DOES ASYMMETRIC INFORMATION MATTER IN COMPETITIVE INSURANCE MARKETS?*

ABSTRACT

Does asymmetric information matter in insurance markets? Recent evidence on the automobile insurance market suggests not, rejecting the separating equilibrium of the Rothschild-Stiglitz model. However, I show that a two-period version of that model can sustain a pooling equilibrium with experience rating which is consistent with the evidence and it mimics the bonus-malus policies of the automobile insurance markets. I also simulate the model showing that under reasonable conditions coordination failures emerge due to multiple equilibria.

JEL Classification: D 82, G 22
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I - INTRODUCTION

The implications of asymmetric information for competitive equilibria have been the subject of wide attention at least since the pioneering contributions of Akerlof (1970) and Spence (1973). One of the most exciting investigations of this research has focused on insurance markets. Akerlof (1970) taught us that under price competition, «bad» types may drive «good» types out of an insurance market causing its collapse. Rothschild and Stiglitz (1976, R-S hence on) extended the model to price-quantity competition[1]. Their screening equilibrium foresees a positive correlation between coverage and risk, together with rationing for low risk agents: low risk agents can be separated by the high risk agents because they are willing to accept an higher deductible.

However, recent empirical investigations, notably Cawley and Philipson (1999), Chiappori and Salanié (2000) and Dionne *et Al.* (2001)[2], reject these results, claiming that the role played by asymmetric information is negligible in insurance markets. Chiappori and Salanié (2000) and Dionne *et Al.* (2001) obtain this negative result in a market which is a traditional textbook example on adverse selection: the automobile

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[1] See also Wilson (1977).

[2] See Chiappori (2000) for a survey on econometric models of insurance under asymmetric information

insurance market[3]. Positive correlation between coverage and risk is also rejected in the life insurance markets according to Cawley and Philipson (1999). In addition, Cawley and Philipson (1999) claim the theoretical necessity of a convex total price of insurance and empirically reject it. In reality, the standard theory does not imply this convexity of the total price in the amount of coverage: I show this in the *Appendix*, where I review the basic *R-S model* with many types.

The main thesis of this paper is in defence of the relevance of asymmetric information in insurance markets. In particular, I will advance a theoretical model which may reconcile the existing empirical evidence with the pervasive role of adverse selection, claiming that a dynamic perspective on insurance contracts endogenously provides equilibrium outcomes which are consistent with that evidence.

Many insurance markets are characterized by short term contracts which are periodically updated. The *bonus-malus* system for automobile insurance implies yearly or quarterly revisions of the premia paid by the drivers according to their performance: a car accident implies a higher premium, otherwise a discount is awarded. The information on the history of each driver is public, which implies that in each period a driver can change insurance company and sign a contract – based on his own history – with an other company. This complex mechanism is the standard contract used in the automobile insurance markets of virtually all the world. I will show that exactly the presence of asymmetric information can rationalize it in a dynamic extension of the R-S model.

Cooper and Hayes (1987) and Dionne and Doherty (1994) have already dealed with a two period model of competitive insurance. However, no one of these papers individuates a set of equilibria, and their separating two-period contracts with precommitment are subject to opportunistic behaviour and renegotiation. Relaxing the precommitment hypothesis, I show that a new kind of pooling equilibrium emerges and it mimics the *bonus-malus* system. Nilssen (2000) also considers a two period R-S model but under the assumption that a consumer's accident record is not publicly available and insurance companies can act as constrained monopolists with their old customers. This assumption does not seem to be realistic in many markets like the automobile insurance market (under the *bonus malus* policy, the accidents history is generally publically available), and is different from the one of full information on accident history adopted in this paper[4]. However, since it is probably true that the information of insurers on their customers is wider than the one of outsiders, the results of Nilssen (ibid.) should be seen as complementary to ours.

To gain insights on the nature of the new equilibrium, let us suppose that a pooling contract is offered in the first period by all firms. The usual problem is that a new firm

[3] See Puelz - Snow (1994) for an initial attempt in favour of the presence of adverse selection and the critique of their result by Dionne *et Al.* (2001).

[4] Moreover, Nilssen (2000) does not obtain a full characterization of the possible equilibria, which is instead obtained in our model.

may deviate by offering a contract which is profitable if accepted just by the «low risk» types. In the R-S model, this kind of contract always exists. Here, however, the high risk types have a new incentive to accept a similar deviation, since by doing that, they may gain a reputation as «low risk» types and the associated future contracts with cheap full insurance. If agents are patient enough, any deviation is accepted by both types and so it cannot be profitable. Hence, in equilibrium a sequence of pooling contracts emerges, with information being gradually revealed only from the accidents' histories, and agents being periodically distributed between different risk classes through bayesian updating of their accident probability.

The recent empirical literature on adverse selection in the automobile insurance market has taken into account the classification of insureds in risk classes. Its exercise has been to verify if residual adverse selection is present within some risk classes – that is between observationally identical agents – by testing a self selection hypothesis: «lower risk individuals» should choose higher deductibles, where «low risk individuals» means individuals with higher accident probabilities or less claims *ex post*. Chiappori and Salanié (2000) and Dionne *et Al.* (2001) cannot reject the hypothesis that the deductible choice provides no useful information in predicting the number of claims. In the words of Dionne *et Al.* (2001), the conclusion is that «by an appropiate risk classification procedure, the insurer is able to control for adverse selection and does not need any additional self-selection mechanism». Chiappori and Salanié (2000) concentrate their focus on beginners, that is drivers at the beginning of their history: according to them, «asymmetric information seems to be at most a negligible phenomenon in the market for automobile insurance, at least for young drivers». Their point seems to be quite strong given that new insureds (*i.e.* the younger drivers) should be associated with unobservable information more than older drivers. Nevertheless, I will claim that these empirical findings are consistent with the relevance of asymmetric information and actually they support its fundamental role in the automobile insurance market. Under reasonable conditions, self-selection does not characterize equilibrium contracts within risk classes, and adverse selection gives rise to pooling contracts for beginners. In other words the theory implies no correlation between risk and coverage within risk classes for the beginners. However, private information is gradually revealed from the accident history and at a certain point, self selection is possible which implies that we should see the correlation between risk and coverage for older drivers. Indeed, Chiappori and Salanié (ibid.) have just used data on beginners finding no correlation, but in a recent and important empirical paper, Cohen (2001) has replicated their result but also found that a clear negative correlation emerges for older drivers.

The paper contains three more sections. Section II develops the two period model and a simulation, while Section III discusses some extensions and Section IV draws the conclusions. The *Appendix* presents a version of the basic R-S model with one period but more than just two types.

II - THE MODEL

I will consider a simple two-period endowment economy. In each period many identical agents with income w may have an accident and loose d. A fraction λ faces a higher accident probability π_H, while the remaining fraction (1 - λ) faces the lower probability π_L. Agents are risk averse and discount the future at rate δ.

There are many risk neutral firms. Each of them can offer any number of insurance contracts to the agents in both periods. An insurance contract gives the right to consumption C_a and C_{na} in the states of the world with and without an accident. A contract gives the right to buy a compensation α in case of accident by paying the premium $q\alpha$, where q is the unit price. This implies that $C_a = w - d - q\alpha + \alpha$ while $C_{na} = w - q\alpha$. Hence, we can describe an insurance contract with the vector (α, q). Since there are two types, as usual, we can assume without loss of generality that firms offer at most two different contracts to a group of agents with the same history.

The timing of the game is the following:

- At the beginning of period 1, firms offer insurance contracts for period 1.
- Consumers choose if to buy an insurance contract for period 1 and which one.
- Accidents occur and period 1's contracts are enforced. Every firm can observe which contracts are chosen by each agent and who did have an accident.
- At the beginning of period 2, firms offer insurance contracts for period 2.
- Consumers choose if to buy an insurance contract for period 2 and which one.
- Accidents occur and period 2's contracts are enforced.

Expected utility in one period from the contract (α, q) is:

$$U_i = (1 - \pi_i)\, u\,(w - q\alpha) + \pi_i u\,(w - d - q\alpha + \alpha) = \\ = (1 - \pi_i)\, u\,(C_{na}) + \pi_i u\,(C_a) \tag{1}$$

where $u(\cdot)$ is a standard concave utility function. As well known, indifference curves satisfy the *single-crossing property*:

$$\frac{\partial}{\partial \pi}\left(\frac{dC_a}{dC_{na}}\right) = \frac{\partial}{\partial \pi}\left[-\frac{(1 - \pi_i)\, u'\,(C_{na})}{\pi_i u'\,(C_a)}\right] > 0$$

In the space (α, q) this implies that indifference curves are inverted U functions and at each point they are steeper for the high risk agents.

Let us define:

$$U_i^{SQ} \equiv (1 - \pi_i)\, u\,(w) + \pi_i u\,(w - d) \tag{2}$$

as the *status quo* expected utility, that is the utility without insurance ($\alpha = 0$) for types $i = H, L$.

Under perfect information all agents would obtain full insurance in both periods paying a unit price at which insurance companies break even. In figure 1 this contracts are points H and L in the space (α, q), where indifference curves at the first best levels:

$$U_i^{FB} \equiv u\,(w - d\pi_i) \tag{3}$$

are tangent to the correspondent *zero profits loci*. In particular, these imply:

$$\pi_i\,(q\alpha - \alpha) + (1 - \pi_i)\,q\alpha = 0$$

from which:

$$q = \pi_i$$

for types i. The *full insurance locus* is obviously the vertical line for which:

$$\alpha = d$$

We will look for *perfect bayesian equilibria* of the above game. In a perfect bayesian equilibrium, each one-period contract must expect zero profits exactly as in the standard R-S model: if some contracts were individually earning positive profits on some agents, other firms could offer contracts prefered by those agents and still obtain positive profits[5]. Consequently, in the first period, either the two types choose two different contracts or everybody chooses the same contract. In the first case, types have been revealed and competition automatically delivers the first best contracts for the second period: I will call this a *Revealing Equilibrium*. In the latter case, firms do not know who is who, so the last period is analogous to the R-S model and can only be characterized by separating contracts: I will call this a *Quasi-Pooling Equilibrium* since the first period reveals some information, but only through the realization or not of the accident.

2.1. *The Revealing Equilibrium*

Here the situation is analogous to the static separating equilibrium *à la R-S*. High risk agents will obtain the first best contract (d, π_H), that is point H in Fig. 1, in both periods, while low risk agents will accept a low insurance contract R today, but they will obtain the first best contract (d, π_L) tomorrow, that is point L in Fig. 1. Let us call U_i^R the utility obtained by types i if they choose the first period contract R, while the

[5] This matches empirical evidence in the automobile insurance market: see both Puelz - Snow (1994) and Cohen (2001).

second period contract for the low risk agents is the first best one, with associated utility U_L^{FB}.

The first period contract for low risk agents maximizes their utility under a zero profit constraint and an incentive compatibility condition for which high risk agents do not find advantageous to «imitate» the low risk agents by accepting their contract:

$$(1 + \delta)\, U_H^{FB} \geq U_H^R + \delta U_L^{FB} \tag{4}$$

which, holding as equality, defines:

$$\begin{aligned} U_H^R &= U_H^{FB} - \delta\,(U_L^{FB} - U_H^{FB}) = \\ &= u\,(w - d\pi_H) - \delta\,[u\,(w - d\pi_L) - u\,(w - d\pi_H)] \end{aligned}$$

where I used (3). This utility level defines the utility of high risk agents when buying contract R in Fig. 1. This utility is clearly a decreasing function of the discount factor, say $U_H^R\,(\delta)$[6]. The corresponding contract must be characterized by a price $q = \pi_L$ and a partial coverage $\alpha^R < d$ delivering utility $U_H^R\,(\delta)$. Such a contract (α^R, π_L) will give utility $U_L^R\,(\delta)$ to low risk agents. But these agents will accept it only if their overall utility is greater than what obtained under the *status quo*. In other words, their individual rationality constraint is:

$$(1 + \delta)\, U_L^{SQ} < U_L^R\,(\delta) + \delta U_L^{FB}$$

This condition holds if the discount factor is not too large, and I will assume that this is the case; otherwise a Revealing equilibrium would not exist.

Finally, we need to check that there are no profitable quasi-pooling deviations. This is the case if, and only if, low risk agents do not accept the best between all the quasi-pooling alternatives, which is characterized by their best first period contract under a zero profit constraint for all the population. In particular the zero profit constraint for the all population is:

$$q\,(\lambda)\,(q\alpha - \alpha) + [1 - q\,(\lambda)]\, q\alpha = 0$$

where:

$$q\,(\lambda) = \lambda\pi_H + (1 - \lambda)\,\pi_L$$

[6] Notice that:

$$U_L^R\,(\delta) = (1 - \pi_L)\, u\,(C_{na}^R) + \pi_L u\,(C_\alpha^R)$$

where $C_{na}^R = w - \pi_L\alpha^R$ and $C_{na}^R = w - d - \pi_L\alpha^R + \alpha^R$, hence:

$$\frac{d\alpha^R}{d\delta} = \frac{-\,(U_L^{FB} - U_H^{FB})}{\pi_H\,(1 - \pi_L)\, u'\,(C_a^R) - (1 - \pi_H)\,\pi_L u'\,(C_{na}^R)} < 0$$

is the average probability of having an accident in the all population. Simplifying, the zero profit constraint for the all population can be rewritten as:

$$q = q\,(\lambda)$$

Maximizing U_L with respect to α under this constraint we obtain the first order condition:

$$q\,(\lambda)\,(1-\pi_L)\,u'\,[w - q\,(\lambda)\,\alpha^P] = \pi_L\,[1 - q\,(\lambda)]\,u'\,[w - d - q\,(\lambda)\,\alpha^P + \alpha^P] \tag{5}$$

which defines the contract (α^P, q (λ)), that is point P in Fig. 1. The utility associated with this contract, defined as U_L^P (λ), must be decreasing in the fraction of high risk agents because when ë increases, consumption decreases in both states of the world. The second period contract of any quasi-pooling alternative, as already suggested, is the standard R-S contract for low risk agents (as we will see again in the next section, in the second period the only possible equilibrium is the separating equilibrium of the R-S model), which provides expected utility U_L^R (0)[7].

Hence quasi-pooling deviations are not accepted by low risk agents if and only if:

$$U_L^R\,(\delta) + \delta U_L^{FB} \geq U_L^P\,(\lambda) + \delta U_L^R\,(0) \tag{6}$$

Holding as an equality this condition defines a cut-off value for the fraction of high risk agents as a function of the discount factor, $\hat{\lambda}$ (δ), such that:

$$U_L^P\,(\hat{\lambda}) = U_L^R(\delta) + \delta\,[U_L^{FB} - U_L^R\,(0)] \tag{7}$$

Since U_i^P (λ) is decreasing in λ, we can conclude that a profitable deviation does not exists for any $\lambda > \lambda$ (δ). We can summarize what we found in the following extension of the R-S result:

PROPOSITION 1. *In the two-period Rothschild-Stiglitz model, a Revealing Equilibrium, where low risk agents reveal themselves initially accepting low coverage, exists if and only if the fraction of high risk agents is greater than the cut-off* $\hat{\lambda}$ (δ).

The interpretation of this result is analogous to the standard R-S case. There is a competitive equilibrium where firms can screen high risk and low risk agents and offer them different contracts and this is possible because low risk agents accept partial coverage in exchange for a lower price. In the future, types will be revealed and each

[7] This is because when $\delta = 0$, we are in the R-S world and our Revealing Equilibrium must be characterized by the same contracts of the static R-S case.

agent will obtain its actuarially fair contract with full insurance. Such an equilibrium collapses if there are too many low risk agents because in such a case it could be profitable to provide high coverage at a relatively low price for everybody withouth screening. The introduction of a future market modifies things in a fundamental way: it makes information on types more valuable. Hence low risk agents are ready to accept a very low coverage in the initial period to be able to be recognized as low risk agents in the future. As a consequence, low risk agents must initially accept a very low coverage to reveal themselves. As the static R-S model implies, a positive correlation between risk and coverage should emerge especially for initial contracts.

Notice that the cut-off for the fraction of high risk agents above which the equilibrium exists, depends ambiguously on the discount factor, since an increase in the discount factor reduces the first period utility of low risk agents ($U_L^R(\delta)$), but increases the value of their second period utility (U_L^{FB})[8]. In the simulation below I will show that, under reasonable parametrizations, the first factor tends to prevail and $\hat{\lambda}$ tends to increase with δ: in other words, it becomes more difficult to sustain a revealing equilibrium when agents are more concerned with the future. This makes sence because information becomes more valuable and its revelation harder.

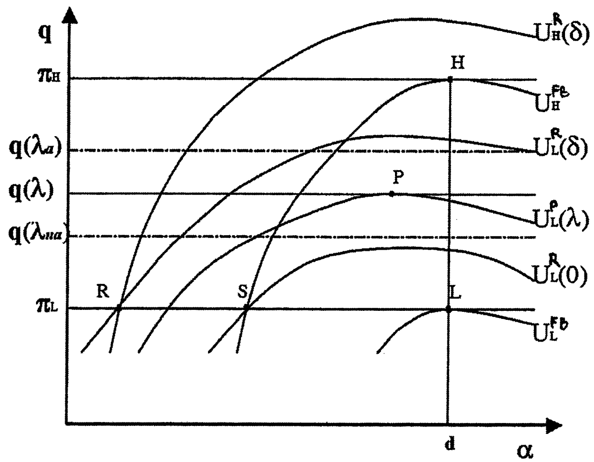

FIG. 1 - Revealing and Quasi-Pooling Equilibria.

[8] In particular the derivative of the *r.h.s.* of (7) with respect to δ is:

$$\frac{dr.h.s.}{d\delta} = -\left[\frac{\pi_L(1-\pi_L)\,[u'(C_\alpha^R) - u'(C_{na}^R)]}{\pi_H(1-\pi_L)\,u'(C_a^R) - (1-\pi_H)\,\pi_L u'(C_{na}^R)}\right](U_L^{FB} - U_H^{FB}) + [U_L^{FB} - U_L^R(0)]$$

where the first ratio is smaller than one. Despite we know that $U_L^R(0) > U_H^R(0) = U_H^{FB}$ we cannot sign the above derivative with certainty.

2.2. *The Quasi-pooling equilibrium*

When the same contract is chosen by all agents in the first period, it must be the most favourite by low risk agents under the break-even constraint for the all population, that is again point *P* in Fig. 1, otherwise a profitable deviation always exists. As already shown, such a contract (α^P, q (λ)) provides a utility level U_i^P (λ), which is decreasing in λ for each type of agent $i=H, L$.[9]

As anticipated, in the second period firms do not know who is who. They know who had an accident in the first period and who did not, and in principle, they may discriminate on this basis, offering different contracts for the two «risk classes». This would require revising the respective probabilities to be high risk agents according to Bayes' law. For instance, this probability for the agents who did not have an accident in the first period becomes:

$$Pr\ [\pi_H\ [No\ Accident\,] = \frac{Pr\ (\pi_H) \cdot Pr\ [No{+}Accident\ \lfloor \pi_H]}{Pr\ (\pi_H) \cdot Pr\ [No\ Accident\ \lfloor\ \pi_H] + Pr\ (\pi_L) \cdot Pr\ [No\ Accident\ \mid \pi_L]} \tag{8}$$

which I am going to define as λ_{na}. Substituting the corresponding probabilities, we have:

$$\lambda_{na} = \frac{\lambda\ (1 - \pi_H)}{[\lambda\ (1 - \pi_H) + (1 - \lambda)\ (1 - \pi_L)]} \tag{9}$$

But for this group – and for the other as well – we know from R-S that only a separating equilibrium can emerge in a single period. Hence, in the second period, contracts *H* and *S* of Fig. 1 are offered and accepted respectively by high and low risk agents.

However, an equilibrium does not exist if there is a pooling deviation. Analogously to R-S, we can exclude this only if λ_{na} is higher then the cut-off $\hat{\lambda}$ (0) such that $U_L^P\ \hat{\lambda} = U_L^R$ (0). This condition:

$$\frac{\lambda\ (1 - \pi_H)}{[\lambda\ (1 - \pi_H) + (1 - \lambda)\ (1 - \pi_L)]} \geq \hat{\lambda}\ (0)$$

[9] Totally differentiating the condition (5) defining the Quasi-Pooling contract, and defining $A\ (C) \equiv -u''\ (C) / u'\ (C)$ as the coefficient of absolute risk aversion, we can clarify the relationship between coverage in the first period and the fraction of high risk agents:

$$\frac{d\alpha^P}{d\lambda} = -\frac{(\pi_H - \pi_L) \left\{ \dfrac{1}{\pi\ (\lambda)} + [1 - \pi\ (\lambda)]\ \alpha^P\ [A\ (C_{na}) - A\ (C_a)] \right\}}{[1 - \pi\ (\lambda)]\ [\pi\ (\lambda)\ A\ (C_{na}) - [1 - \pi(\lambda)]\ A\ (C_a)]}$$

This is always negative if absolute risk aversion is increasing, constant or slightly decreasing.

can be rewritten as:

$$\lambda \geq \frac{\hat{\lambda}(0)(1-\pi_L)}{\hat{\lambda}(0)(1-\pi_L)+[1-\hat{\lambda}(0)](1-\pi_H)} \equiv \lambda* \tag{10}$$

Notice that, when (10) is satisfied, there are no pooling deviations for the group of agents who had the accident in the first period as well[10]. More important is to remark that $\lambda* > \hat{\lambda}(0)$, so that the non-existence problem is made worse in the two-period model.

The last issue we need to analyze concerns profitable revealing deviations from the Quasi-Pooling Equilibrium. To find the condition under which these are impossible, we proceed in three steps. First, let us focus on the set of revealing deviations, that is, the first period contracts which, if accepted by low risk agents only, would generate non-negative profits. Second, let us consider the worst acceptable deviations for the low risk agents, with utility U_L^D. These leave low risk agents overall indifferent with the Quasi-Pooling Equilibrium and hence they are implicitly defined by:

$$U_L^P(\lambda) + \delta U_L^R(0) = U_L^D + \delta D_L^{FB} \tag{11}$$

This condition defines a set of contracts representing the worst acceptable deviation and implicitly defines the associated utility for low risk agents $U_L^D = U_L^D(\lambda, \delta)$ with $\frac{\partial U_L^D}{\partial \delta} \leq 0$ and $\frac{\partial U_L^D}{\partial \lambda} \leq 0$. Notice also that $\frac{\partial^2 U_L^D(\lambda, \delta)}{\partial \delta^2} = 0$.

Finally, between the deviations above indicated, let us consider the worst one for the high risk agents, which, as can be easily verified from Fig. 3, implies a zero profit contract for low risk agents. This delivers the worst deviation contract (α^D, π_L) which is acceptable by all agents. The associated utility $U_H^D(\lambda, \delta)$ must be also characterized by $\frac{\partial U_H^D}{\partial \delta} \leq 0$ and $\frac{\partial U_H^D}{\partial \lambda} \leq 0$[11]. If and only if high risk agents are going to accept this

[10] Indeed, using Bayes'law, their probability of being high risk types is:

$$Pr[\pi_H[Accident] = \frac{Pr(\pi_H) \cdot Pr[Accident \llcorner \pi_H]}{Pr(\pi_H) \cdot Pr[Accident \llcorner \pi_H] + Pr(\pi_L) \cdot Pr[Accident \llcorner \pi_L]} \equiv \lambda_a$$

that is:

$$\lambda_a = \frac{\lambda \pi_H}{[\lambda \pi_H + (1-\lambda)\pi_L]}$$

but it is easy to verify that:

$$\lambda_a > \lambda_{na} > \hat{\lambda}(0)$$

[11] Notice that:

$$U_L^D(\delta) = (1-\pi_L)\, u(C_{na}^D) + \pi_L\, u(C_a^D)$$

deviation, it means that they are going to accept any better one, and that none of them can be profitable! Hence, the pooling contract in the first period can be on the equilibrium path only if:

$$U_H^P(\lambda) + \delta U_H^{FB} \leq U_H^D(\lambda, \delta) + \delta U_P^{FB}$$

This condition can be rewritten as a constraint on the discount factor:

$$\delta \geq \frac{[U_H^P(\lambda) - U_H^D(\lambda, \delta)]}{[U_L^{FB} - U_H^{FB}]} \tag{12}$$

requiring that the discount factor is high enough If high risk agents are patient enough to sacrifice their initial utility so as to obtain cheaper insurance in the future, screening deviations collapse and the pooling solution is viable. Let us define the cut-off $\hat{\delta}(\lambda)$, as a function of the fraction of high risk agents, through the implicit condition:

$$U_H^P(\lambda) + \hat{\delta} U_H^{FB} = U_H^D(\lambda, \hat{\delta}) + \hat{\delta} U_L^{FB}$$

We can now derive the main result of the paper:

PROPOSITION 2. *In the two period Rothschild-Stiglitz model, a Quasi-Pooling Equilibrium, where types are not initially revealed, exists only if the fraction of high risk agents is greater than the cut-off* λ^* *and the discount factor is greater than a cut-off* $\hat{\delta}(\lambda)$.

Proof. First of all, note that a Quasi-Pooling Equilibrium is possible only if $\lambda \geq \lambda^*$ for reasons discussed above. A further restriction on the discount factor and the fraction of high risk agents comes from (12) Let us study both its sides in function of the discount factor. Its *l.h.s.* is linear in δ with unitary slope. The *r.h.s.* is strictly increasing in δ. We know from R-S that when $\delta = 0$ pooling is not an equilibrium, hence the *r.h.s* must be positve for $\delta = 0$: $U_H^P(\lambda) > U_H^D(\lambda, \delta)$. But we also know from (11) that $\frac{\partial^2 U_L^D(\lambda, \delta)}{\partial \delta^2}$ and so even $U_H^D(\lambda, \delta)$ must be linearly decreasing in δ. Hence, the *r.h.s.* of (12) must be linearly increasing in δ. If and only if the slope is lower than unity there is a unique value of the discount factor above (below) which there can (not) be Quasi-Pooling

where $C_{na}^D = w - \pi_L \alpha^D$ and $C_{na}^D = w - d - \pi_L \alpha^D + \alpha^D$, hence:

$$\frac{d\alpha^D}{d\delta} = \frac{-[U_L^{FB} - U_L^R(0)]}{\pi_L(1-\pi_L)[u'(C_a^D) - u'(C_{na}^D)]} < 0$$

Equilibria. In conclusion a Quasi-Pooling Equilibrium exist if $\lambda > \lambda*$ and $\delta > \delta(\lambda)$. *Q.E.D*[12].

The Quasi-Pooling Equilibrium is characterized by zero correlation between risk and coverage in the initial period and positive correlation in the next period. More in general, as long as different types can be pooled in the same contract, there should not be any correlation between coverage and risk. Nevertheless asymmetric infomation matters even in such an equilibrium! What we need for the existence of a Quasi-Pooling Equilibrium is an high enough fraction of high risk agents or an high enough discount factor: what is impossible in the static R-S model, is possible here only if there are few low risk agents and agents are patient enough. To know how likely this can be, we need to simulate the model, which will be my next step.

2.3. *Numerical simulation*

The fact that a quasi-pooling equilibrium could exist is an interesting fact, but it is more important to verify if it could exist under reasonable conditions. For this reason I undertake a simulation of the model under the realistic assumption that $\delta \in [0, 1]$ and that utility is characterized by constant relative risk aversion[13]. Despite this restrictive hypothesis, Quasi-Pooling Equilibria easily arise. In Fig. 2 I show a typical case for logarithmic utility. Above the solid line is the region in which a Revealing equilibrium emerges, while above the dotted line a Quasi-Pooling Equilibrium emerges. Notice that the standard R-S case can be found for $\delta = 0$: in this case, Revealing Equilibria are possible only for λ big enough, while pooling is always impossible. Instead, with positive discount factors Revealing Equilibria require higher levels of λ, but also Quasi-Pooling Equilibria emerge for high values of λ. The space (δ, λ) is typically divided into four regions corresponding to Revealing equilibrium (high λ, low δ), Quasi-Pooling Equilibrium (high λ, high δ), no equilibrium (low λ) and multiple equilibria (high λ, intermediate δ). The Quasi-Pooling region expands when we increase δ.

[12] Notice that analytically we cannot guarantee that $\hat{\delta}(\lambda)$ is finite. Hence what Proposition 2 proves is just what are the conditions allowing for a Quasi-Pooling Equilibrium. What we need is that the *r.h.s.* of (12) has a less than unitary slope in the discount factor. This slope is:

$$\frac{dr.h.s.}{d\delta} = \left[\frac{U_L^{FB} - U_L^R(0)}{U_L^{FB} - U_H^{FB}}\right]\left[\frac{\pi_H(1-\pi_L)\,u'(C_a^D) - (1-\pi_H)\,\pi_L\,u'(C_{na}^D)}{\pi_L(1-\pi_L)\,[u'(C_a^D) - u'(C_{na}^D)]}\right]$$

where the first term is smaller than one and the second is greater than one but decreasing in δ. The following simulation proves that there are cases where $\hat{\delta}(\lambda)$ is finite.

[13] I run the simulation using *Mathcad 2000 Professional*. The program is available from the author.

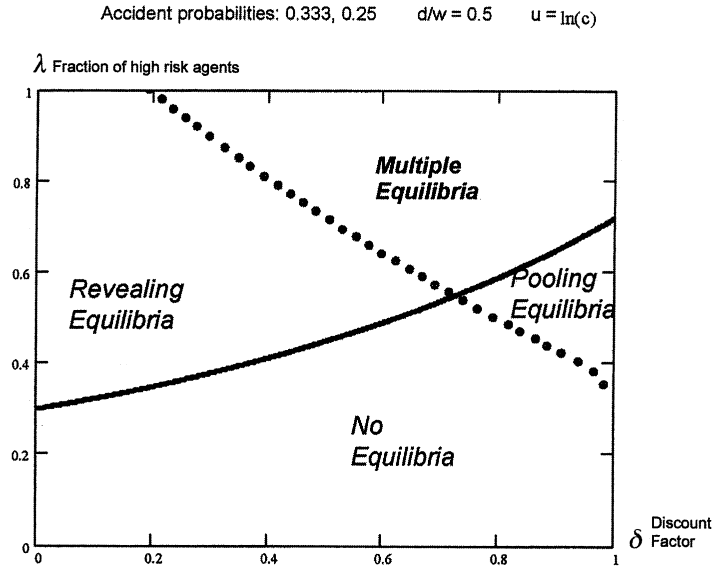

FIG. 2 - Above the solid locus is the region of Revealing Equilibria and above the dotted locus is the region of Quasi-Pooling Equilibria.

Further simulations show the effect of changes in risk aversion. In particular, a Quasi-Pooling Equilibrium is more likely if risk aversion is not too high. The intuition is straightforward. For a given unit price, expected utility changes with the amount of insurance according to the degree of risk aversion: the lower is risk aversion, the smaller is the sacrifice from choosing any low-insurance contract in the first period in order to obtain cheap full-insurance in the second.

This means that deviations from any equilibrium are easily accepted by high risk agents, which is exactly what we need for a Revealing Equilibrium to fail and a Quasi-Pooling Equilibrium to exist. Moreover, notice that for the same reason, the non-existence problems are relaxed when risk aversion is low: pooling deviations are hardly accepted by low risk agents.

It is important to remark the possibility of multiple equilibria, since they are a regular outcome in signalling models but not in this class of screening models. Moreover, when $U_H^P(\lambda) \leq U_H^{FB}$, that is for λ high enough, multiple equilibria arise for intermediate values of the discount factor, but the Revealing one is strictly prefered by everybody. In other words genuine coordination failures emerge. In any case, both equilibria are constrained Pareto-inefficient since cross-subsidization could make everybody better off in two possible ways: intraperiod cross subsidization in the first period of the Revealing Equilibrium and in the second of the Quasi-Pooling Equilibrium, or interperiod cross subsidization.

2.4. *Extensions*

The natural question after the previous results is: how do they generalize? A full discussion of generalization is beyond the scope of this paper, hence I will sketch some avenues for further research suggesting that the possibility of quasi-pooling equilibria may be enhanced in more general models.

A generalization to many periods is quite natural even if analytically involved and subject to non trivial non-existence problems. A Quasi-Pooling Equilibrium would be something very similar to the *bonus-malus* system in the automobile insurance market. In the first period every agent accepts the same contract. In the second period two different contracts are offered to agents who did and did not have the accident. These contracts are the preferred contracts by low risk agents for groups whose expected probabilities of accident are $q\ (\lambda_{na})$ and $q\ (\lambda_a)$. Analogously, in the third period four different groups will receive differentiated contracts and so on[14]. All these contracts are uniquely determined by maximizing low risk agents' utility under a zero profit constraint estimated using the ratio # accident / # periods and Bayes' law: this is a good description of what happens in the *bonus-malus* system. Moreover, these contracts lie on a locus which is generally downward sloping[15], consistently with the non positive correlation between risk and coverage, and they imply rationing only for high risk agents: the opposite of the static R-S model.

The possibility of a quasi-pooling equilibrium emphasized in this paper becomes more than a possibility in the more realistic case of a continuous distribution of types (see the *Appendix* for a review of the R-S model with one period and many types). We know from Riley (1979) that when $\delta = 0$ a separating equilibrium – the only possible equilibrium – exists under restrictive conditions on the distribution of types. Whenever $\delta > 0$, a Revealing Equilibrium is automatically unfeasible because separation in the first period between contiguous types requires a discrete gap in utilities between equilibrium choice and out of equilibrium choice, but this cannot be achieved for an infinity of types. Hence, only complicated versions of our quasi-pooling equilibrium are viable: these equilibria would partition agents in groups of contiguous types[16], offering a different contract to each of group, and implementing experience rating within this group in the following periods. The bottom line is that also in this case, revelation of information would be gradual, as empirical evidence suggests.

[14] Notice that the expirience-rating process has to end (with the offer of revealing contracts) after visiting certain risk-classes - indeed, the number of risk classes of existing *bonus-malus* systems is generally low. This may happen for different reasons. Low risk classes may face the inexistence of semi-pooling continuation equilibria so as to convert to revealing continuation equilibria (if they exists, otherwise equilibria do not exist). High risk classes may just switch to revealing continuation equilibria in presence of multiple equilibria or because, for very high concentrations of high risk agents, there are not pooling contracts acceptable by low risk agents.

[15] This come from the fact that under reasonable conditions we noticed that $d\alpha^P/d\lambda < 0$.

[16] See Laffont - Tirole (1987, 1988, 1993) for a related theory in a different context.

III - CONCLUSION

Does asymmetric information matter in insurance markets? Recent evidence on the automobile insurance market suggests not, rejecting the separating equilibrium of the Rothschild-Stiglitz model. However, I have shown that a multi-period version of that model can sustain a quasi-pooling equilibrium with experience rating which is consistent with the evidence and it mimics the *bonus-malus* policies of the automobile insurance markets. This equilibrium exists for an high enough discount factor and under moderate degrees of risk aversion and simulations show that it is compatible with realistic assumptions on both factors. The dynamic extension of the traditional separating equilibrium appears for low values of the discount factor and high degrees of risk aversion, while multiple equilibria (quasi-pooling and revealing) are possible in intermediate cases.

Hence, insurance markets like the one described in this paper are drastically affected by the asymmetry of information between firms and consumers in a way which is consistent with the available empirical evidence on the automobile insurance market, as recently emphasized by Cohen (2001).

In conclusion, I want to stress the generality of the theoretical results of this paper: they extend to any risk sharing competitive market characterized by short term contracts and affected by adverse selection, notably the labor market and the credit market. One could also discuss the consequences of allowing agents to save and borrow at an exogenous interest rate or to store income for the second period, which is particularly relevant for a credit market description. Applications of our quasi-pooling equilibrium to labor and credit markets could be fruitfully investigated in future research.

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Appendix

The Rothschild-Stiglitz model and its implications

The original model by R-S studied a static (one-period) version of the insurance model of this paper. In this *Appendix* I review that model. The original analysis was worked out in the case of only two types of agents, exactly as in the main part of this paper. However, the analysis can be easily extended to more than two types and I will consider a model with many types of agents characterized by different accident probabilities. This could be helpful not only to survey the standard analysis, but also to shed new light on the theoretical and empirical debate on the relevance of asymmetric information in insurance market, which provides the title of this paper.

In a recent contribution, Cawley and Philipson (1999, CP hence on) have tested the implications of the R-S model of competitive insurance markets in presence of asymmetric information. They interpret their evidence on life insurance markets as inconsistent with the relevance of adverse selection. This *Appendix* will also show that their claim is erroneous, because it is based on the test of a theoretical implication of the R-S model which is not true[17].

CP claim that in the insurance market with adverse selection studied by R-S, the equilibrium price function should be convex. In their words, «Since the high-risk consumers buy larger quantities, an insurer can break even in a competitive market only if marginal prices rise with quantity - the opposite of a bulk discount. Consequently the total price is convex in the quantity of coverage. In a technical jargon, such nonlinear prices are crucial for the risk-sorting across contracts to be incentive-compatible [...] If bulk discounts exists, the separating equilibrium cannot occur; the pricing schedule is not compatible with the incentives of risks to sort themselves out across contracts». This view has acquired the dignity of a basic empirical implication of the R-S model at least after the subsequent works by Chiappori and Salanié (2000), Chiappori (2001) and Finkelstein and Poterba (2001). CP were the first to test for this convexity of the total price function and they rejected it, with the conclusion that asymmetric information does not matter, at least in the life insurance market. Unfortunately this is an invalid test, since the convexity of the total price function is a feature of equilibrium contracts that has not been proven anywhere by R-S and that indeed is not true.

As already noticed, the original R-S model considered just two types of agents obtaining two equilibrium contracts, that is two points in the space of quantity and price of insurance (points H for high risk agents and S for low risk agents in Fig. 1). In this case we cannot talk about convexity or concavity of the price function. Obviously, the example by R-S was meant to simplify a more general situation with many or a continuum of types, and any claim on the nonlinearity of the price function must be based on such a case. I will show that the equilibrium price function is never a fully convex function of the quantity of insurance and, under some circumstances, it is a function everywhere concave in the quantity of insurance.

[17] This part is based on Etro (2001).

Let us consider many identical agents with income w who may have a loss d with probability π_t for type $t = 1, 2, ..., n$ where $\pi_1 > \pi_2 > \ldots > \pi_{n-1} > \pi_n$. The fraction of type t's in the population is f_t with $\sum_{t=1}^{n} f_t = 1$. Every agent of type t has utility:

$$U_t = \pi_t\, u\,(w - d + \alpha - q\alpha) + (1 - \pi_t)\, u\,(w - q\alpha)$$

where α is the amount of insurance and q is the unitary price of insurance.

Quantity-price competition in the insurance market is the same as in R-S and it implies that, independently from the distribution of types[18], firms offer n contracts (α_t, q_t) such that:

$$U_1 = u\,(w - d\pi_1)$$
$$U_2 = \pi_2\, u\,(w - d + \alpha_2 - \pi_2\, \alpha_2) + (1 - \pi_2)\, u\,(w - \pi_2\, \alpha_2)$$

where α_2 satisfies the incentive compatibility condition:

$$U_1 = \pi_1\, u\,(w - d + \alpha_2 - \pi_2\, \alpha_2) + (1 - \pi_1)\, u\,(w - \pi_2\, \alpha_2)$$

and so on. As well known, the highest risk types obtain full insurance, while the contracts for the types with immediately lower risk must be incentive compatible. All the other contracts must be incentive compatible in analogous fashion.

More in general, the equilibrium allocation can be solved recursively. For a given α_{t-1}, each type t pays the unit price $q_t = \pi_t$, since this is required from the zero profit condition on type t's, and buys the amount α_t of insurance such that:

$$U_{t-1} = \pi_{t-1}\, u\,(w - d + \alpha_{t-1} - \pi_{t-1}\, \alpha_{t-1}) + (1 - \pi_{t-1})\, u\,(w - \pi_{t-1}\, \alpha_{t-1}) =$$
$$= \pi_{t-1}\, u\,(w - d + \alpha_t - \pi_t\, \alpha_t) + (1 - \pi_{t-1})\, u\,(w - \pi_t\, \alpha_t)$$

while the initial condition $\alpha_1 = d$ allows to solve the all system of finite difference equations. What we are interested in is the total price for types t, $P_t = q_t \alpha_t$. Notice that as $n \to \infty$, for a given interval $[\pi_1, \pi_n]$, the equilibrium sequence of contracts approximates the equilibrium with a continuum of types, which is the solution to a differential equation, and we obtain a price function $P\,(\alpha)$ which is increasing and generally non linear. The erroneous claim of CP is that this function should be convex.

In Fig. 3 I run a number of simulations for the recursive system of equilibrium contracts derived above. The results are always qualitatively the same and, together with the *MathCad Professional* program, they are available from the author. Here I report one simulation based on *CRRA* utility – which has the advantage of making the results independent from w for a given ratio d/w – with parameter of relative risk aversion R. In the example below, I assume $\pi_1 = 0.1$ and $\pi_n = 0$ and $d/w = 0.5$. The four cases correspond to $R = 0.5,1,3,5$. As evident from the simulation, the total price function is typically a S-shaped function which is concave for the highest risk types and convex for low risk types. The critical part, however, is the concave one.

[18] Notice that, as emphasized by Riley (1979, 1985), the conditions under which an equilibrium exists depend on the distribution of types and are quite restrictive.

This is for two reasons. The first is that most of the insurance is concentrated on high risk types. The second is that if the lowest risk type was not too different from the highest risk type, the total price function would be entirely concave.

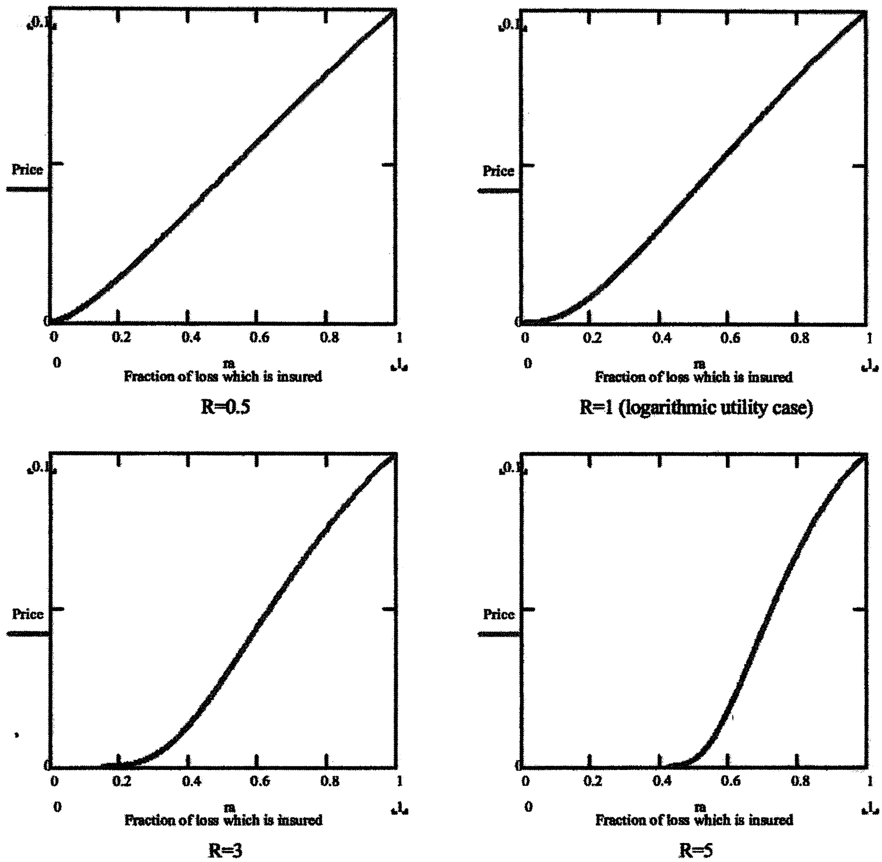

FIG. 3 - Equilibrium price in the Rothschild-Stiglitz model.

In conclusion, CP test a wrong implication of the R-S model and bulk discounts are perfectly consistent with adverse selection in the insurance market: indeed they are a typical implication of the R-S model! As emphasized in the main part of this paper, theoretical problems undermine also the empirical analysis of Chiappori and Salanié (2000) which denies the relevance of asymmetric information in the automobile insurance market. In light of these results, it seems that the recent empirical critique to the relevance of adverse selection in insurance markets has been in part out of place, and it should be rethought.

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