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Advantageous selection in insurance markets

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This article reverses the standard conclusion that asymmetric information plus competition results in insufficient insurance provision. Risk-tolerant individuals take few precautions and are disinclined to insure, but they are drawn into a pooling equilibrium by the low premiums created by the presence of safer, more risk-averse types. Taxing insurance drives out the reckless clients, allowing a strict Pareto gain. This result depends on administrative costs in processing claims and issuing policies, as does the novel finding of a pure-strategy, partial-pooling, subgame-perfect Nash equilibrium in the insurance market.

1. Introduction

■ Such empirical evidence as we have appears to conflict with the major implications of the standard economic model of insurance. For example, 4.8% of U.K. credit cards are reported lost or stolen each year, whereas for insured cards the corresponding figure is only 2.7%.[1] In a similar vein, Cawley and Philipson (1999) find that the mortality rate of U.S. males purchasing life insurance is below that of the uninsured, even when controlling for many factors, such as income, that are correlated with life expectancy. Chiappori and Salanie (2000) establish a methodology for such studies and report that, controlling for observable characteristics known to insurers, the accident rate is lower for young French drivers choosing comprehensive insurance than for those opting for the legal minimum coverage, although the difference is not statistically significant.

These findings contradict the predictions of models of insurance markets under asymmetric information, as initiated and exemplified by Rothschild and Stiglitz (1976). Analysis in this tradition is built around the idea that the incentive to purchase insurance is greatest for those having private information that they are relatively likely to suffer a loss. Augmenting this adverse-selection effect is moral hazard, the tendency of insurance to dull the incentive to take precautions, thereby intensifying the loss propensity of the insured relative to that of the uninsured.

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[1] The first figure is supplied by APACS, the credit-card issuers representative body, and the second figure comes from an insurance company that does not wish to disclose its identity.

This article adopts a different perspective. It drops the assumption that people have identical risk preferences but differ in the level of exogenously determined risk they are exposed to. Instead, our starting point is that cautious people are not only more inclined to buy insurance but also put more effort into limiting risk exposure, compared to individuals of a more reckless disposition. This formulation potentially explains the evidence that the insured are less accident prone and, in so doing, reverses the standard welfare conclusion that asymmetric information results in insufficient insurance provision. The usual underinsurance result arises because companies anticipate a self-selection bias and so set high premiums, making it unattractive for good risks to take out policies, even though they would be more than willing to pay the actuarially fair price for their characteristics. In our model, the presence of cautious types lowers premiums and thus draws into the market relatively risk-tolerant, reckless types. Taxing insurance purchase drives out the bold types, eliminating a negative externality and permitting a strict Pareto gain. This result, and indeed the existence of equilibrium itself, depends on the presence of administrative costs in processing claims. These are not only realistic, they also help provide a way round the celebrated result of Rothschild and Stiglitz (1976) concerning the nonexistence of pooling equilibria.

Hidden heterogeneity in risk preferences has been looked at in an insurance market with a monopoly provider by Landsberger and Meilijson (1994), but their setup does not yield major changes to the conclusions of the standard model. It is the combination of hidden preventive activity and hidden types that yields the most interesting results, a case discussed to some extent by Pauly (1974). More recent analyses are Stewart (1994) and Chassagnon and Chiappori (1997), both of which explicitly examine equilibria in which agents differ with regard to the cost and effectiveness of preventive effort. Using a version of the Rothschild and Stiglitz model with this feature, Chassagnon and Chiappori show the existence of a positive-profit separating equilibrium, but in their setup, subgame-perfect Nash pooling equilibria do not exist.

Wambach (1997) is rather closer to our model. Exogenous, unobservable wealth differences coexist with unobservable exogenous loss probabilities. Partial-pooling equilibria are shown to arise, possibly involving positive profits. This is related to our existence result, though we endogenize the correlation between insurance purchase and precautionary behavior and introduce administrative costs. Jullien, Salanie, and Salanie (2000) is similar to our work in that heterogeneous risk preferences drive both precautionary action and insurance choices, although the specification of preferences is different. The major distinction, though, is that in their model there is a single principal, in effect monopoly provision, whereas we adopt a competitive setting. The positive results are in the same spirit as ours, but, in common with Wambach, there is no welfare analysis. Monopoly involves a quite different set of externalities to competition, and the conventional result of underprovision is to be expected.

Both our existence and policy results depend on positive administrative costs, which are indeed significant in practice. Between 1985 and 1995 for U.K. insurers, expenses as a percentage of premium income averaged 25% for motor insurance and 37% for property damage insurance.[2,3]

The other key ingredient of our analysis is that precautionary effort is positively correlated with insurance purchase. For example, controlling for observable characteristics, our approach implies that buyers of accidental death insurance are cautious types who will experience lower-than-average accident rates. Evidence along these lines has already been reported.

To see more explicitly how these features fit together, suppose there are equal numbers of two types of potential client, the timid or risk averse, T, and the bold or reckless, B. The value each puts on a particular insurance policy and the cost of providing it are shown in Table 1. This example has the property that the bold value insurance less despite having higher expected claims.

Assume that the insurance industry is competitive and that an individual's type is private information. If the contract in question is the only one offered, there is evidently a pooling

[2] Data from the Association of British Insurers.

[3] Cawley and Philipson (1999) report that the premium per dollar of coverage falls with the level of coverage. They attribute this bulk discounting to fixed costs of underwriting, but our model predicts that it is also an implication of the highly insured being the good risks.

TABLE 1

	Client Type	
	T	B
Client's valuation of policy	85	80
Expected claim	40	60
Expected processing cost	20	30

equilibrium in which both types are insured and pay a premium of \$75. This is despite the fact that type Bs value the policy less than the cost of providing it to them so that it would be socially efficient were they not to be supplied. Indeed, suppose that every policy carried a tax of \$22, with the proceeds distributed as a lump-sum subsidy to the whole population. There is then a separating equilibrium, with premium \$82, in which only Ts are insured, but both groups are strictly better off. The Bs lose their expected surplus of \$5 from the policy but gain \$11 from the poll subsidy, whereas the T's tax-inclusive premium rises by \$7 but they gain \$11 from the poll subsidy. Everyone gains from intervention.[4]

In this example there is, by assumption, only one policy, and its payout is taken as given, so only the premium is to be determined. Whether equilibrium policies really exist and what form they take is a notoriously delicate matter. The remainder of the article formally demonstrates the existence of pooling, partial-pooling, and separating equilibria exhibiting overinsurance even when contractual form is endogenous. To make the case as clearly as possible, we adopt the simplest assumptions capable of yielding the novel results, but it should be clear that this stripped-down specification is not necessary to obtain our conclusions.

2. The model

■ We offer two justifications for the positive correlation between insurance purchase and precautionary activity. The first follows from heterogeneous wealth and lays the foundation for the particular form of heterogeneous tastes that constitutes our second justification.

Suppose, first, that everyone has the same opportunity to lower the probability of a given financial loss through undertaking preventative effort. In the two-state case, the expected utility of an insured individual i is

$$EU_i\,(F_i, y_i, \lambda_i, W_i) = p\,(F_i)\,U\,(W_i - y) + (1 - p\,(F_i))\,U\,(W_i - D + \lambda y) - F_i, \tag{1}$$

where W_i is the person's wealth, D is the gross loss, y is the insurance premium, and λy, $\lambda > 0$, is the net of premium payout in the event of loss. F_i is a binary-choice variable that affects the probability of loss in the same way for all individuals. If $F_i = 0$, the probability of avoiding the loss $p(F_i)$ is p_0, but if $F_i = \overline{F}$, the probability rises to p_F. The wealth-dependent part of the utility function exhibits decreasing absolute risk aversion. This standard assumption implies that the marginal rate of substitution between y and λy falls with wealth. Given the magnitude and probability of loss, lower insurance coverage is therefore chosen by wealthier individuals.

The increase in expected utility from taking precautions is

$$\Delta_i = (p_F - p_0)\,(U\,(W_i - y) - U\,(W_i - D + \lambda y)) - \overline{F}. \tag{2}$$

It follows from decreasing absolute risk aversion that if insurance coverage is partial, $(D - \lambda y > y)$, then $\partial \Delta_i / \partial W_i < 0$. According to this formulation, there may be a wealth threshold above which

[4] A monopolist would charge \$85, which in this example maximizes aggregate surplus.

precautions are not taken. Moreover, if administrative costs or other reasons lead to high loading factors, wealthy individuals may prefer to be uninsured.

Now consider a reinterpretation involving differences in preferences. Intuitively, more timid types may lower their risk exposure through increased insurance purchase *and* greater precautionary effort. However, the concept of a pure change in risk aversion is ambiguous; changing the curvature of the utility function alters its height almost everywhere, and the issue is, where should the pivot occur? In general, results are ambiguous, but suppose that the utility function of individual i is $U_i = U(\alpha_i + W) - F_i$, where α_i is an individual-specific parameter making taste differences formally equivalent to wealth differences. Just as a rich person is less likely than a poor person to take unfair insurance against the loss of \$100 and to expend effort to reduce the chance of its loss, this formulation embodies the view that "bold" people behave as if they were much wealthier than they really are. They buy less insurance and take fewer precautions than those with a more "timid" disposition.[5] In what follows we analyze market equilibrium in the heterogeneous taste formulation. Similar results apply for the heterogeneous wealth case.

Assume two types of individual, T and B, both equally wealthy. Bs have a high α and so exhibit "bold" behavior, while Ts are more "timid," reflecting a low α. For simplicity, but without affecting the qualitative results, we now suppose the special case that at sufficiently high $\alpha + W$, the utility function becomes linear and Bs are in this zone of risk-neutrality with respect to income. In the relevant range, the utility functions are

$$EU_i(F_i, y_i, \lambda_i, W) = p(F_i)\,U_i(W - y) + (1 - p(F_i))\,U_i(W - D + \lambda y) - F_i, \qquad i = T, B, \tag{3}$$

where U_B is linear and U_T is strictly concave and $W - y \geq W - D + \lambda y$ are the wealth levels in the good and bad states.[6] Given the formulation in (3), the gain in expected utility from taking precautions is

$$\Delta_i = (p_F - p_0)\,[U_i(W - y) - U_i(W - D + \lambda y)] - \overline{F}, \qquad \text{with } \Delta_T > \Delta_B. \tag{4}$$

There are at least two insurance companies and they incur a strictly positive processing cost, C, per claim handled.[7] Insurers cannot observe the characteristics or verify the actions of individual applicants, but they do know the distribution of characteristics among the population of applicants. The expected profit, π, of an insurance company selling a contract on which the probability of a claim is $(1 - p(F_i))$ is given by

$$\pi = p(F_i)\,y - (1 - p(F_i))(\lambda y + C). \tag{5}$$

□ **Equilibrium.** The structure of the game is as follows:

Stage 1. Insurance companies make irrevocable offers of contracts that specify premium y and payout λy in the event of loss.

Stage 2. Clients apply for at most one contract from one insurance company. If two insurance companies offer the same contract, clients toss a fair coin to decide between them. In the light of the contract chosen, the client decides whether to take unobservable precautions.

In what follows we only consider pure-strategy, subgame-perfect Nash equilibria. Depending on parameter values, separating, full-pooling, and partial-pooling equilibria are possible. We begin by outlining the requirements for the various kinds of equilibria.

[5] Jullien, Salanie, and Salanie (1999, 2000) also examine the relation between risk preference and choice of precautions, but they assume safety enhancement is a marketed input. This too leads to ambiguous results, though our specialization that the taste-for-risk parameter is additive in wealth, plus decreasing absolute risk aversion, always yields the intuitive relationship.

[6] In principle, the magnitude of loss is endogenous. For example, the cost of accidental damage depends on the type of car owned. This complicates the modelling but does not invalidate our insights.

[7] Allowing C to be endogenous, perhaps due to monitoring expenditures, or introducing fixed costs of issuing policies does not fundamentally change the results.

Separating equilibrium. A separating equilibrium involves the Ts and Bs ending up with distinct allocations, z_T and z_B respectively. Such an equilibrium must satisfy the conditions below.

Incentive compatibility:

$$EU_T\left(z_T\right) \geq EU_T\left(z_B\right),$$
$$EU_B\left(z_B\right) \geq EU_B\left(z_T\right). \tag{6a}$$

Effort incentives:

$$F_i = \begin{cases} \overline{F} & \text{if } \Delta_i \geq 0, \\ 0 & \text{if } \Delta_i < 0, \end{cases} \tag{6b}$$

with Δ_i defined in (4).

Participation: For each type $i = B, T$, if they buy insurance, the contract they subscribe to is at least as good as the null contract, z_0,

$$EU_i\left(z_i\right) \geq EU_i\left(z_0\right). \tag{6c}$$

Profit maximization: Given the contracts offered by the other companies, no company can increase its expected profit by varying the terms of the contracts it offers, or by not offering a contract at all.

Pooling equilibrium. In a full-pooling equilibrium, only the contract z_p is offered and everybody buys it. In a partial-pooling equilibrium, z_p attracts at least some of each type of agent but not everyone in the population buys it. Of those applying for z_p, a proportion ρ are of type T. In both cases, the equilibrium satisfies the conditions below.

Effort incentives:

$$F_i = \begin{cases} \overline{F} & \text{if } \Delta_i \geq 0, \\ 0 & \text{if } \Delta_i < 0. \end{cases} \tag{7a}$$

Participation: For both types, z_p is at least as good as the null contract, z_0,

$$U_i\left(z_p\right) \geq U_i\left(z_0\right), \qquad i = B, T. \tag{7b}$$

In the partial-pooling case, (7b) must hold with equality for at least one group.

Profit maximization: Given that z_p is offered by other companies, no company can increase its expected profit by introducing a different contract or by not offering a contract at all.

□ **Anatomy of equilibria.** It is easiest to proceed diagrammatically. In all the figures, the individuals' wealth endowment, $(W, W - D)$, denoted by $(\overline{H}, \overline{L})$, is labelled E. The upward-sloping locus PP' shows the values of (H, L) yielding $\Delta_T = 0$ and so partitions the space into the lower region where Ts take precautions, and the upper region where they do not. More explicitly, the slope and curvature of PP' is derived from (4) set equal to zero. Since $U_T''(\cdot) < 0$ and $H > L$, it follows that $0 < dL/dH = U_T'(H)/U_T'(L) < 1$. Decreasing absolute risk aversion implies that $d^2L/dH^2 > 0$, so PP' is convex. As for the Bs, we normalize so that their utility of income equals income and assume that at the endowment point, precautions increase expected wealth and hence utility by less than $\overline{F}$. Hence, Bs never take precautions.

Indifference curves are drawn in income space assuming the optimal level of precautions is chosen. It follows that the indifference curves of the Ts, labelled I_T, are kinked where they cross PP'. Above PP' the loss probability is raised, so the indifference curves flatten. EE' is an indifference curve of a B, which is linear since the Bs are risk neutral and $\overline{F}$ is sufficiently high that in the relevant range they never take precautions.

The location of the insurers' zero-profit offer curves depends on the level of administrative costs, C. When all applicants take precautions, the zero-profit offer curve is JJ', and JM' is the full-pooling offer curve given that the Ts take precautions and the Bs do not. Finally, JN' is the offer curve when no applicant takes precautions. The reason that J lies below E is the need to cover processing costs.

In identifying equilibria, it is evident that when the administrative cost is sufficiently high, insurance is not viable and all agents remain at their endowment point. We show that at lower levels of C, a separating equilibrium exists. As C falls further, partial pooling emerges as an equilibrium.

The propositions that follow display how the nature of equilibrium depends on C. To conserve space and a sense of proportion, not every case is dealt with. In all that follows we assume that even though the Ts take steps to limit their risk exposure, at E their indifference curve is flatter than that of a B not taking precautions:

Assumption 1. $[U_T'(\overline{H})/U_T'(\overline{L})][p_F/(1-p_F)] < [p_0/(1-p_0)]$.

Assumption 1 is required for a partial-pooling equilibrium.

The features of the equilibria in our model also depend upon the location of the tangency between EE' and the indifference curve of a T taking precautions. Note that, assuming an Iñada condition, a tangency must exist. On the 45° line both types of client are locally risk neutral, so if precautions are taken, the indifference curve of a T is steeper than EE', reflecting the higher loss probability of a B. As L approaches zero, T's indifference curve tends to flatness as the marginal utility of income in that state tends to infinity. Whether the tangency occurs between PP' and E depends on the magnitude of $\overline{F}$ and $(\overline{H}, \overline{L})$. Here we only consider in detail cases where the tangency of EE' and B's indifference curve (denoted X) lies to the right of PP'. The results when the tangency lies to the left of PP' are briefly summarized later.[8]

We start with the configuration yielding a partial-pooling equilibrium in which those who take precautions subsidize the entry of those who do not.[9] The number of Ts and Bs buying insurance policies is thus determined endogenously and depends upon the cross-subsidy implied by the insurance contract relative to the expected administrative cost of insurance.

As the model is now specified, there is potentially a continuum of positive-profit partial-pooling equilibria (see also Wambach (1997)). This is an artifact of the discreteness of the model and occurs if there are pooling offers at which the Bs are indifferent between insurance purchase and remaining at E. Suppose that all companies offer a contract that is zero profit when taken by all Ts and Bs. The Bs are indifferent as to whether they purchase, and suppose only some of the Bs choose to do so. Positive profits would then be earned by the contract. Nevertheless, no insurer would undercut by an epsilon, for the consequence is that all the Bs then strictly prefer to purchase, and their high claim rate eliminates profits. This knife-edge feature reflects an extreme but inessential modelling assumption and is not of central economic interest. To ensure that only zero-profit equilibria emerge, the model is modified to introduce some vanishingly small heterogeneity between agents of each type:

Assumption 2. Each agent i has a utility cost ε_i in applying for a policy. The distribution of ε_i in the population is continuous with support $[0, \overline{\varepsilon}]$, where $\overline{\varepsilon}$ is arbitrarily small.

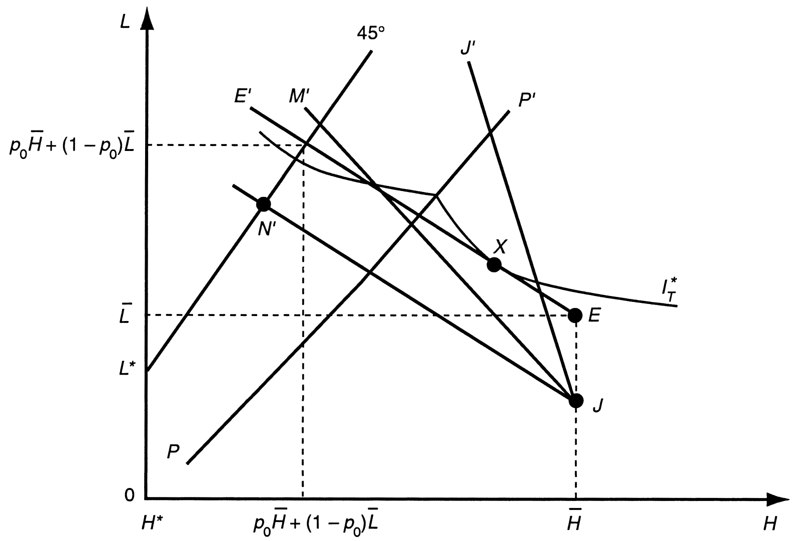
The ε could be thought of as the effort cost of filling in a proposal form. The role of the εs is to remove the discontinuity in the best-response functions and so eliminate positive-profit equilibria.[10]

[8] The full analysis of this case is available from the authors.

[9] Dionne and Doherty's (1994) and Puelz and Snow's (1994) evidence of a plethora of different automobile insurance offers does not imply full separation if, as here, there is double crossing of indifference curves.

[10] In all the equilibria we examine, the Ts are strictly better off if they purchase insurance, so the εs have no effect on their decisions.

FIGURE 1



Proposition 1. If C is sufficiently low that JJ' cuts EE' to the right of X but JM' does not cut I_T^* to the right of PP', and N' lies below I_T^*, there exists a unique equilibrium. The equilibrium insurance contract, z_p, is partial pooling and located above but arbitrarily close to X.[11] More precisely, the contract maximizes the utility of the Ts subject to the insurers attracting the number of Bs required to break even. It is therefore located at the tangency between a T and B indifference curve, just above X.[12]

Proof. It is trivial that z_p is an equilibrium. All Ts are strictly better off if they take z_p rather than go uninsured, while the fraction of Bs preferring z_p to E is just enough to render z_p zero profit granted that only Ts take precautions. Now suppose an insurer deviated by offering a contract below PP'. Due to the tangency, to attract any customers, an offer must be more attractive than z_p to Bs, but if only Bs take the proposed contract, it is certainly loss making. The only offers that are also taken by Ts must involve losses since, by construction, z_p maximizes the utility Ts subject to breakeven. If a deviation lies above PP', the most profitable offer must involve full insurance, but even the break-even offer at N' is inferior to z_p for the Ts. Thus there is no profitable deviation. For uniqueness, note that by construction, Ts prefer z_p to any other zero-profit offer in which at least some Ts participate, so it is the only possible pooling offer. Moreover, a separating offer to the Ts must be on JJ' and on or below EE' and so would be destroyed by z_p. Uniqueness follows. *Q.E.D.*

In the interval defined in Proposition 1, the insurance contract is effectively invariant to the level of C, but the lower is C, the more Bs are insured.

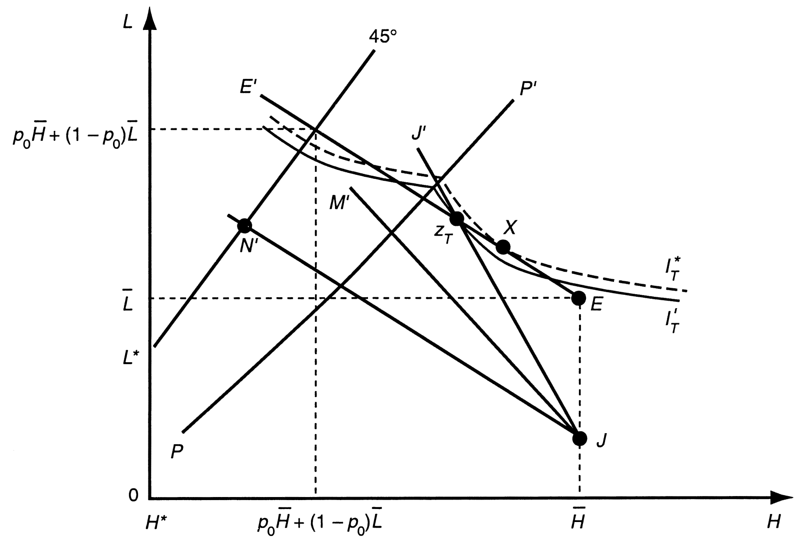
If C is above this interval, then, as shown in Figure 2, JJ' cuts EE' at or below PP' but to the left of the tangency of I_T^* and EE'. At this intersection, the indifference curve of the Ts is flatter than JJ', and a separating equilibrium arises.

Proposition 2. Suppose C is sufficiently low that JJ' cuts EE' at or below PP' but is high enough that JJ' does not cut EE' to the right of X, and I_T', the indifference curve of Ts through

[11] The contract actually at X is not an equilibrium. No Bs purchase because of the application cost, but as X lies below JJ', it is strictly profitable. An insurer would therefore gain by making a slightly more generous offer that captures all the Ts, even though a few extra Bs also purchase.

[12] To preclude undercutting, equilibrium requires zero profits, so some but not all Bs must participate. The application costs therefore imply that the offer must be above X, but as distribution of η is compressed, equilibrium is arbitrarily close to X.

FIGURE 2



the intersection point of JJ' and EE', does not cut JM' to the right of PP' and lies above N'. Then there exists a unique separating equilibrium with the Ts' contract, z_T, at or arbitrarily close to the intersection of JJ' and EE'. The Bs are uninsured.

Proof. At z_T, no Bs purchase insurance because of the application cost. Now test z_T by considering deviations. Offers above JJ' are unprofitable even if no Bs buy. No profitable offer below PP' and below I_T' attracts the Ts. There is, however, a zone bounded by I_T' and JJ' in which offers attract all Ts and some Bs. The issue is whether so many Bs are attracted that such offers are unprofitable. If the distribution of the εs is sufficiently compressed, any break-even offer that involves lower good-state income than at z_T must be arbitrarily close to EE' and therefore below I_T'. Hence, the pair z_T and the endowment point is a separating equilibrium.[13] For uniqueness, note that z_T is preferred by the Ts to any other offer on or below JJ' and EE'. So there can be no other separating equilibrium. Full pooling is ruled out because I_T' does not cut JM' to the right of PP'. Partial-pooling offers must be between z_T and PP' close to EE' but, with a compressed ε distribution, would be broken by z_T. Uniqueness follows. *Q.E.D.*

Notice that separation is achieved with the Ts underinsured relative to the equilibrium with full information about types. Also, this zone has the counterintuitive property that the lower is C, the less insurance coverage taken by Ts.[14]

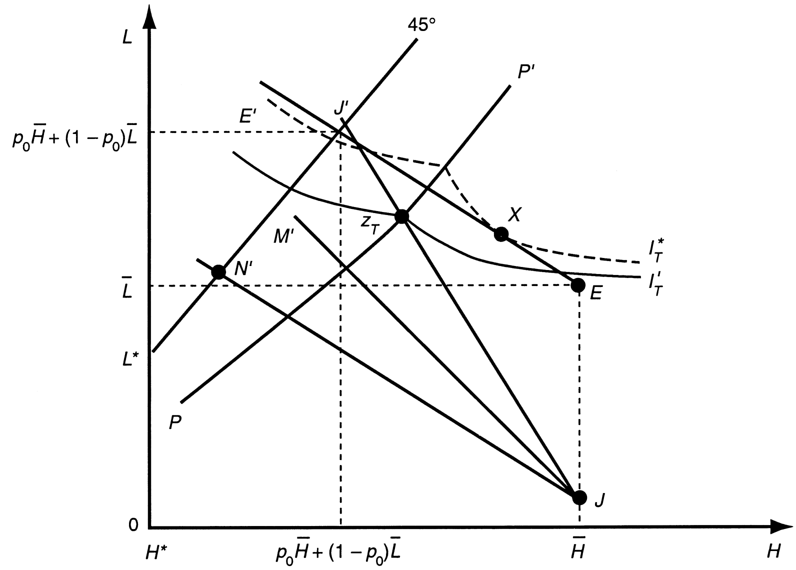
Now suppose that C exceeds the interval identified in Proposition 2 but is still not prohibitive. As illustrated in Figure 3, equilibrium now lies at the intersection of JJ' and PP' provided this puts the Ts on an indifference curve that passes above N'. There is then a unique equilibrium. It is separating, with all the Ts taking the insurance contract at the intersection and the Bs uninsured. If the indifference curve passes below N', the Ts take the without-precautions full-insurance contract at N'.

When administrative costs are low, it becomes an issue whether a pure-strategy subgame-perfect Nash equilibrium exists. Consider first the configuration of Figure 1 where Proposition 1 establishes that a partial pooling equilibrium exists at X. Now let C fall so that J slides up $E\bar{H}$. There is some threshold value of C below which JM' still passes below X but cuts I_T^* below PP'

[13] If the distrbution of εs is insufficiently compressed there will be a partial-pooling equilibrium with the insurance contract above but close to z_p.

[14] Note that given risk aversion, the indifference curve of the Ts is tangent to JJ' when income is the same in both states, ruling out interior separating equilibria.

FIGURE 3



(when JM' passes through X it certainly cuts I_T^*). In this zone, there is no equilibrium. There will be some offers along JM' that are better for Ts than X and so break the partial-pooling offer (which in turn breaks full pooling at the intersection of JJ' and EE'). Moreover, full pooling on JM' above EE' is also ruled out as an equilibrium. Since the indifference curve of a B is flatter than that of a T at such points, a small deviation to less coverage attracts only Ts, so it is certainly profitable. This argument applies even when there is no tangency between JM' and the indifference curve of a T. The only candidate equilibrium is then where JM' and PP' intersect, but since the Bs' indifference curve is flatter than that of the Ts, there must exist deviations to lower coverage that yield profitable separation.

When C is so low that JM' passes above X, a similar argument applies. Separation is again broken by offers along JM' and above EE'. Full pooling on JM' is ruled out as an equilibrium. There is now a zone along JM' where the indifference curves of the Ts are flatter than those of the Bs, so here pooling is broken by deviating to an offer involving a little more coverage, which profitably only attracts Ts. [15]

Even when C is sufficiently high that X lies below JJ', nonexistence may arise. Figure 2 can be modified so that JM' cuts I_T' below PP'. Now there are offers along JM' that Ts prefer to the separating contract at z_T, which is therefore eliminated as an equilibrium. However, as previously, offers on JM' can in turn be broken by deviations that only attract Ts.

To summarize, the comparative statics of our model as the administration cost, C, changes are as follows. At very high values of C, no insurance is purchased. As C falls, a zone is entered in which separating equilibria exist. Here, the Bs do not purchase insurance and the Ts take either full or partial insurance. As C falls further, partial-pooling emerges, and finally, for C sufficiently low, there exists no subgame-perfect Nash equilibrium.[16]

Finally, we sketch outcomes when there is no tangency between the Ts' indifference curve and EE' to the right of PP'. All these "single-crossing" cases involve equilibrium on PP' (assuming such contracts are not dominated for the Ts by the without-precautions full-insurance

[15] There is a point on JM' above EE' where the indifference curves of Bs and Ts are tangent, but then insurance companies can make profitable deviations to offers below JM' that make even Ts better off.

[16] Existence can always be restored if the equilibrium concept is Wilson rather than Nash (see Wilson (1977)). This is not a novel observation, the interest being that, using arguments along the lines of those in Section 3, such equilibria can be shown to exhibit excessive coverage.

offer at N'). When administrative costs are high but not prohibitive, so that JJ' cuts PP' below EE', there exists a separating equilibrium in which the Ts are partially insured. The insurance contract lies at the intersection of JJ' and PP', and the Bs go uninsured. At lower values of C, JJ' cuts PP' above EE', but JM' cuts PP' below EE'. There then exists a partial-pooling equilibrium at the intersection of PP' and EE'.

At still lower values of C, JM' cuts PP' above EE', at which intersection there is a full-pooling equilibrium.[17]

Looking to the most interesting cases, the existence of zero-profit partial or full pooling equilibria depends upon the marginal buyer being the boldest and highest risk of those active. In our formulation, zero profit can be achieved with incomplete participation by the marginal types. What allows pooling is the double crossing of indifference curves, which becomes possible once precautions are endogenous. In a pooling configuration, a small cut in the premium or alteration in coverage causes a flood of bold entrants, taking no precautions, and therefore is unprofitable. The conventional model sees a cut in the premium leading to an influx of good risks and thus an increase in profit, thereby precluding a partial-pooling equilibrium.

Just as in the conventional model, separating equilibria may also arise. This occurs when there is single crossing or, as in Proposition 2, if double crossing does not apply in the relevant zone. The difference with the standard model is that here the good risks make their contracts undesirable to the bad risks by *raising* coverage from the full-information level. [18]

3. Welfare

■ In our setup, it is possible to find policies that yield strict Pareto gains. Consider the equilibrium of Proposition 1 in which entry of the Bs has taken place up to the point at which they gain no surplus from insurance and some, but not all, are uninsured.

Proposition 3. In the partial-pooling equilibrium of Proposition 1, introducing a small fixed tax per policy issued, with the proceeds returned as a lump-sum subsidy to the whole population, yields a strict Pareto improvement.

Proof. The subsidy shifts the endowment point up the 45° line to $\widehat{E}$, and the new indifference curve of a type B is $\widehat{E}\widehat{E}'$. The tax raises the fixed cost of insurance to $\widehat{C}$. As the subsidy is received by all, but the tax is paid only by those buying insurance, endowments rise by less than the cost of insurance, so J moves down the 45° line to $\widehat{J}$ and the new zero-profit curve is $\widehat{J}\widehat{J}'$. The new equilibrium is at z_p', arbitrarily close to $\widehat{X}$, which is preferred by all. *Q.E.D.*

Note that the premium per dollar of coverage remains the same despite the tax. This is possible since fewer higher-risk Bs are insured. Also, for a sufficiently large tax, the pooling equilibrium breaks down and separation results.

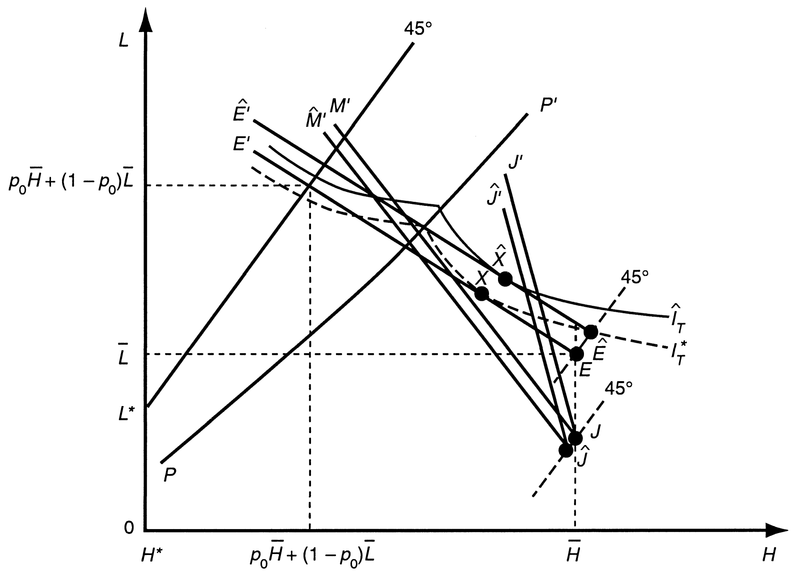
If the laissez-faire equilibrium is separating, as in Proposition 2, the possibility of a strict Pareto improvement again arises. The tax makes it less attractive for the Bs to purchase insurance and so allows the Ts to achieve separation with increased insurance coverage. More specifically, the tax on each policy and return of the proceeds as a poll subsidy slides the zero-coverage contract, J, down the 45° line to $\widehat{J}$, and the subsidy to the uninsured shifts the endowment point E up to $\widehat{E}$ (definitely benefiting Bs). The contract at the intersection of $\widehat{J}\widehat{J}'$ and $\widehat{E}\widehat{E}'$, the new equilibrium, lies to the northwest of the initial contract. The question is whether the Ts have gained.

Proposition 4. In the separating equilibrium of Proposition 2, introducing a fixed tax per policy issued, τ, with the proceeds returned as a lump-sum subsidy of s to the whole population yields a strict Pareto improvement if the absolute value of the slope of the Ts' indifference curve at E is less than $[p_0 + (p_F - p_0)(1 - r)]/[(1 - p_0) - (p_F - p_0)(1 - r)]$, where r is the fraction of the population that are Bs.

[17] This is an artifact of the discreteness of precautionary choice, but even when precautions are continuous, single crossing permits equilibria in which bold types are overinsured relative to the full-information equilibrium.

[18] Our main results apply if the marginal buyer is risk neutral and if precautionary effort is a continuous variable.

FIGURE 4



Proof. The balanced-budget condition is

$$s = \tau(1 - r). \tag{8}$$

The equation of $\widehat{E}\widehat{E}'$ is

$$p_0(W - y + s) + (1 - p_0)(W - D + \lambda y + s) = p_0(W + s) + (1 - p_0)(W - D + s), \tag{9}$$

which implies that

$$\lambda = \frac{p_0}{1 - p_0}. \tag{10}$$

The equation of $\widehat{J}\widehat{J}'$ is

$$p_F - (1 - p_F)(\lambda y + C) = \tau. \tag{11}$$

Substituting (10) into (11) yields

$$y = \frac{(\tau + (1 - p_F)C)}{p_F - p_0}(1 - p_0), \qquad \lambda y = \frac{(\tau + (1 - p_F)C)}{p_F - p_0} p_0. \tag{12}$$

Now

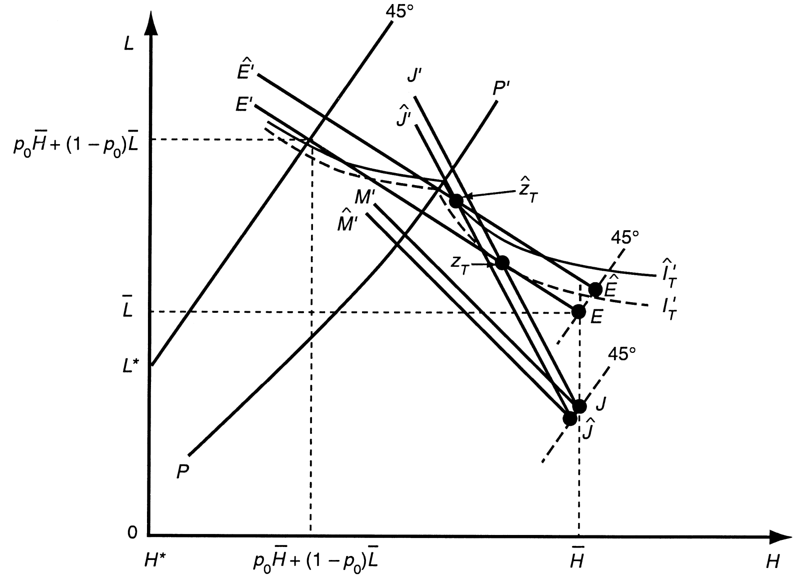
$$EU_T = p_F U(W - y + s) + (1 - p_F) U(W - D + \lambda y + s). \tag{13}$$

Using (8) and (12), $dEU_T/dT > 0$ if

$$\frac{p_F U'(\overline{H})}{(1 - p_F) U'(\overline{L})} < \frac{p_0 + (p_F - p_0)(1 - r)}{(1 - p_0) - (p_F - p_0)(1 - r)}. \tag{14}$$

The left-hand side of (14) is the absolute value of the slope of Ts' indifference curve at E. The slope of the locus of intersections generated by balanced-budget variations of the tax is given by the term on the right-hand side of (14), and it varies between the slope of $\widehat{J}\widehat{J}'$ and EE' as r ranges from zero to one. So when there are sufficiently few Bs in the population, a small tax makes everyone strictly better off. *Q.E.D.*

FIGURE 5



The reason the tax is more effective when there are few Bs is that the per-capita subsidy is then high and so there is a large effect on the utility of the uninsured Bs and hence also on the Ts.

4. Conclusions

■ Unlike the standard insurance model, the formulation developed here may yield a unique, subgame-perfect, partial-pooling Nash equilibrium with the property that insurance market failure may be in the direction of excessive provision. Separating equilibria with this property are also possible. The key to these results is that as premiums rise, it is the least risk-averse types who drop out of the market, the very people most inclined to reckless behavior. Thus, the marginal purchasers impose an externality on the other buyers and it would be better if they were out of the market. Indeed, there exist feasible policy interventions that make everyone better off. The argument was made explicit using the simplest model possible, but it is clearly more general.

Casual observation does suggest that the worst risks are often uninsured, whereas in the standard model it is the best risks who are not covered. The evidence cited in the Introduction that the insured are less likely to suffer losses is consistent with this view.[19] Chiappori and Salanie's (2000) findings deserve special note, though, in which the accident rate of drivers choosing comprehensive insurance is higher, but not significantly so, than that of those opting for the legal minimum of third-party coverage. Although our model implies that the comprehensively insured have the lowest accident rates, minor modification allows for equality. Comprehensive insurance allows claims to be made for contingencies not covered by a third-party policy and so entails higher expected administrative costs which, in our analysis, can be represented by C. In a partial-pooling equilibrium, some bold types purchase comprehensive policies and others opt for the third-party coverage. Due to moral hazard, selecting a comprehensive policy induces fewer precautions than if third party coverage is chosen.[20] So comprehensive insurance is taken by the safest drivers of all, the timid, and also by those with the very worst accident rates, bold types with no incentive to take care. Average accident rates may thus be the same for holders of the two policies. Whereas the Rothschild and Stiglitz (1976) model of adverse selection is inconsistent

[19] Chiappori (2000) includes a useful overview of the evidence.

[20] This assumes at least three levels of precautionary effort.

with Chiappori and Salanie's (2000) findings, the more so if moral hazard is added, advantageous selection plus moral hazard does potentially account for them.

Our approach also explains the striking observation of Cawley and Philipson (1999) that insurance premiums display quantity discounts, the opposite of the prediction of the standard model in which those buying the most insurance are the bad risks. For expositional simplicity, we assumed the bold types to be risk neutral so, in the absence of intervention, they do not buy insurance at all in a separating equilibrium. If instead we assumed that the bold, though more risk tolerant than the timid types, were nevertheless risk averse, separation may involve both types buying some insurance. Administrative costs are then sufficient to generate quality discounts, a conclusion reinforced by a second effect. Bold types tend to insure against fewer contingencies and are less inclined to take precautions, so comprehensive policies may be cheaper per dollar of coverage, even net of administrative costs.

The key to our resolution of the puzzling empirical features of insurance markets is that those who are reluctant to purchase insurance are also disinclined to take precautions. We argued that heterogeneous risk preference with endogenous precautionary effort could lead to just such a correlation. Other explanations are possible.[21] There is a wealth of psychological evidence that people tend to be unrealistically optimistic about the probability of suffering losses, particularly when events are perceived as under the individual's control.[22] Indeed, Adam Smith in *The Wealth of Nations* regarded the failure of people to take out insurance as the result of "thoughtlessness, rashness and presumptuous contempt of risk." It is easily seen that such unrealistic optimists will be less inclined to purchase insurance, and even if they do so they may well take fewer precautions.[23] The positive results of the article continue to hold if behavior is driven by heterogenous optimism rather than risk preferences, but of course the welfare results are reversed: now the equilibrium involves too little insurance. The way this works through is that the most optimistic types will tend to be the least willing to purchase insurance, and it is also possible that an attitude of "it won't happen to me" is a discouragement to take precautions. A misperception that risks are already low suggests few precautions are necessary, an attitude that may be reinforced by overestimation of the efficacy of what actions are taken. The net result is similar to heterogeneous risk preferences; the marginal insurance buyers are the riskiest of all and separating and pooling equilibria paralleling those analyzed here may emerge. The major difference concerns policy. Optimism implies a mistaken reluctance to purchase insurance. The cross subsidy that potentially overexpands the market may now be insufficient to offset the cognitive bias that leads individuals to reject insurance against their own interest. The policy analysis is by no means straightforward, and we do not pursue it here.[24]

Finally, putting diverse preferences at the heart of the analysis has interesting implications for agency problems other than insurance. The design of managerial compensation schemes, corporate finance issues, and selection into self-employment may be fruitful applications of the approach.

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[21] Similar results apply even if there is no causal link between risk attitudes and loss propensity. For example, it could be that there is no moral hazard but clumsy people happen to be the least risk averse. There is no obvious reason why this should be so, nor even stylized evidence in favor.

[22] Weinstein (1980) is the seminal reference. For a more recent survey, see Weinstein and Klein (1996). For applications to economics, see Roll (1986), de Meza and Southey (1996), and Manove and Padilla (1999)

[23] Rutter, Quine, and Alberry (1998) find that motorcyclists are generally prone to overoptimism about the chance of accident, but there is no clear tendency for those taking the most safety precautions to perceive lower absolute risks. This suggests that the most reckless riders are optimists.

[24] There is evidence that people overweight the probability of rare events (e.g., Kahneman and Tversky, 1979) in which case insurance purchase against such eventualities would be subject to unrealistic pessimism. As long as this trait is unequally distributed, a version of our positive analysis applies.

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