Asymmetric Information, Heterogeneity in Risk Perceptions and Insurance: An Explanation to a Puzzle

By

Kostas Koufopoulos

DISCUSSION PAPER 402

February 2002

FINANCIAL MARKETS GROUP
AN ESRC RESEARCH CENTRE

LONDON SCHOOL OF ECONOMICS

E·S·R·C
ECONOMIC & SOCIAL RESEARCH COUNCIL

ISSN 0956-8549-402

Asymmetric Information, Heterogeneity in Risk Perceptions and Insurance:
An Explanation to a Puzzle

Kostas Koufopoulos*

February 3, 2002

Abstract

Given that, in equilibrium, all agents freely opt for strictly positive own coverage, competitive models of asymmetric information predict a positive relationship between coverage and ex post risk (accident probability). On the other hand, some recent empirical studies find either negative or no correlation. This paper, by introducing heterogeneity in risk perceptions into an asymmetric information competitive model, provides an explanation to this puzzle. The more optimistic agents underestimate their accident probability relative to less optimistic and so purchase less insurance. They also tend to be less willing to take precautions. This gives rise to separating equilibria exhibiting negative or no correlation between coverage and ex post risk that potentially explain the puzzling empirical findings. Moreover, the no-correlation equilibrium involves some agents being quantity-constrained due to adverse selection. Thus, although the no-correlation empirical findings indicate that there may not be risk-related adverse selection, they do not imply the absence of other forms of adverse selection that have significant effects on the resulting equilibrium.

* Department of Economics, London School of Economics; k.koufopoulos@lse.ac.uk.
I would like to thank Sudipto Bhattacharya, David de Meza, Jean-Charles Rochet and David Webb for invaluable discussions and comments.

1. Introduction

Most recent empirical studies of insurance markets have focused on the relationship between the coverage of the contract and the (average) ex post risk (accident rate) of its buyers. The results are mixed. De Meza and Webb (2001) provide casual evidence for a negative relationship in the credit card insurance market.[1] Cawley and Philipson (1999) study of life insurance contracts also shows a negative relationship which, however, is not statistically significant. A similar result is obtained by Chiappori and Salanie (2000)[2] and Dionne, Gourieroux and Vanasse (2001) for the automobile insurance market.[3] On the other hand, Brugiavini (1993) and Finkelstein and Poterba (2000) find a strong positive relationship in the annuities market.

Starting with the seminal Rothschild-Stiglitz paper (1976), most theoretical models of competitive insurance markets under asymmetric information predict a positive relationship between coverage and the (average) ex post risk of the buyer of the contract. This prediction is shared by models of pure adverse selection (e.g. Rothschild and Stiglitz (1976)), pure moral hazard (e.g. Arnott and Stiglitz (1988)) as well as models of adverse selection plus moral hazard (e.g. Chassagnon and Chiappori (1997) and Chiappori et.al. (2001)). In fact, Chiappori et.al. (2001) argue that the positive correlation property is extremely general. However, in a recent paper, de Meza and Webb (2001) provide a model where agents are heterogeneous with respect to their risk aversion and face a moral hazard problem. Also, insurance companies pay a strictly positive fixed administrative cost per claim. In this model, there exist a separating and a partial pooling equilibrium predicting a negative relationship but due to the fixed cost the less risk-averse agents go uninsured.

This paper first shows that these (seemingly) contradictory theoretical results can be reconciled. Given that fixed administrative costs are strictly positive, it is shown that the Chiappori et.al. argument holds necessarily true only if, in equilibrium, all agents choose contracts offering strictly positive own coverage. If, in equilibrium, some agents choose zero own coverage, then their assertion is not necessarily true. In this case, there exist separating equilibria that exhibit negative (de Meza and Webb (2001)) or no correlation (Koufopoulos (2001a)) between coverage and ex post risk. It should be stressed that the choice of zero own coverage and these fixed administrative costs are not independent. It is precisely the presence of these costs that results in some agents (the risk tolerant) choosing not to insure and hence in the breaking of the positive relationship.

Therefore, competitive models of insurance markets under asymmetric information can explain the observed negative or no-correlation between coverage and ex post risk in cases where some agents choose zero own insurance and/or purchase only the legal minimum of third-party coverage. For example, the Chiappori and Salanie (2000) and the de Meza and Webb (2001) empirical findings are perfectly consistent with the predictions of these models. However, their prediction is not consistent with negative or no-correlation in insurance markets where all agents freely opt for strictly positive own coverage. For example, the fact that per unit insurance premiums fall with quantity and the negative (point estimate) or no correlation between coverage and the accident rate reported by Cawley and Philipson (1999) remain a puzzle.

---

[1] 4.8% of U.K. credit cards are reported lost or stolen each year. The corresponding figure for insured cards is 2.7%.

[2] In the Chiappori and Salanie (2000) study those opting for less coverage just purchase the legal minimum of third-party coverage which can be interpreted as zero own coverage.

[3] All three studies control for observable characteristics known to insurers.

Some answers have been provided in the context of the principal-agent framework (monopoly). For example, Jullien, Salanie and Salanie (2000), in a moral hazard model, obtain a negative relationship between coverage and ex post risk. In a similar framework, Villeneuve (2000) reverses the information structure, he assumes that insurers know better the insuree's accident probability than the insuree himself, and finds that a negative relationship is possible. However, insurance markets seem to be fairly competitive and so monopoly is not a good approximation. A question then arises: How can we go about explaining the negative or no correlation empirical findings in a competitive framework under asymmetric information?

This paper does so by introducing heterogeneity in risk perceptions in an otherwise standard competitive model of asymmetric information. Several psychological studies indicate that the majority of human beings are unrealistically optimistic, in the sense that they underestimate their accident probability.[4] [5] On the other hand, Viscusi (1990) finds that more individuals overestimate the risk of lung-cancer associated with smoking than underestimate it and, on average, they greatly overestimate it. Also, those who perceive a higher risk are less likely to smoke. As these studies indicate, regardless of the direction of the bias, people hold different beliefs about the same or similar risks.[6] In general, the more optimistic (henceforth Os) agents underestimate their accident probability relative to less optimistic (henceforth Rs) and so purchase less insurance. They also tend to be less willing to take precautions. This gives rise to separating equilibria exhibiting negative or no correlation between coverage and ex post risk that potentially explain the puzzling empirical findings.

Two examples of separating equilibria are presented where both the Os and the Rs choose strictly positive own coverage. The first equilibrium exhibits a negative relationship between coverage and ex post risk. The Rs purchase more coverage and take precautions whereas the Os, although buy less insurance, do not take precautions. In the second one, there is no correlation between coverage and accident probability. Both types take precautions but the Rs choose more coverage than the Os. Furthermore, the first equilibrium exists even if there is full information about types. That is, asymmetric information about types does not affect the nature of this equilibrium. However, adverse selection does affect the characteristics of the second equilibrium. One type (the Rs) is quantity-constrained. Under full information about types, the Rs would have purchased more insurance.

Cawley and Philipson (1999), Chiappori and Salanie (2000) and Dionne et.al. (2001) argue that the no-correlation empirical findings imply that there is no (risk-related) adverse selection. The result in the latter equilibrium suggests that their conclusion cannot be generalised. Other forms of adverse selection (e.g. asymmetric information about risk perceptions) may be present and give rise to equilibria involving some agents being quantity-constrained even if the data show no correlation between coverage and the accident rate.

The next section briefly describes the Chiappori et.al. framework and shows that if some agents choose zero own coverage, then both negative and no correlation between coverage and ex post risk are possible. In Section 3, I present a model where the agents differ with respect to their risk perceptions and face a moral hazard

---

[4] For a survey see Weinstein and Klein (1996).

[5] For applications of optimism to Economics see de Meza and Southey (1996) and Manove and Padilla (1999).

[6] Given that agents have different information sets, heterogeneity in risk perceptions is not necessarily inconsistent with rationality (or even rational expectations).

problem. Section 4 provides a diagrammatical proof for the existence of the two separating equilibria described above. Finally, section 5 concludes.

2. The Chiappori et.al. Framework

There are two states of nature: good and bad. In the good state the agent incurs no loss whereas in the bad state he incurs a loss of D_θ. The parameter θ represents all the characteristics of the agent (potential insuree) that are his private information (risk, risk aversion, loss, etc). An agent of type θ may privately choose his loss probability $1-p$ in some subset of [0,1]. In pure adverse selection models this subset is a singleton whereas in moral hazard models where agents choose their preventive effort level, this subset may include two or more points. A contract consists of coverage and premium: $C=(\lambda y, y)$, $\lambda > 1$. The ex post risk of an insuree is a function of the contract he chooses. The average ex post risk of insurees choosing contract C is $1-p(C)$. Also, the following assumptions are made:

Assumption 1: For all contracts offered and all agent types overinsurance is ruled out by assuming $\lambda y \leq D_\theta$.
Assumption 2: Agents are risk averse (in the sense that they are averse to mean-preserving spreads on wealth).
Assumption 3: Insurance companies are risk neutral, and incur a cost per contract $c \geq 0$ and a cost per claim $c' \geq 0$. So, the expected profit of an insurance company offering contract $C=(\lambda y, y)$ to an agent with ex post risk $1-p$ is

$$\pi = y-(1-p)(\lambda y + c') - c$$

Profit Monotonicity (PM) Assumption: If two contracts C_1 and C_2 are chosen in equilibrium and $\lambda_1 y_1 < \lambda_2 y_2$, then $\pi(C_1) \geq \pi(C_2)$.

We can now state and prove the main result of this section.

Proposition 1: Under Assumptions 1 to 3 and PM if two contracts C_1 and C_2 are chosen in equilibrium and $\lambda_1 y_1 < \lambda_2 y_2$, then $1-p(C_1) < 1-p(C_2)$ is necessarily true if $0 < \lambda_1 y_1 < \lambda_2 y_2$ and $c, c' \geq 0$. If $\lambda_1 y_1 = 0$ and $c > 0$ or $c' > 0$ or $c, c' > 0$, then $1-p(C_1) < 1-p(C_2)$ is not necessarily true. Both $1-p(C_1) = 1-p(C_2)$ and $1-p(C_1) > 1-p(C_2)$ are possible.

Proof: The proof is done through two lemmas.

Lemma 1: Suppose an agent θ chooses the contract $C_1 = (\lambda_1 y_1, y_1) = (0,0)$ over the contract $C_2 = (\lambda_2 y_2, y_2)$ where $\lambda_2 y_2 > 0$. Then it must be true that

$$1-p(C_1) < \frac{1}{\lambda_2} = \frac{y_2}{\lambda_2 y_2}$$

Proof: See Appendix.

Intuitively, given risk aversion, if the per unit premium under C_2, $1/\lambda_2$, were less than the ex post risk (accident probability) under C_1 the agent would be strictly better off taking contract C_2, rather than going uninsured, while keeping $1-p(C_1)$.

Lemma 2: Suppose $C_1=(\lambda_1 y_1, y_1)=(0,0)$ and $C_2=(\lambda_2 y_2, y_2)$ are chosen in equilibrium. If $c>0$ or $c'>0$ or $c,c'>0$, then it may be true that $1-p(C_1)\geq 1-p(C_2)$. If $\lambda_2 y_2>\lambda_1 y_1>0$, then $1-p(C_1)<1-p(C_2)$ is always true.

Proof: By Lemma 1 we have

$$1-p(C_1)<\frac{y_2}{\lambda_2 y_2} \quad \Rightarrow \quad y_2-(1-p(C_1))\lambda_2 y_2>0 \tag{1}$$

In this case, $\pi(C_1)$ is (identically) equal to zero. Therefore,

$$\pi(C_1)=0<y_2-(1-p(C_1))\lambda_2 y_2 \tag{2}$$

The expected profit for an insurance company offering contract C_2 is

$$\pi(C_2)=y_2-(1-p(C_2))(\lambda_2 y_2+c')-c \tag{3}$$

Given (PM), $\pi(C_1)=0$, and the fact that in equilibrium profits cannot be negative, it follows that $\pi(C_1)=\pi(C_2)=0$. Then, using (2) and (3) we obtain:

$$[1-p(C_2)-(1-p(C_1))](y_2\lambda_2+c')>-[(1-p(C_1))c'+c] \tag{4}$$

Given $\lambda_2 y_2>0$ and $c>0$ or $c'>0$ or $c,c'>0$, it is clear from (4) that it may well be true that $1-p(C_1)\geq 1-p(C_2)$.

If $\lambda_2 y_2>\lambda_1 y_1>0$, using similar arguments we have:

$$1-p(C_1)<\frac{y_2-y_1}{\lambda_2 y_2-\lambda_1 y_1} \quad \Rightarrow \quad (y_2-y_1)-(1-p(C_1))(\lambda_2 y_2-\lambda_1 y_1)>0 \tag{5}$$

Using the expected profit functions $\pi(C_i)$, $i=1,2$, and (5) we obtain:

$$\pi(C_1)-\pi(C_2)<[(1-p(C_2))-(1-p(C_1))](\lambda_2 y_2+c') \tag{6}$$

Given (PM), (6) implies $1-p(C_1)<1-p(C_2)$. Q.E.D.

In the de Meza and Webb (2001) framework (a special case of the above general framework) there exist separating (and partial pooling) equilibria where the risk tolerant agents (or some of them) choose zero own coverage ($\lambda_1 y_1=0$). Therefore, both $1-p(C_1)>1-p(C_2)$ (de Meza and Webb (2001)) and $1-p(C_1)=1-p(C_2)$

(Koufopoulos (2001a)) are perfectly possible and consistent with the predictions of Chiappori et.al. general framework. It should be emphasised that the choice of zero own coverage by the less risk-averse agents and the fixed administrative costs are not independent. It is precisely the presence of these costs that leads those agents to go uninsured and breaks the positive relationship between coverage and (average) ex post risk.

In summary, if some agents choose zero own coverage, then both negative and no correlation between coverage and (average) ex post risk can arise. However, if, in equilibrium, all agents choose contracts offering strictly positive own coverage, then asymmetric information plus competition among insurance companies imply a strictly positive relationship. Therefore, competitive models of insurance markets under asymmetric information can explain the observed negative or no-correlation between coverage and ex post risk in cases where some agents choose zero own insurance and/or purchase only the legal minimum of third-party coverage. For example, the Chiappori and Salanie (2000) and the de Meza and Webb (2001) empirical findings are perfectly consistent with the predictions of these models. However, their prediction is not consistent with negative or no-correlation in insurance markets where all agents freely opt for strictly positive own coverage. For example, the fact that the per unit insurance premiums fall with quantity and the negative correlation between coverage and the accident rate reported by Cawley and Philipson (1999) remain a puzzle.

Given that insurance markets are fairly competitive, explanations provided by models cast in the principal-agent framework (monopoly) are not satisfactory. This paper provides an explanation to this puzzle by introducing heterogeneity in risk perceptions. Most standard asymmetric information models of insurance markets (including the Chiappori et.al. (2001) model) implicitly assume that all insurees have an accurate estimate of their accident probability (given the precautionary effort level).[7] However, several empirical studies both by psychologists and economists indicate that people tend to either underestimate (e.g. Weinstein and Klein (1996)) or overestimate (e.g. Viscusi (1990)) their accident probability. The model presented below retains the assumption of perfect competition among insurance companies but allows agents (insurees) to have different perceptions of the same risk.

3. The Model

There are two states of nature: good and bad. In the good state there is no loss whereas in the bad state the individual (insuree) suffers a gross loss of D. Before the realisation of the state of nature all individuals have the same wealth level, W. Also, all individuals are risk averse and have the same utility function but differ with respect to their perception of the probability of suffering the loss. There are two types of individuals, the Rs and the Os. The Rs have an accurate estimate of their true probability of avoiding the loss, p, whereas the Os overestimate it.[8]

Furthermore, all agents can affect the true probability of avoiding the loss by involving in preventive activities. Given the level of precautionary effort, the true probability of suffering the loss is the same for both types. I examine the case where agents either take precautions or not (two effort levels). If an individual takes

[7] Villeneuve (2000) is an exception.

[8] For expositional simplicity, I assume that the more optimistic are optimists whereas the less optimistic are realists. However, all the results go through if two types are respectively optimists and pessimists or both are optimists with different degrees of optimism.

precautions ($F_i = \overline{F}$), he incurs a utility cost of $\overline{F}$ and his true probability of avoiding the loss $p(F_i)$ is p_F. If he takes no precautions ($F_i = 0$), his utility cost is 0 but his true probability of avoiding the loss $p(F_i)$ is p_0, where $p_F > p_0$.

Now, let $p^i = p(F_i, K_i)$ be the (perceived) probability function. Where K_i is the degree of "optimism" and takes two values: 1 for the Rs $(K_R = 1)$, and $\overline{K} > 1$ for the Os $(K_O = \overline{K} > 1)$. This probability function is assumed to be strictly increasing in K_i. As a result, the following relationships are true:

$$p_j^R = p(F_i, K_R) = p(F_i, 1) = p(F_i) = p_j, \qquad i = O, R, \qquad j = F, 0 \tag{7}$$

$$p_j^O = p(F_i, K_O) = p(F_i, \overline{K}) > p(F_i) = p_j, \qquad i = O, R, \qquad j = F, 0 \tag{8}$$

where p_j is the true probability of avoiding the loss.

In this environment, the (perceived) expected utility of an insured agent i is given by:

$$EU_i(F_i, K_i, y_i, \lambda_i, W) = p_j^i U(W - y) + (1 - p_j^i) U(W - D + (\lambda - 1)y) - F_i, \qquad j = F, 0 \quad i = O, R \tag{9}$$

where W: insuree's initial wealth
D: gross loss
y: insurance premium
$(\lambda - 1)y$: net payout in the event of loss, $\lambda > 1$
λy : coverage (gross payout in the event of loss)

Hence, the increase in (perceived) expected utility from taking precautions is:

$$\Delta_i = \left(p_F^i - p_0^i\right)\left[U(W - y) - U(W - D + (\lambda - 1)y)\right] - \overline{F}, \qquad i = O, R \tag{10}$$

where U is strictly concave and $W - y \geq W - D + (\lambda - 1)y$ are the wealth levels in the good and the bad state respectively.

There are two risk neutral insurance companies involved in Bertrand competition. Perceived probabilities and actions are private information of each insuree. However, insurance companies know the true probability of suffering a loss, the cost for the insuree corresponding to each precautionary effort level, the utility function of the insurees and the proportion of the Os and Rs in the population. In order to make the distinction between the results under different risk perceptions and those of the standard competitive models of asymmetric information clearer, I assume that the costs of processing claims (or underwriting costs) are zero.[9]

The insurance contract $(y, \lambda y)$ specifies the premium y and the coverage λy. As a result, since insurance companies know the true accident probability, the expected profit of an insurer offering such a contract is:

$$\pi = p(F_i)y - (1 - p(F_i))(\lambda - 1)y \tag{11}$$

[9] All results go through if fixed administrative costs are strictly positive but not very large.

Equilibrium

Insurance companies and insurees play the following two-stage screening game:

Stage 1: The two insurance companies simultaneously make offers of sets of contracts $(y, \lambda y)$. Each insurance company may offer any finite number of contracts.

Stage 2: Given the offers made by the insurers, insurees apply for at most one contract from one insurance company. If an insuree's most preferred contract is offered by both insurance companies, he takes each insurer's contract with probability ½. The terms of the contract chosen determine whether the insuree will take unobservable precautions.

I only consider pure-strategy subgame-perfect Nash equilibria (SPNE). Depending on parameter values, four kinds of equilibria can arise: separating, partial-separating, full-pooling and partial-pooling. In this paper, I only present the two most interesting separating equilibria.[10]

In a separating equilibrium the Os and Rs choose different consumption allocations, z_O and z_R respectively. This equilibrium must satisfy:

i) The revelation constraints

$$EU_R(z_R) \geq EU_R(z_O)$$
$$EU_O(z_O) \geq EU_O(z_R) \tag{12.a}$$

ii) The effort incentive constraints

$$F_i = \begin{cases} \overline{F} & \text{if } \Delta_i \geq 0, \quad i = O, R \\ 0 & \text{otherwise} \end{cases} \tag{12.b}$$

with Δ_i defined in (4).

iii) The participation (or IR) constraints of both types:

$$EU_i(z_i) \geq EU_i(z_0), \quad i = O, R \tag{12.c}$$

where $z_0 = (y, \lambda y) = (0,0)$

iv) Profit maximisation for insurance companies:

- No contract in the equilibrium pair (z_O, z_R) makes negative expected profits.
- No other set of contracts introduced alongside those already in the market would increase an insurer's expected profits.

[10] See Koufopoulos (2001b) for an analysis of all different kinds of equilibria.

4. Diagrammatic Analysis

Let $H = W - y$ and $L = W - D + (\lambda - 1)y$ denote the income of an insuree who has chosen the contract $(y, \lambda y)$ in the good and bad state respectively. Let also $\overline{H} = W$ and $\overline{L} = W - D$ denote the endowment of an insuree after the realisation of the state of nature.

4.1. Effort Incentive Constraints

The contract is effort incentive compatible if

$$(p_F^i - p_0^i)[U(H) - U(L)] \geq \overline{F} \quad \Leftrightarrow \quad \Delta_i \geq 0, \quad i = O, R \tag{13}$$

Let $P_i P_i'$ be the locus of combinations (H, L) such that $\Delta_i = 0$. Since $\overline{F}$, $U' > 0$, the $P_i P_i'$ locus lies entirely below the 45^0 line in the (L, H) space. This locus divides the (L, H) space into two regions: On and below the $P_i P_i'$ locus the insurees take precautions (this is the set of effort incentive compatible contracts) and above it they do not. The slope and the curvature of $P_i P_i'$ in the (L, H) space are given respectively by:

$$\left.\frac{dL}{dH}\right|_{P_i P_i'} = \frac{U'(H)}{U'(L)} > 0 \qquad \text{since } U' > 0 \tag{14}$$

$$\left.\frac{d^2 L}{dH^2}\right|_{P_i P_i'} = \frac{U'(H)}{U'(L)}\left[A(L)\frac{U'(H)}{U'(L)} - A(H)\right] \tag{15}$$

where $A(L) = -\dfrac{U''(L)}{U'(L)}$ is the coefficient of absolute risk aversion.

Since both types have the same utility function, it is clear from the above formulas that the shape of $P_i P_i'$ is independent of the type of the insuree. In addition, $P_i P_i'$ is upward sloping. Also if $U(\cdot)$ exhibits either increasing or constant absolute risk aversion $P_i P_i'$ is strictly concave. If $U(\cdot)$ exhibits decreasing absolute risk aversion, it can be either concave or convex. (See the Appendix for a necessary and sufficient condition in order for $P_i P_i'$ to be strictly convex).

However, the position of $P_i P_i'$ does depend upon the insuree's type. Although the Os overestimate their probability of avoiding the loss at any given precautionary effort level, they may either overestimate or underestimate the increase in that probability from choosing a higher preventive effort level. Though both cases are possible, the latter seems to be more reasonable especially if, given that no precautions are taken, the perceived probability of avoiding the accident is high.[11] In

[11] This assumption is also consistent with Viscusi's (1990) finding that those who perceive a higher risk are less likely to smoke. The more pessimistic agents take more precautions.

this paper the analysis is conducted under the assumption that the latter case is relevant.[12] In particular, the following assumption is made:

Assumption 1: $p_F^R - p_0^R > p_F^O - p_0^O$

That is, the Rs' set of effort incentive compatible contracts is strictly greater than that of the Os. It is also assumed that

Assumption 2: $(p_F^i - p_0^i)\left[U(\overline{H}) - U(\overline{L})\right] > \overline{F}$, $i = O, R$

Assumption 2 implies that both $P_R P_R'$ and $P_O P_O'$ pass above the endowment point, and so the effective set of effort incentive compatible contracts is not empty for either type.

Two points must be stressed here. First, Assumption 1 is required for but does not necessarily imply a negative relationship between coverage and ex post risk. It may well be the case that Assumption 1 holds and a separating or a partial pooling equilibrium arises exhibiting a positive relationship.[13] Second, although, Assumption 1 is necessary for the negative correlation prediction, Assumption 2 does not need to hold for the Os. In fact, this result obtains more easily if the direction of inequality in Assumption 2 is reversed for the Os. That is, if the Os never take precautions. On the contrary, the no-correlation result requires Assumption 2 but not Assumption 1.[14] It obtains even if the Os overestimate not only their probability of avoiding the accident but also the increase in that probability from taking precautions.

4.2. Indifference Curves

The indifference curves, labelled I_i, are kinked where they cross the corresponding $P_i P_i'$ locus. Above $P_i P_i'$, insurees of the the i-type do not take precautions, their perceived probability of avoiding the loss is p_0^i, and so the slope of I_i is:

$$\left.\frac{dL}{dH}\right|_{I_i, p=p_0} = -\frac{p_0^i}{1-p_0^i}\frac{U'(H)}{U'(L)} \qquad i = O, R \tag{16}$$

On and below $P_i P_i'$ insurees of the i-type do take precautions, their perceived probability of avoiding the loss rises to p_F^i and so the slope of I_i becomes:

$$\left.\frac{dL}{dH}\right|_{I_i, p=p_F} = -\frac{p_F^i}{1-p_F^i}\frac{U'(H)}{U'(L)} \qquad i = O, R \tag{17}$$

Hence, just above $P_i P_i'$ the i-type indifference curves become flatter.

---

[12] See Koufopoulos (2001b) for a comprehensive analysis of both cases.
[13] See Koufopoulos (2001b) for some examples.
[14] The no-correlation result obtains even if the direction of the inequality in Assumption 2 is reversed. However, this assumption would imply that both types never take precautions and so this case is not very interesting.

4.3. Insurers' Zero-profit Lines (Offer Curves)

Using the definitions $H = W - y$ and $L = W - D + (\lambda - 1)y$, and the fact that insurance companies know the true accident probabilities, the insurers' expected profit function becomes:

$$\pi = p(F_i)(W - H) - (1 - p(F_i))(L - W + D) \qquad (18)$$

The zero-profit lines are given by:

$$L = \frac{1}{1 - p(F_i)} W - \frac{p(F_i)}{1 - p(F_i)} H - D \qquad (19)$$

Conditional on the preventive effort level chosen by the two types of insurees, there are three zero-profit lines with slopes:

$$\left.\frac{dL}{dH}\right|_{\pi=0} = -\frac{p_0}{1 - p_0} \qquad \text{(EN' line)} \qquad (20)$$

$$\left.\frac{dL}{dH}\right|_{\pi=0} = -\frac{p_F}{1 - p_F} \qquad \text{(EJ' line)} \qquad (21)$$

$$\left.\frac{dL}{dH}\right|_{\pi=0} = -\frac{q}{1 - q} \qquad \text{(EM' line (pooled –line))} \qquad (22)$$

p (1 0)p

$L = W -$, Eq.(19) becomes: D (23)

Eq. (23) is independent of the value of $p(F)$. This implies that all three zero-profit lines have the same starting point (the endowment point, E).

We can now state and prove the two main results. The negative correlation result is shown in Proposition 2 whereas Proposition 3 provides an example that shows the theoretical possibility of no-correlation between coverage and ex post risk.

Proposition 2: , I , passes above the E intersection of J and $_{P\ R P\ R}$ and meets , then there exists a unique (separating equilibrium z z), where the Rs take precautions whereas the Os do not. Both types choose strictly positive own coverage but the Rs buy more than the Os (see Figure 1).[15]

---

p $-p$

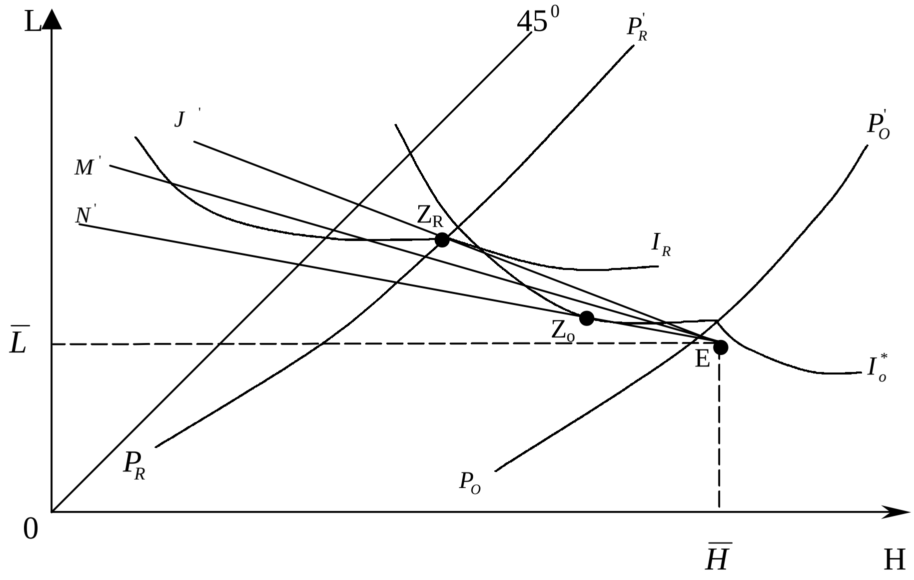

Figure 1

Proof: We test whether (z_R, z_O) is an equilibrium by considering deviations. Clearly, the Os strictly prefer z_O to z_R. Offers above EJ' are clearly loss-making. Similarly, offers above $P_R P_R'$ either do not attract any type or, if they do, are unprofitable. Below EJ' and below $P_R P_R'$ there is no offer that attracts the Rs but there are some offers that attract the Os and so are unprofitable (given the equilibrium contract z_R, the Rs are attracted only by contracts that lie above EJ' which are, of course, loss-making). So, there is no profitable deviation and the (z_R, z_O) pair is the unique separating equilibrium. The fact that I_O^* passes above z_R rules out any pooling equilibrium. Therefore, (z_R, z_O) is the unique equilibrium. Q.E.D.

The result in Proposition 2 is consistent with both the negative correlation between coverage and ex post risk (point estimate) and the fact that per unit premiums fall with the quantity of insurance purchased as reported by Cawley and Philipson (1999). The Rs not only purchase more coverage but also take more precautions and so their accident probability is lower than that of the Os. Competition among insurance companies then implies that they will also pay a lower per unit premium. Moreover, this separating equilibrium exists even if there is full information about types. Both types choose the contract they would have chosen if their type were publicly observable but they faced the moral hazard problem. That is, adverse selection has no effect on the nature of this equilibrium (neither revelation constraints is binding in equilibrium).

Proposition 3: Suppose EM' does not cut I_R through the intersection point of EJ' and I_O^* (the Os' indifference curve tangent to EJ' below $P_O P_O'$ and to the left of E). Then there exists a unique separating equilibrium where both types purchase strictly positive coverage and take precautions but the Rs buy more insurance than the Os. That is, this equilibrium exhibits no correlation between coverage and the accident probability (see Figure 2).

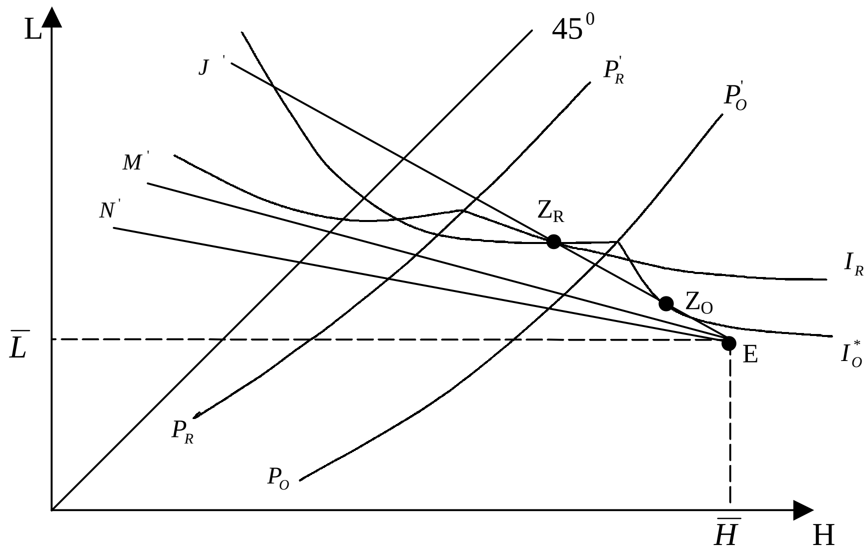

Figure 2

Proof: Consider the following deviations. Clearly, offers above EJ' are loss-making. The same is true for offers above $P_R P_R'$. Between $P_R P_R'$ and $P_O P_O'$ and below EJ' there is no offer that attracts Rs and does not attract the Os, although there are some offers that attract only the Bs. Thus, any offer in this region is unprofitable. Given the equilibrium contracts, below EJ' and below $P_O P_O'$ there is no offer that is attractive to either type. Hence, the pair (z_R, z_O) is the unique separating equilibrium. Furthermore, the fact that EM' does not cut below (to the right of) $P_R P_R'$ rules out any pooling equilibrium. Therefore, the pair (z_R, z_O) is the unique equilibrium. Q.E.D.

Strictly speaking, the no-correlation prediction is highly unlikely to be observed in practice. However, if one interprets it as a failure to reject the no-correlation null, then it is consistent with the findings of Cawley and Philipson (1999) and Dionne et.al. (2001) about the relationship between coverage and the accident probability. Furthermore, if we allow for strictly positive administrative and/or underwriting costs, the model also explains the negative relationship between coverage and per unit premiums. Since both types take precautions they have the same accident probability and so are charged the same constant marginal price (per unit premium). But the fact that the Os purchase less coverage implies that their total per unit premium is higher. In fact, Cawley and Philipson find that a fixed production (underwriting) cost and a constant marginal cost explain almost all risk-adjusted variation in prices.

Also, a slight modification of the model gives rise to a separating equilibrium consistent with the Chiappori and Salanie (2000) findings. If the Os underestimate their accident probability even more and/or we allow for positive administrative or underwriting costs, the resulting equilibrium involves the Os going uninsured, the Rs purchasing strictly positive own coverage and both types taking precautions (see Figure 3). As a result, both types have the same accident probability and so there is no correlation between coverage and ex post risk.

Finally, it should be noted that the separating equilibrium in Proposition 3 involves the Rs being quantity-constrained. This is due to adverse selection (the Os' revelation

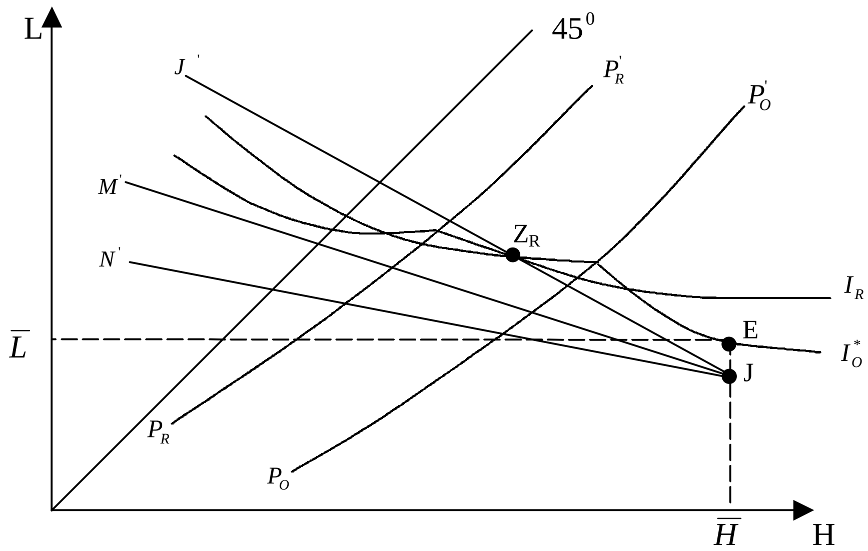

Figure 3

constraint is binding in equilibrium). Under full information about types, the Rs would have purchased more insurance (they would have taken the contract at the intersection of $P_R P_R'$ and EJ' instead of z_R). The Rs' most preferred contract is not offered because it violates the Os' revelation and effort incentive constraints and so is loss-making for the insurance companies. In order to reveal their type, the Rs accept lower coverage than they would have chosen in the absence of the Os. Cawley and Philipson (1999), Chiappori and Salanie (2000) and Dionne et.al. (2001) argue that no correlation between coverage and ex post risk implies that there is no (risk-related) adverse selection problem. The result in Proposition 3 (and Figure 3) suggests that their conclusion cannot be generalised. Although risk-related adverse selection may not be a problem, other forms of adverse selection (e.g. asymmetric information about risk perceptions) may be present and give rise to equilibria involving some agents being quantity-constrained even if the data show no correlation between coverage and the accident rate.

5. Conclusions

On the one hand, some recent empirical studies find either negative or no correlation between coverage and the accident rate. On the other hand, given that all agents choose strictly positive own coverage, competitive models of asymmetric information predict a positive relationship between coverage and ex post risk. This is a puzzle that needs to be explained.

This paper provides an explanation to this puzzle by introducing heterogeneity in risk perceptions in a competitive model of asymmetric information. It is shown that under heterogeneous risk perceptions there exist separating equilibria exhibiting either negative or no correlation between coverage and ex post risk even if all agents choose strictly positive own coverage. The more optimistic agents underestimate their accident probability relative to less optimistic and so purchase less insurance. Depending on the difference in risk perceptions and the effectiveness of precautionary effort, they either take precautions or not. This potentially explains both the negative and the no-correlation results reported by empirical studies.

It is also shown that no correlation between coverage and the accident rate does not necessarily imply that adverse selection is absent or has no significant effects on the resulting equilibrium. In fact, there exist equilibria exhibiting no correlation between coverage and ex post risk that involve some agents (insurees) being quantity-constrained due to adverse selection.

Appendix A: Proof of Lemma 1

Consider a contract $C' = (\lambda_2 y_2, y')$ with premium: $y' = (1-p)\lambda_2 y_2$
We will show that the agent prefers C' to C_1. Notice that if the agent still has ex post risk $1-p$ under C' ($1-p(C_1) = 1-p(C')$), then he faces the following lottery:

$$L' = (-D_\theta + \lambda_2 y_2 - y', 1-p; -y', p)$$

The expectation of this lottery is:

$$(1-p)(-D_\theta + \lambda_2 y_2 - y') - py' = (1-p)(-D_\theta + \lambda_2 y_2) - y' = -(1-p)D_\theta$$

Clearly, it is equal to the expectation of the lottery

$$L_1 = (-D_\theta, 1-p; 0, p)$$

which the agent faces under C_1. Since $0 = \lambda_1 y_1 < \lambda_2 y_2$ and contracts do not overinsure, lottery L_1 is a mean-preserving spread of L'. Thus, given risk aversion, the agent strictly prefers L' to L_1. Furthermore, since under C' he may choose another $1-p' \neq 1-p$ that costs him less than $1-p$, he strictly prefers C' to C_1 and hence to C_2 (by assumption, C_1 is preferred to C_2). However, contracts C' and C_2 offer the same coverage. Therefore, since C' is strictly preferred to C_2, it must be the case that

$$y_2 > y' = (1-p)\lambda_2 y_2 \quad \Rightarrow \quad 1-p(C_1) < \frac{y_2}{\lambda_2 y_2} = \frac{1}{\lambda_2} \qquad \text{QED.}$$

Appendix B

The equation of the $P_i P_i'$ locus $(\Delta_i = 0)$ is:

$$\Delta_i = (p_F^i - p_0^i)\left[U(H) - U(L)\right] - \overline{F} = 0 \qquad \text{(B.1)}$$

By totally differentiating (B.1) we obtain:

$$(p_F^i - p_0^i)\left[U'(H)dH - U'(L)dL\right] = 0 \quad \Rightarrow \quad \left.\frac{dL}{dH}\right|_{P_i P_i'} = \frac{U'(H)}{U'(L)} > 0 \qquad \text{(B.2)}$$

Also $P_i P_i'$ implicitly defines L as a function of H, that is

$$L = g(H) \qquad \text{(B.3)}$$

Using (B.2) and taking into account (B.3) we obtain:

$$\left.\frac{d^2L}{dH^2}\right|_{P_iP_i'} = \frac{U''(H)}{U'(L)} - \frac{U'(H)U''(L)}{[U'(L)]^2}\frac{dg(H)}{dH} = \frac{U''(H)}{U'(L)} - \frac{U'(H)U''(L)}{[U'(L)]^2}\frac{U'(H)}{U'(L)} \Rightarrow$$

$$\left.\frac{d^2L}{dH^2}\right|_{P_iP_i'} = \frac{U'(H)}{U'(L)}\left[\frac{U''(H)}{U'(H)} - \frac{U''(L)}{U'(L)}\frac{U'(H)}{U'(L)}\right] = \frac{U'(H)}{U'(L)}\left[A(L)\frac{U'(H)}{U'(L)} - A(H)\right] \qquad \text{(B.4)}$$

where $A(\cdot) = -\frac{U''(\cdot)}{U'(\cdot)}$ is the coefficient of absolute risk aversion.

P_iP_i' is concave in the (L,H) space iff $\left.\frac{d^2L}{dH^2}\right|_{P_iP_i'} \leq 0$, and using (B.4) we have:

$$\frac{A(L)}{U'(L)} \leq \frac{A(H)}{U'(H)} \qquad \text{(B.5)}$$

Since H>L, increasing or constant absolute risk aversion implies that P_iP_i' is concave in the (L,H) space.

P_iP_i' is strictly convex in the (L,H) space iff $\left.\frac{d^2L}{dH^2}\right|_{P_iP_i'} > 0$ and using (B.4) we have:

$$\frac{A(L)}{U'(L)} > \frac{A(H)}{U'(H)} \qquad \text{(B.6)}$$

Notice that A/U' is the derivative of the inverse of the marginal utility $(1/U')$. This implies that the condition (B.6) is satisfied iff $(1/U')$ is strictly concave. This condition is stronger than decreasing absolute risk aversion. Therefore, decreasing absolute risk aversion is a necessary but not a sufficient condition for P_iP_i' to be strictly convex in the (L,H) space.

References

Arnott, R. and J. Stiglitz (1988), "The Basic Analytics of Moral Hazard", Scandinavian Journal of Economics, 90, 383-413.

Bragiavini, A. (1993), "Uncertainty Resolution and the Timing of Annuity Purchases", Journal of Public Economics, 50, 31-62.

Cawley, J. ant T. Philipson (1999), "An Empirical Examination of Information Barriers to Trade in Insurance", American Economic Review, 89, 827-846.

Chassagnon, A. and P.-A. Chiappori (1997), "Insurance Under Moral Hazard and Adverse Selection: The Case of Perfect Competition", mimeo, DELTA.

Chiappori, P.-A., B. Jullien, B. Salanie and F. Salanie (2001), "Asymmetric Information in Insurance: A Robust Characterisation", mimeo.

Chiappori, P.-A. and B. Salanie (2000), "Testing for asymmetric Information in Insurance Markets", Journal of Political Economy, 108, 56-78.

De Meza, D. and D. Webb (2001), "Advantageous Selection in Insurance Markets", Rand Journal of Economics, 32, 68-81.

De Meza, D. and C. Southey (1996), "The Borrower's Curse: Optimism, Finance and Entrepreneurship", Economic Journal, 106, 375-386.

Dionne, G., C. Gourieroux and C. Vanasse (2001), "Testing for Evidence of Adverse Selection in the Automobile Insurance Market: A Comment", Journal of Political Economy, 109, 444-453.

Finkelstein, A. and J. Poterba (2000), "Adverse Selection in Insurance Markets: Policyholder Evidence from the UK Annuity Market", NBER WP 8045.

Jullien, B., B. Salanie and F. Salanie (2000), "Screening Risk-averse Agents under Moral Hazard", mimeo, IDEI Toulouse.

Koufopoulos, K. (2001a), "Asymmetric Information in Insurance Markets: A Reconciliation of Theory and Evidence", mimeo.

Koufopoulos, K. (2001b), "Heterogeneity in Risk Perceptions and Insurance: Positive Analysis", mimeo.

Manove, M. and A.J. Padilla (1999), "Banking (Conservatively) with Optimists", Rand Journal of Economics, 3, 324-350.

Rothschild, M. and J. Stiglitz (1976), "Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information", Quarterly Journal of Economics, 90, 629-649.

Villeneuve, B. (2000), "The consequences for a Monopolistic Insurer of Evaluating Risk Better than Customers: The Adverse Selection Hypothesis Reversed", Geneva Papers on Risk and Insurance Theory, 25, 65-79.

Viscusi, W. K. (1990), "Do Smokers Underestimate Risks?" Journal of Political Economy, 98, 1253-1269.

Weinstein, N.D. and W.M. Klein (1996), "Unrealistic Optimism: Present and Future", Journal of Social and Clinical Psychology, 15, 1-8.