$  is determined by

$$\int_0^{\hat{\pi}} u(y - \alpha_s^* + y_c(\pi) - y_c(\hat{\pi}))\phi(\pi)d\pi + u(y - \alpha_s^*)(1 - \Phi(\hat{\pi})) - u(y_c(\hat{\pi})) = 0. \quad (20)$$

Equation (20) defines the implicit function  $\Psi(\hat{\pi}, \alpha_s^*) = 0$ . From the Implicit Function Theorem it follows that there exists a function  $\alpha_s^*(\hat{\pi})$ .<sup>15</sup> Applying the Implicit Function Rule to equation (20) yields

$$\frac{d\alpha_s^*}{d\hat{\pi}} = -y_c'(\hat{\pi}) \frac{\int_0^{\hat{\pi}} u'(y - \alpha_s^* + y_c(\pi) - y_c(\hat{\pi}))\phi(\pi)d\pi}{\int_0^{\hat{\pi}} u'(y - \alpha_s^* + y_c(\pi) - y_c(\hat{\pi}))\phi(\pi)d\pi + u'(y - \alpha_s^*)(1 - \Phi(\hat{\pi}))}. \quad (21)$$

<sup>14</sup>Note that because a profit-maximizing monopolist will always choose  $S$  as high as possible, there is the unique value of  $S = \alpha_s - l$  corresponding to  $\hat{\pi} = 1$ . Hence for all  $S$  that lead to  $\hat{\pi} \in (0, 1]$ , there must be a one-to-one correspondence between  $S$  and  $\hat{\pi}$ . For  $\hat{\pi} = 0$ ,  $S$  can take all values above  $\alpha_s$ . As in this case the monopolist will not receive  $S$  from anybody, it is reasonable to assume that he chooses the lowest value  $S = \alpha_s$ . Then, given any  $\alpha_s$ , the function  $f(S) = \hat{\pi}(\alpha_s, S)$ ,  $f : [\alpha_s - l, \alpha_s] \rightarrow [0, 1]$  is a one-to-one correspondence and the inverse function  $S(\hat{\pi}, \alpha_s)$  exists.

<sup>15</sup>The partial derivatives of  $\Psi(\hat{\pi}, \alpha_s^*) = 0$  are continuous and for the partial derivative with respect to  $\alpha_s^*$  we have

$$\frac{\partial \Psi}{\partial \alpha_s^*} = \int_0^{\hat{\pi}} u'(y - \alpha_s^* + y_c(\pi) - y_c(\hat{\pi}))\phi(\pi)d\pi + u'(y - \alpha_s^*)(1 - \Phi(\hat{\pi})) \neq 0$$

for  $\hat{\pi} \in [0, 1]$ .

Since  $y'_c(\hat{\pi}) < 0$  and  $\phi(\pi)$  is strictly positive, we must have  $d\alpha_s^*/d\hat{\pi} > 0$  for  $\hat{\pi} \in [0, 1]$ . Thus there exists a one-to-one correspondence between  $\alpha_s^*$  and  $\hat{\pi}$ . This also applies to  $\beta_s^*$  and  $\hat{\pi}$  because  $\beta_s^*(\hat{\pi}) = l - \alpha_s^*(\hat{\pi})$ . Hence the long-run contract  $(\alpha_s, \beta_s, S)$  can be seen as a means of the monopolist to choose the optimal  $\hat{\pi}$ . From now on we write these contracts as  $(\alpha_s^*(\hat{\pi}), \beta_s^*(\hat{\pi}), S(\hat{\pi}))$ . The following lemma will prove to be fruitful in interpreting these contracts.

**Lemma 1:** *If the individual is risk averse, then  $\alpha_s^{*'}(\hat{\pi}) + y'_c(\hat{\pi})\Phi(\hat{\pi}) \leq 0$  with equality for  $\hat{\pi} = 0$  and strict inequality for  $\hat{\pi} > 0$ .*

*Proof:* See Appendix.

This lemma allows us to characterize the contracts  $(\alpha_s^*(\hat{\pi}), \beta_s^*(\hat{\pi}), S(\hat{\pi}))$ . We restrict ourselves to the variables  $\alpha_s^*(\hat{\pi})$  and  $S(\hat{\pi})$  as  $\beta_s^*(\hat{\pi})$  is determined by  $\alpha_s^*(\hat{\pi})$ . With Lemma 1 we can determine the dependence of  $S$  on  $\hat{\pi}$ . From equation (18) we obtain

$$S'(\hat{\pi}) = \alpha_s^{*'}(\hat{\pi}) + y'_c(\hat{\pi})$$

By Lemma 1, we must have  $\alpha_s^{*'}(\hat{\pi}) + y'_c(\hat{\pi}) < 0$ . Hence, we obtain  $S'(\hat{\pi}) < 0$ . Furthermore we can determine the values of  $S(\hat{\pi})$  and  $\alpha_s^*(\hat{\pi})$  at  $\hat{\pi} = 0$  and  $\hat{\pi} = 1$  by equations (18) and (20). We obtain

$$\alpha_s^*(0) = y - y_c(\bar{\pi}) \quad \text{and} \quad \alpha_s^*(1) = l,$$

$$S(0) = y - y_c(\bar{\pi}) \quad \text{and} \quad S(1) = 0.$$

Figure 2 sketches the functions  $S(\hat{\pi})$  and  $\alpha_s^*(\hat{\pi})$ . When  $\hat{\pi} = 0$  we have the full commitment case. Consumers pay a premium based on their average loss probability. The switching payment prevents even the best types from opting out of the long-run contract. The no-commitment solution is characterized by  $\hat{\pi} = 1$ . The premium for the long-run contract is equal to the loss  $l$  while leaving this contract is cost-free. This implies that no insurance against premium risk is offered. All values of  $\hat{\pi}$  between 0 and 1 are partial commitment solutions. As  $\alpha_s^*(0) < \alpha_s^*(\hat{\pi}) < \alpha_s^*(1)$ , there is partial insurance against premium risk. The price for more insurance against premium risk is a higher payment  $S(\hat{\pi})$ . We can interpret this payment as the price that a low risk who opts out faces ex post for having had a premium guarantee ex ante. The better that guarantee has been, i.e. the lower  $\alpha_s^*(\hat{\pi})$ , the higher is this price.

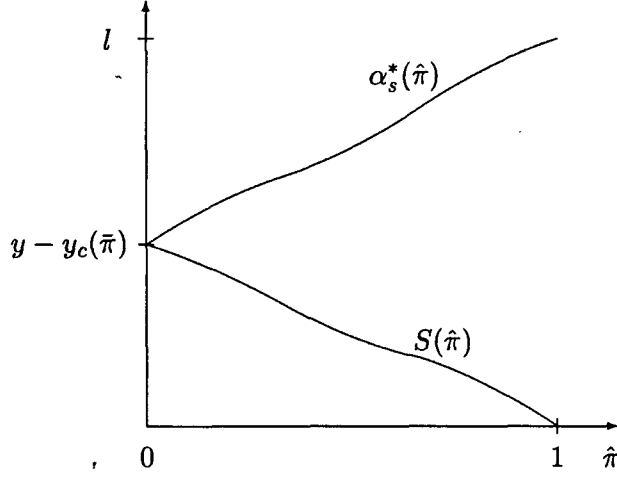


Figure 2

### 3.2.3 The trade-off between risk allocation and quality

The trade-off between risk allocation and quality can be made explicit by examining the profits of the monopolist. Note that under contract  $(\alpha_s^*(\hat{\pi}), \beta_s^*(\hat{\pi}), S(\hat{\pi}))$ , the monopolist will collect  $\alpha_s^*(\hat{\pi})$  from all types with  $\pi > \hat{\pi}$ . These types will receive  $\beta_s^*(\hat{\pi})$  in case of a loss. From types  $\pi \leq \hat{\pi}$  who switch, he will receive  $S(\hat{\pi})$ . He will sell high quality contracts  $(\alpha_1^*, \beta_1^*)$  to types with  $\pi \geq \tilde{\pi}$  and low quality contracts  $(\alpha_0^*, \beta_0^*)$  to types  $\pi < \tilde{\pi}$ , i.e. he obtains expected profit  $p_0^*$  for types  $\pi < \hat{\pi}$  and additional profits due to quality  $p_1^* - p_0^* = \pi(\theta - c)$  for types  $\pi \geq \hat{\pi}$  (see equations (7) and (10)). Defining the gains from trade due to quality by the function

$$g(\pi) = \begin{cases} 0 & \text{if } \pi < \tilde{\pi} \\ \pi(\theta - c) & \text{if } \pi \geq \tilde{\pi} \end{cases} \quad (22)$$

we can write expected profits per consumer of contract  $(\alpha_s^*(\hat{\pi}), \beta_s^*(\hat{\pi}), S(\hat{\pi}))$ ,  $p_s(\hat{\pi})$ , as

$$p_s(\hat{\pi}) = \int_0^{\hat{\pi}} [p_0^*(\pi) + g(\pi) + S(\hat{\pi})] \phi(\pi) d\pi + \int_{\hat{\pi}}^1 [(1 - \pi)\alpha_s^*(\hat{\pi}) - \pi\beta_s^*(\hat{\pi})] \phi(\pi) d\pi. \quad (23)$$

Noting that income for the types  $\pi \leq \hat{\pi}$  is reduced by  $S(\hat{\pi})$  we obtain from equation (7)

$$p_0^*(\pi) = y - S - y_c(\pi, S) - \pi l.$$

Due to CARA this simplifies to

$$p_0^*(\pi) = y - y_c(\pi) - \pi l.$$

Substituting in equation (23) for  $p_0^*(\pi)$ , inserting  $\beta_s^*(\hat{\pi})$  and  $S(\hat{\pi})$  from equations (15) and (18), and simplifying yields

$$p_s(\hat{\pi}) = \int_0^{\hat{\pi}} g(\pi)\phi(\pi)d\pi + \alpha_s^*(\hat{\pi}) - \int_0^{\hat{\pi}} [y_c(\pi) - y_c(\hat{\pi})] \phi(\pi)d\pi - \bar{\pi}l. \quad (24)$$

The first term in equation (24) are gains from trade due to quality by serving all types  $\tilde{\pi} \leq \pi \leq \hat{\pi}$ . The second term is premium income if nobody switches. The third term  $\int_0^{\hat{\pi}} [y_c(\pi) - y_c(\hat{\pi})] \phi(\pi)d\pi$  is positive due to  $y'_c(\pi) < 0$ . This term is subtracted because types with  $\pi < \hat{\pi}$  switch and pay less than they are willing to at stage (iii) because the payment  $S(\hat{\pi})$  is type-independent. The last term measures expected losses for all types because the monopolist will assume all damage risk.

The monopolist chooses  $\hat{\pi}$  as to maximize (24). The first derivative of the profit function with respect to  $\hat{\pi}$  is

$$p'_s(\hat{\pi}) = \underbrace{g(\hat{\pi})\phi(\hat{\pi})}_{\geq 0} + \underbrace{\alpha_s^{*'}(\hat{\pi}) + y'_c(\hat{\pi})\Phi(\hat{\pi})}_{\leq 0}. \quad (25)$$

where the sign of  $\alpha_s^{*'}(\hat{\pi}) + y'_c(\hat{\pi})\Phi(\hat{\pi})$  is given by Lemma 1. Equation (25) thus reveals the trade-off the monopolist faces when increasing  $\hat{\pi}$ . On the one hand, there are more gains from trade due to quality by letting more types switch. This *quality effect* is captured by  $g(\hat{\pi})\phi(\hat{\pi})$ . On the other hand, the sum of the remaining terms is negative. We call this the *risk distortion effect*. It can be interpreted as follows. First, notice that  $\alpha_s^{*'}(\hat{\pi}) + y'_c(\hat{\pi})\Phi(\hat{\pi}) \leq 0$  is due to the consumers who already switched at  $\hat{\pi}$  because only the distribution function  $\Phi(\pi)$  is relevant.<sup>16</sup> Second, recall figure 2. When increasing  $\hat{\pi}$ , the insurance company has to lower  $S(\hat{\pi})$  and raise  $\alpha_s^*(\hat{\pi})$ . This implies that consumers who switch are even better off while individuals who stay are even worse off. Individuals evaluate this prospect at stage (i) when they do not know their type. If the expected value of payments to the insurer and hence expected profits due to risk exchange were to remain unchanged, they would thus face a mean-preserving increase in risk. As has first been shown by Rothschild and Stiglitz (1970), expected utility for risk-averse individuals would decrease. However, this is not possible since the participation constraint is binding at the optimum. Therefore the insurer has to lower the expected value of payments from consumers and expected profits due to risk exchange must fall.

<sup>16</sup>The density function  $\phi(\pi)$  does not play a role for risk allocation because we assumed individuals to switch when indifferent between remaining in the contract and staying. From the standpoint of risk allocation the monopolist never loses profits on the types who marginally switch because these do not obtain any rent when switching.

### 3.2.4 Profit-maximizing contracts

The profit-maximizing  $\hat{\pi}^*$  determines the optimal degree of commitment. Types with  $\pi > \hat{\pi}^*$  will commit, while types with  $\pi \leq \hat{\pi}^*$  remain noncommitted. As can be seen from equation (25),  $\hat{\pi}^*$  on the one hand depends on the properties of the distribution function  $\Phi(\pi)$ . On the other hand, risk aversion of consumers is crucial. To obtain some insights into the nature of profit-maximizing contracts, we characterize the first-order condition of the monopolist. We have to consider boundary and interior solutions. The description of an interior solution is complicated by the fact that  $g(\pi)$  is discontinuous at  $\tilde{\pi}$ . The function  $p_s^{*'}(\hat{\pi})$  makes an upward jump at  $\tilde{\pi}$ . Besides the usual condition for an interior optimum,  $p_s^{*'}(\hat{\pi}^*) = 0$ , we must therefore also take into account that an interior solution can exist at  $\hat{\pi}^* = \tilde{\pi}$  when  $p_s^{*'}(\tilde{\pi}) \leq 0$ .<sup>17</sup> Boundary solutions may exist at  $\hat{\pi} = 0$  when  $p_s^{*'}(0) \leq 0$  or at  $\hat{\pi} = 1$  when  $p_s^{*'}(1) \geq 0$ . Proposition 2 gives us a sufficient condition for  $\hat{\pi}^* = 0$  to be a local optimum:

**Proposition 2:** *If  $\tilde{\pi} > 0$ , then  $\hat{\pi} = 0$  is a local optimum.*

*Proof:* As  $g(0) = 0$  and  $\alpha_s^{*'}(0) + y_c'(0)\Phi(0) = 0$  due to Lemma 1, we have  $p_s'(0) = 0$ . For all  $\hat{\pi}$  such that  $0 < \hat{\pi} < \tilde{\pi}$ , we obtain  $g(\hat{\pi}) = 0$ . Therefore  $p_s'(\hat{\pi}) = \alpha_s^{*'}(\hat{\pi}) + y_c'(\hat{\pi})\Phi(\hat{\pi}) < 0$  for all  $0 < \hat{\pi} < \tilde{\pi}$  by Lemma 1. Thus  $\hat{\pi} = 0$  is a local optimum. *Q.E.D.*

The proof of Proposition 2 implies that  $\hat{\pi}^* = 0$  is a global optimum if  $g(\pi)\phi(\pi) = 0$  for all  $\pi \in [0, 1]$ . We can thus state:

**Corollary 2.1:** *If quality cannot credibly be sold to any type, i.e.  $\tilde{\pi} > 1$ ,  $\hat{\pi}^* = 0$  is a global optimum, i.e. full commitment is optimal.*

The intuition of Proposition 2 is that letting the best types marginally switch yields no extra profits if the monopolist cannot sell quality to them. Letting further types switch decreases profits due to an inefficient risk allocation. Since allowing the best types to switch is not profitable, it can be optimal not to let any types switch. In this full commitment solution at least risk allocation is efficient. Corollary 2.1 confirms the idea that in absence of a quality motive full commitment is optimal as it allows full insurance against premium risk.

It can also be optimal that all types switch, i.e. that there is no-commitment. The following proposition states sufficient conditions under which we will

<sup>17</sup>Note that at  $\tilde{\pi} - \epsilon$  we cannot have a profit-maximum. As no quality can be sold we have either  $p_s^{*'}(\tilde{\pi} - \epsilon) < 0$  or  $p_s^{*'}(\tilde{\pi} - \epsilon) = 0$  by Lemma 1. In the first case we clearly cannot have a maximum. In the latter case, we must have  $p_s^*(\tilde{\pi} - \epsilon) < p_s^*(\tilde{\pi})$  because of the upward jump of  $p_s^{*'}(\pi)$  at  $\tilde{\pi}$ .

obtain this result.

**Proposition 3:** *If  $\tilde{\pi} < 1$ , then there exists (i) an upper limit of risk aversion  $\underline{a}$  and (ii) a lower limit  $\bar{a}$  such that it is profit-maximizing to let all possible types switch, when constant absolute risk aversion  $a$  is smaller than  $\underline{a}$  or larger than  $\bar{a}$ .*

*Proof:* See Appendix.

Given that quality can be sold to some types, the intuition of the existence of an upper limit  $\underline{a}$  of risk aversion is straightforward. When consumers are almost risk neutral then there are few gains from risk transfer. Quality supply will be the dominant source of profit for the monopolist and he will let all types switch in order to sell as much quality as possible. The existence of a lower limit  $\bar{a}$  of risk aversion, however, is less obvious. This result is due to the effect that with highly risk averse individuals, premium risk vanishes under a monopolist who extracts all consumer surplus. Individuals are willing to pay almost the amount of the loss  $l$  as a premium even if they turn out to be a very good type. Insuring premium risk thus yields little extra premium but destroys the credibility of high quality.<sup>18</sup>

To obtain more insight into profit-maximizing contracts, we performed a numerical simulation. We use the exponential utility function  $u(y) = -e^{-ay}$  where  $a$  is the constant Pratt-Arrow-measure of risk aversion and a truncated normal distribution with the density function

$$\phi(\pi) = \frac{1}{\sqrt{2\Pi}\sigma} e^{-\frac{(\pi - \mu)^2}{2\sigma^2}} + k$$

where  $k$  is chosen as to obtain  $\int_0^1 \phi(\pi) d\pi = 1$  and  $\Pi$  is the number  $\pi$ . For the parameters we assumed  $y = 100, l = 20, \tilde{\pi} = 0.05, \mu = \sigma = 0.2, k \approx 0.159, \theta - c = 1.73$ .

The results are depicted in Figure 3 where the profit-function  $p_s^*(\hat{\pi})$  is shown for four levels of risk aversion. For  $a = 0.01$  the no-commitment contract yields the highest profits. This confirms Proposition 3, part (i). When the individual is only slightly risk averse, it is profit-maximizing to sell as much quality as possible. Risk allocation is inefficient. When  $a = 0.05$ , then the partial commitment contract is profit-maximizing. The monopolist will set  $\hat{\pi}^* \approx 0.45$ . Risk allocation is inefficient as is quality supply.

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<sup>18</sup>In a competitive market where individuals pay a fair premium against the risk of a monetary loss, this result is not likely to hold. There would still be demand for insurance against premium risk by very risk averse individuals as the premium they pay is much lower than their maximum willingness to pay.

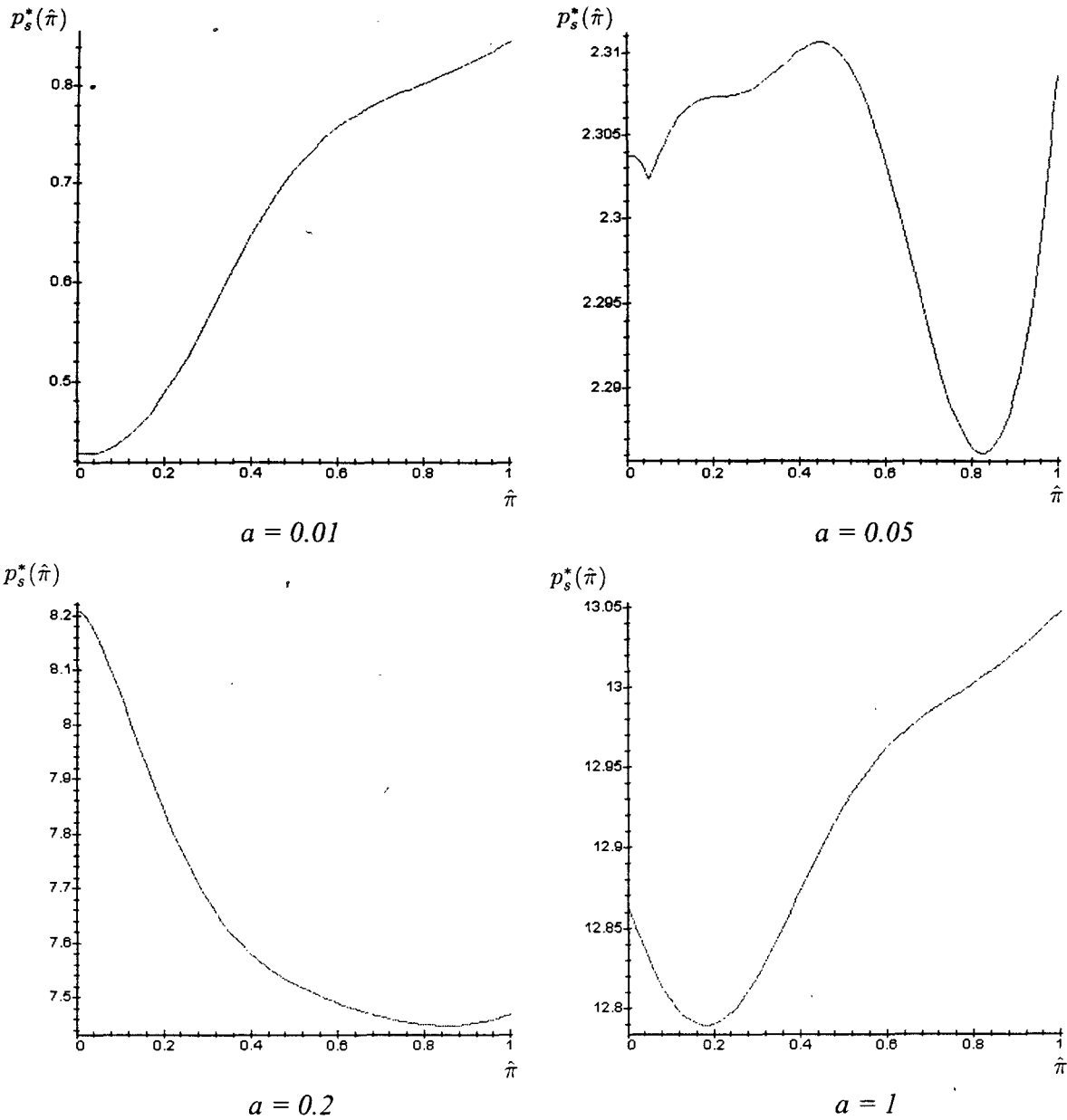


Figure 3

The full commitment contract is most profitable when  $a = 0.2$ . Risk allocation is efficient but there is no quality supply. Finally, for  $a = 1$  the no-commitment contract yields the highest profits. This illustrates Proposition 3, part (ii). Very risk averse individuals are already willing to pay a high premium even if they turn out to be a good type. Additional insurance against premium risk yields little extra profits but implies less quality sold. Risk allocation is inefficient while quality supply is efficient. To conclude, the numerical example confirms the theoretical results and in addition shows that for intermediate degrees of risk aversion partial commitment contracts can be profit-maximizing.



## 4 Conclusion

The key result of our paper is the existence of a trade-off between risk allocation and quality supply when individuals' types are uncertain. The two crucial assumptions are that neither quality of insurance service nor the individual type is verifiable in front of a court. We first showed that in the absence of premium risk, no-commitment is a necessary condition for the supply of unverifiable quality. Full commitment, however, was necessary for complete insurance of premium risk when types are unverifiable. Thus, it is not possible to have an efficient risk allocation and quality supply simultaneously. Under no-commitment risk allocation is inefficient while full commitment implies an inefficient quality supply. Under partial commitment neither risk allocation nor quality supply are efficient. Examining the profit-maximizing contract for the monopolist we found that under slight and extreme risk aversion no-commitment is optimal. For intermediate degrees of risk aversion, however, full and partial commitment can be optimal as we demonstrated by a numerical example. These results were derived for a monopolistic market. However, the trade-off between risk allocation and quality supply can be expected to exist under competition as well. With the exception of the optimality of no-commitment when consumers are extremely risk averse, we are convinced that our results also apply in a competitive market.

While the main purpose of our model is to highlight the trade-off between risk allocation and quality supply, it may nevertheless prove helpful in considering possible government intervention. Firstly, mechanisms for holding health insurers accountable for quality should be installed.<sup>19</sup> For example, regular external quality audits could be required. A semi-autonomous public agency could be a trustworthy third party that guarantees that these mechanisms are reliable. Secondly, measures to increase the verifiability of types can be useful. Although it seems unlikely that an exhaustive list of criteria to classify types can be developed, there exists a limited number of diagnostics that are fairly indisputable. A government sanctioned catalogue of such diagnostics could allow insurers to set fixed amounts that will be paid an insured who switches to another insurer and who contracted the disease while being insured.<sup>20</sup> This would lessen the need for commitment in order to insure against premium risk. Finally, an approach to competition in health insurance being tested in the Netherlands may be a viable alternative to a market where premiums are risk-rated. This system relies on premium regulation, open enrollment and health insurance contributions to insurers by the government based on a risk assessment model that classifies the composition of the insured of each insurer. The regulation that insur-

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<sup>19</sup>For a review of such mechanisms, see Gosfield (1997).

<sup>20</sup>This idea has first been advanced by Fischer and Serra (1996) as part of a proposal for the reform of private health insurance in Chile.

ers can charge only uniform premiums solves the premium risk problem. There are strong incentives for insurers to supply good quality as consumers can switch regularly. However, as discussed by van de Ven and van Vliet (1991), a cream skimming problem may appear when the risk assessment model is too inexact. In this case insurance companies have a strong incentive to attract individuals for whom the premium plus the government transfer is larger than expected costs. Hence the type identification problem reappears although this time without the requirement that the criteria are legally enforceable. The cream skimming problem thus reinforces an important insight from our model, namely that it is unlikely that the incentives for health insurers can be completely aligned with the interest of consumers.

## 5 Appendix

### *Equivalence of the one-period and the intertemporal maximization problem*

In Section 3 we restricted the analysis to a one-period problem. Here we show that the solution is equivalent to an intertemporal maximization problem.

In all periods after the first one, types remain unchanged. An individual who stayed in contract  $(\alpha_s, \beta_s, S)$  will pay  $\alpha_s$ . Her income is thus  $y - \alpha_s$ . An individual who switched in the first period has to pay  $S$  and buys contract  $(\alpha_0^*(\pi), \beta_0^*(\pi))$  or  $(\alpha_1^*(\pi), \beta_1^*(\pi))$ . By equations (6) and (9)  $\alpha_0^*(\pi) = \alpha_1^*(\pi)$ . Regardless of the contract signed, her income therefore is  $y - S - \alpha_0^*(\pi)$ . Following equation (6) we obtain for  $\alpha_0^*(\pi)$ :

$$\alpha_0^*(\pi) = y - S - y_c(\pi, S).$$

Constant absolute risk aversion implies

$$\alpha_0^*(\pi) = y - y_c(\pi).$$

Substituting for  $S(\hat{\pi}, \alpha_s)$  from equation (18), the income for an individual who switched therefore simplifies to  $y - \alpha_s + y_c(\pi) - y_c(\hat{\pi})$ . Comparing with equation (19) shows that all periods are therefore identical for the individual as seen from stage (i) when the type is still unknown. It follows that  $\alpha_s^*(\hat{\pi})$  as defined by equation (20) is optimal. Hence the monopolist receives  $\alpha_s^*(\hat{\pi})$  from all types with  $\pi > \hat{\pi}$  in all periods after the first. From types  $\pi \leq \hat{\pi}$  who switch, he will receive  $S(\hat{\pi})$  each period. Since he sells high quality contracts  $(\alpha_1^*(\pi), \beta_1^*(\pi))$  to the types  $\hat{\pi} < \pi < \hat{\pi}$  and no quality contracts  $(\alpha_0^*(\pi), \beta_0^*(\pi))$  to the types  $\pi < \hat{\pi}$ , he obtains a profit  $p_0^*(\pi) + g(\pi)$  from the types who switched. Comparison with equation (23) shows that in each period his expected profits are the same as in the first period.

Thus in all periods the optimization problem is identical to the one in the first period. Therefore the solution of the intertemporal problem must be identical to the one given by the maximization of one-period profits (24).

*Proof of Lemma 1*

Equation (21) gives us a relationship between  $\alpha_s^{*\prime}(\hat{\pi})$  and  $y_c'(\hat{\pi})$ . Integration by parts of the common term in numerator and denominator yields

$$\int_0^{\hat{\pi}} u'(y - \alpha_s^*(\hat{\pi}) + y_c(\pi) - y_c(\hat{\pi}))\phi(\pi)d\pi = \\ u'(y - \alpha_s^*(\hat{\pi}))\Phi(\hat{\pi}) - \int_0^{\hat{\pi}} u''(y - \alpha_s^*(\hat{\pi}) + y_c(\pi) - y_c(\hat{\pi}))\Phi(\pi)d\pi.$$

Thus we can rewrite equation (21) as

$$\alpha_s^{*\prime}(\hat{\pi}) = -y_c'(\hat{\pi}) \frac{u'(y - \alpha_s^*(\hat{\pi}))\Phi(\hat{\pi}) - \int_0^{\hat{\pi}} u''(y - \alpha_s^*(\hat{\pi}) + y_c(\pi) - y_c(\hat{\pi}))\Phi(\pi)d\pi}{u'(y - \alpha_s^*(\hat{\pi})) - \int_0^{\hat{\pi}} u''(y - \alpha_s^*(\hat{\pi}) + y_c(\pi) - y_c(\hat{\pi}))\Phi(\pi)d\pi} \\ \leq -y_c'(\hat{\pi})\Phi(\hat{\pi}) \quad \text{for } u''(y) < 0.$$

with equality for  $\Phi(\hat{\pi}) = 0$  and strict inequality for  $\Phi(\hat{\pi}) > 0$ . Since the distribution function  $\phi(\pi)$  is assumed to be strictly positive in  $\pi \in [0, 1]$ , we therefore obtain

$$\alpha_s^{*\prime}(\hat{\pi}) + y_c'(\hat{\pi})\Phi(\hat{\pi}) \begin{cases} = 0 & \text{for } \hat{\pi} = 0 \\ < 0 & \text{for } \hat{\pi} > 0 \end{cases}.$$

*Q.E.D.*

*Proof of Proposition 3*

Letting all possible types switch corresponds to the monopolist choosing  $\hat{\pi}^* = 1$ . Firstly we show that there exist  $\underline{a}_1$  and  $\bar{a}_1$  such that for all  $a$  fulfilling  $0 < a < \underline{a}_1$  and  $a > \bar{a}_1$  we have

$$p_s(1) - p_s(\hat{\pi}) > 0 \quad \text{for all } \hat{\pi} < \bar{\pi}.$$

It can be shown that under the CARA utility function  $u(y) = -e^{-ay}$  the functions  $\alpha_s^*(\pi, a)$  and  $y_c(\pi, a)$  depend on constant absolute risk aversion  $a$  and the function

$$r(\hat{\pi}, a) \equiv \alpha_s^*(\hat{\pi}, a) - \int_0^{\hat{\pi}} [y_c(\pi, a) - y_c(\hat{\pi}, a)] \phi(\pi)d\pi$$

is continuous in  $a$ . Furthermore, we obtain the following results:

$$\lim_{a \rightarrow 0} r(\hat{\pi}, a) = \bar{\pi}l \quad \text{and} \quad \lim_{a \rightarrow \infty} r(\hat{\pi}, a) = l.^{21}$$

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<sup>21</sup>All proofs of continuity and the calculations of limits are available from the author upon request.

Substituting from equation (24), we have

$$p_s(1, a) - p_s(\hat{\pi}, a) = r(1, a) - r(\hat{\pi}, a) + \int_{\hat{\pi}}^1 g(\pi)\phi(\pi)d\pi.$$

Thus

$$\lim_{a \rightarrow 0} p_s(1, a) - p_s(\hat{\pi}, a) = \lim_{a \rightarrow \infty} p_s(1, a) - p_s(\hat{\pi}, a) = \int_{\hat{\pi}}^1 g(\pi)\phi(\pi)d\pi > 0$$

because  $\tilde{\pi} < 1$ ,  $g(\pi) > 0$  for all  $\hat{\pi} \geq \tilde{\pi}$  and  $\phi(\pi) > 0$  by assumption. Since  $r(\hat{\pi}, a)$  is continuous in  $a$ , there must exist (i) an  $\underline{a}_1 > 0$  such that for all  $\hat{\pi} < \tilde{\pi}$

$$p_s(1, \underline{a}_1) - p_s(\hat{\pi}, \underline{a}_1) = r(1, \underline{a}_1) - r(\hat{\pi}, \underline{a}_1) + \int_{\hat{\pi}}^1 g(\pi)\phi(\pi)d\pi \geq 0$$

and

$$p_s(1, a) - p_s(\hat{\pi}, a) > 0 \quad \text{for } 0 < a < \underline{a}_1,$$

and (ii) an  $\bar{a}_1$  such that for all  $\hat{\pi} < \tilde{\pi}$

$$p_s(1, \bar{a}_1) - p_s(\hat{\pi}, \bar{a}_1) = r(1, \bar{a}_1) - r(\hat{\pi}, \bar{a}_1) + \int_{\hat{\pi}}^1 g(\pi)\phi(\pi)d\pi \geq 0$$

and

$$p_s(1, a) - p_s(\hat{\pi}, a) > 0 \quad \text{for } a > \bar{a}_1.$$

Secondly, we consider  $\hat{\pi} \geq \tilde{\pi}$ . We will show that there exist  $\underline{a}_2$  and  $\bar{a}_2$  such that for all  $a$  fulfilling  $0 < a < \underline{a}_2$  and  $a > \bar{a}_2$  we have

$$p'_s(\hat{\pi}) > 0 \quad \text{for all } \hat{\pi} \geq \tilde{\pi}.$$

It can be shown that under the CARA utility function  $u(y) = -e^{-ay}$  the function

$$\frac{\partial r(\hat{\pi}, a)}{\partial \hat{\pi}} = \frac{\partial \alpha_s^*(\hat{\pi}, a)}{\partial \hat{\pi}} + \frac{\partial y_c(\hat{\pi}, a)}{\partial \hat{\pi}} \Phi(\hat{\pi})$$

is continuous in  $a$ . Furthermore, it can be established that

$$\lim_{a \rightarrow 0} \frac{\partial r(\hat{\pi}, a)}{\partial \hat{\pi}} = 0 \quad \text{and} \quad \lim_{a \rightarrow \infty} \frac{\partial r(\hat{\pi}, a)}{\partial \hat{\pi}} = 0.$$

As

$$p'_s(\hat{\pi}, a) = g(\hat{\pi})\phi(\hat{\pi}) + \frac{\partial r(\hat{\pi}, a)}{\partial \hat{\pi}}$$

we obtain

$$\lim_{a \rightarrow 0} p'_s(\hat{\pi}, a) = \lim_{a \rightarrow \infty} p'_s(\hat{\pi}, a) = g(\hat{\pi})\phi(\hat{\pi}) > 0 \quad \text{for all } \hat{\pi} \geq \tilde{\pi}.$$

because  $g(\pi) > 0$  for all  $\hat{\pi} \geq \tilde{\pi}$  and  $\phi(\pi) > 0$  by assumption.

By continuity of  $\partial r(\hat{\pi}, a)/\partial \hat{\pi}$ , there must exist (i) an  $\underline{a}_2 > 0$  such that for all  $\hat{\pi} \geq \tilde{\pi}$

$$p'_s(\hat{\pi}, \underline{a}_2) = g(\hat{\pi})\phi(\hat{\pi}) + \frac{\partial r(\hat{\pi}, \underline{a}_2)}{\partial \hat{\pi}} \geq 0$$

and

$$p'_s(\hat{\pi}, a) > 0 \quad \text{for } 0 < a < \underline{a}_2,$$

and (ii) an  $\bar{a}_2$  such that for all  $\hat{\pi} \geq \tilde{\pi}$

$$p'_s(\hat{\pi}, \bar{a}_2) = g(\hat{\pi})\phi(\hat{\pi}) + \frac{\partial r(\hat{\pi}, \bar{a}_2)}{\partial \hat{\pi}} \geq 0$$

and

$$p'_s(\hat{\pi}, a) > 0 \quad \text{for } a > \bar{a}_2.$$

Define

$$\underline{a} \equiv \min\{\underline{a}_1; \underline{a}_2\} \quad \text{and} \quad \bar{a} \equiv \max\{\bar{a}_1; \bar{a}_2\}.$$

Then the monopolist will set  $\hat{\pi}^* = 1$  for all  $a$  fulfilling  $0 < a < \underline{a}$  and  $a > \bar{a}$ .

*Q.E.D.*

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