SELECTION IN INSURANCE MARKETS

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Consider an insurance market—say, for insurance against accidental injuries. Agents face different levels of accident risk, and have private information about their own risk levels.

Much depends on why individual risk levels differ. If the differences are exogenous, we have the well known case of adverse selection, first modelled by Rothschild and Stiglitz (1976). In the Rothschild-Stiglitz model, the only possible equilibrium is a separating equilibrium where high-risk individuals purchase full insurance and low-risk individuals purchase partial insurance. The outcome is suboptimal in the sense that if risk levels were observable, there would be a new and Pareto-superior equilibrium.

On the other hand, if risk levels differ because of differences in behavior, new issues arise. The most familiar of these is moral hazard, where the opportunity to buy insurance induces suboptimal precautions. Like adverse selection, moral hazard can occur even if all individuals have identical tastes.

More recent literature deals with additional issues that arise when behavior differs because of differences in tastes. For example, Bond and Crocker (1991) tell the following story: relative risk-lovers choose (observably) to smoke, thereby revealing their tastes and their propensity to engage in other (unobservable) risky activities. This enables insurers to separate low-risk from high-risk individuals; non-smokers benefit from smoking because their voluntary abstinence demonstrates their taste for caution and allows them to insure at lower rates.

The Bond and Crocker story suggests that low-risk individuals would prefer a world where risk differences are driven by heterogeneity of tastes, as opposed to the adverse selection world where risk differences are purely exogenous.

In the current paper, I will present a quite different argument leading to the same conclusion. The main idea is that when tastes differ, the demand for precautionary measures is correlated with the demand for insurance. This leads to a sort of selection, where (as we shall see) those who choose to live high-risk lives are precisely those whose presence in the insurance market is least disruptive.

An intuitive but incorrect argument along these lines has gained some currency recently, and has even found its way into print. Hemenway (1990) christens the phenomenon *propitious selection* and tells a story essentially along the following lines: Consider the market for insurance against motorcycle injuries. The high-risk group consists of those who drive without helmets. But those who choose not to wear helmets are likely to have a high tolerance for risk, and hence to opt out of insurance markets altogether. Thus they are less disruptive than if their propensity for serious injury had arisen exogenously.

The preceding argument can be summarized as follows:

1) Under propitious (as opposed to adverse) selection, high risk agents are likely to be less risk averse.

2) When high risk agents are less risk averse they opt out of insurance markets, leaving low risk agents better off.

3) Therefore under propitious (as opposed to adverse) selection, low risk agents are likely to be better off.

I will argue that premises 1) and 2) are both exactly opposite to the truth, and that conclusion 3) therefore remains true. The original argument leads to the correct conclusion only because the two errors cancel each other. In a Rothschild-Stiglitz type model, the correct syllogism is:

1′) Under propitious (as opposed to adverse) selection, high risk agents are certain to be *more* risk averse.

2′) When high risk agents are *more* risk averse, they are less disruptive to insurance markets, leaving low risk agents better off.

3) Therefore under propitious (as opposed to adverse) selection, low risk agents are certain to be better off.

(Here I have continued to use the phrase *propitious selection* to describe the situation where differences in taste drive differences in levels of care, which drive accident probabilities.)

I will now say a few words about the (false) intuition for 2) versus the (correct) intution for 2′) and then do the same for 1) and 1′).

In equilbrium, something must prevent high risk individuals from purchasing insurance at low risk rates. The solution is to tempt high riskers out of the low risk market by offering them full insurance, while low riskers can be only partially insured. But if high riskers are also less risk averse, then a full insurance contract has less value to them. This makes it *more* difficult to tempt them out of the low risk market, and necessitates making the low risk contracts even less attractive. This is a loss to low riskers with no offsetting gain. This correct intuition overturns statement 2) and leads to statement 2′) above.

There is just one exception. The above argument works whenever both groups are risk-averse, but differ in their degree of risk-aversion. If the high-risk group is actually risk-preferring, the outcome can differ. It turns out that a *small* amount of risk preference is actually worse than a small amount of risk aversion; when the high-risk group is only slightly risk-preferring (or when it is perfectly risk-neutral) the insurance market vanishes altogether. (That is, the only equilbrium is where zero contracts are sold.) Only high levels of risk preference can indeed cause high-riskers to drop entirely out of the market, restoring the natural intuition as expressed by Hemenway.

The preceding two paragraphs take as given the tastes and probabilities of injury for the two groups. Now let us allow tastes to determine probabilities through the choice of precautionary measures. There seems to be a natural intuition that risk aversion is positively correlated with the demand for precautionary measures; thus motorcyclists who wear helmets (and hence have low injury risk) can be presumed to be more risk averse than those without helmets (and hence with high injury risk). This is statement 1) above. We know from the work of Eeckhoudt and Dionne (1985) that this intuition need not always hold. Indeed, Eeckhoudt and Dionne show that the demand for insurance (which is controlled by the degree of risk aversion) can be either postively or negatively correlated with the demand for precautionary measures.

Those, like Hemenway, who argue for proptitious selection, have concentrated on the case where the correlation is positive; that is, the case in which the "natural intuition" holds. That is, they assume 1). The results of Eeckhoudt and Dionne seem to allow this as at least a possibility. But that appearance is illusory. Eeckhoudt and Dionne take the terms of the insurance contract as given. But in a Rothschild-Stiglitz model of the insurance market, the decision to take precautions affects the contract one ends up purchasing. Thus the Eeckhoudt/Dionne result does not apply directly.

Here the correct intuition is as follows. Those who take no precautions remain in the high risk group, where they can fully insure. Precautions are valuable only because they allow the opportunity to buy insurance at low-risk rates; this opportunity is valuable only to those who are willing to accept partial insurance. In equilibrium, it is always the *more* risk averse group that is unwilling to make this sacrifice, eschews precautions, and is more likely to sustain injuries. In other words, $1'$) is true.

The remainder of this paper is devoted to fully justifying the arguments above. Sections 1 through 4 justify assertion $2'$) and Section 5 justifies assertion $1'$).

In Section 1, I review the Rothschild-Stiglitz model that will be the basis for the analysis, and categorize the equilibria that are possible when tastes differ.

In Section 2, I demonstrate the falsity of statement 2) above. Specifically, I start with high risk agents who have tastes identical to the low risk agents, then replace the high risk agents with others who are less risk averse, and show that low risk agents are made worse off. The same argument in reverse demonstrates the truth of statment $2'$). This assumes that high-riskers still have some degree of risk aversion; I also consider (in Section 2.3) what happens in the case where high-riskers are positively risk-preferring.

Section 3 is a note on appropriate welfare criteria, and contains a proof that propitious selection equilibria are less likely than adverse selection equilibria to be efficient in the sense of being unimprovable through any system of subsidies from low-riskers to high-riskers.

Thus the results of sections 2 and 3 provide two different sense in which it is undesirable for high riskers to have a high tolerance for risk.

Sections 2 and 3 assume that high riskers differ *exogenously* from low riskers in *both* their tastes *and* their propensity for injuries. This is the appropriate setup for evaluation statements 2) and $2'$). In Section 4, I turn to statements 1) and $1'$). For this I continue to

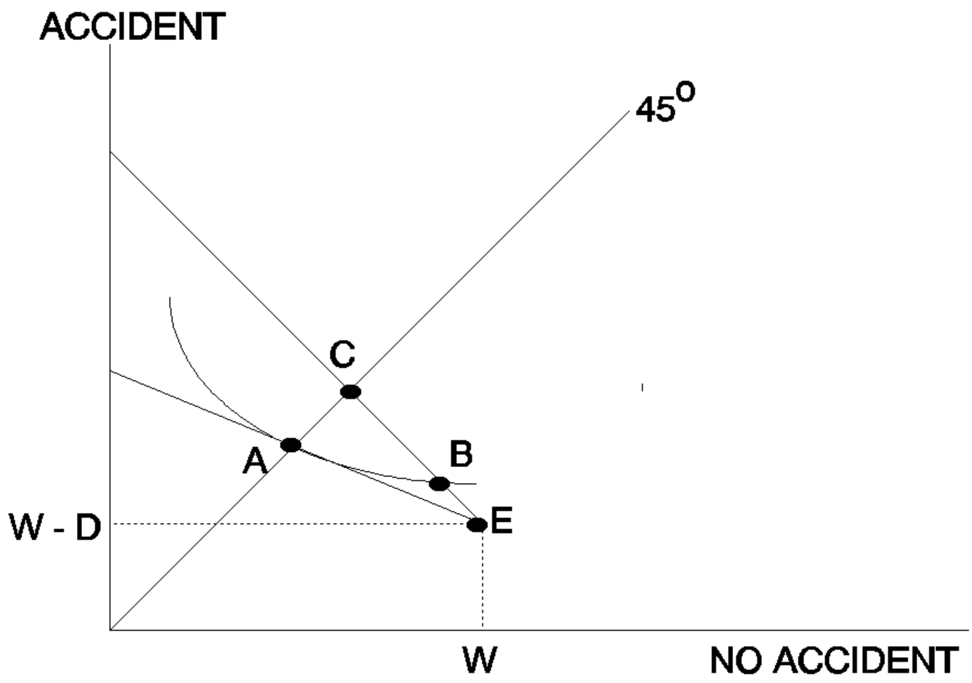


Figure 1.

The standard adverse selection model: The two lines through the endowment point E represent fair odds for the two risk classes. Low-riskers and high-riskers are assumed to have the same utility function. The pictured indifference curve is for a typical high-risker; low-riskers have different indifference curves in accordance with their lower accident probabilities. The only possible zero-profit equilibrium occurs allows consumers a choice between moving to point A and point B; high-riskers choose A and low-riskers choose B. In such an equilibrium, insurance companies earn zero profits.

take tastes as exogenous, but allow accident probabilities to be determined endogenously through individuals' choice of precautionary measures. Here I will show that contrary to the "natural intuition", it is always the *more* risk-averse group that eschews precautions in equilibrium. This refutes 2) and establishes 2′).

Having established 1′) and 2′), 3) follows.

1. Adverse Selection

Assume first that there are two groups of individuals, with different (exogenous) levels of accident risk. One group has accident probability p and the other has probability $q > p$. Each individual is endowed with wealth W, which is reduced to $W - D$ in case of an accident. Within either group, all individuals are identical.

The indifference curve diagram in Figure 1 relates income in two states of the world, "no accident" versus "accident". Everybody starts at the endowment point E. The two lines emerging from E in the first panel represent fair odds for the two groups; their absolute slopes are $(1-p)/p$ and $(1-q)/q$. Within each group, all individuals share the same expected utility function, with the usual properties. The pictured indifference curve is for a typical high-risk individual; low-risk individuals have indifference curves (not pictured) that intersect the 45 degree line at steeper angles.

Low-risk indifference curves differ from high-risk indifference curves first because of the different accident odds and also (possibly) because low-riskers may have a different utility function than high-riskers. The latter possibility is assumed away in Rothschild and Stiglitz.

The insurance company offers a set of contracts. Each individual may choose any one of these contracts, or no contract at all. Following Rothschild and Stiglitz, we say that an equilibrium set of contracts is one where no contract earns negative expected profits and no contract outside the equilibrium set would make a positive expected profit if offered.

An easy argument (see Rothschild and Stiglitz) shows that there can be no pooling equilibrium (i.e. an equilibrium in which only one kind of contract is offered.)

It is also easy to see that in any equilibrium, high-risk individuals are offered full insurance at actuarially fair rates; that is, they are offered the opportunity to move to point A in Figure 1. There are now three possibilities:

1) *A Zero-Profit Equilibrium.* A zero-profit equilibrium consists of contracts A and B in Figure 1. High-riskers are indifferent between the two contracts and choose A in equilibrium. Low-riskers prefer B and choose it. Low-riskers would prefer any point between B and C, but no company can offer such a contract because high-riskers would purchase it.

2) *A Positive-Profit Equilibrium.* If there is a tangency between the high-risk indifference curve H and a low-risk indifference curve L as in Figure 2, then there can be a positive-profit equilibrium consisting of A and B'. Although firms make positive profits, no new entrant can offer a contract that will lure low-riskers without also luring high riskers; depending on the number of high-riskers and their level of risk this might preclude entry and allow an equilibrium.

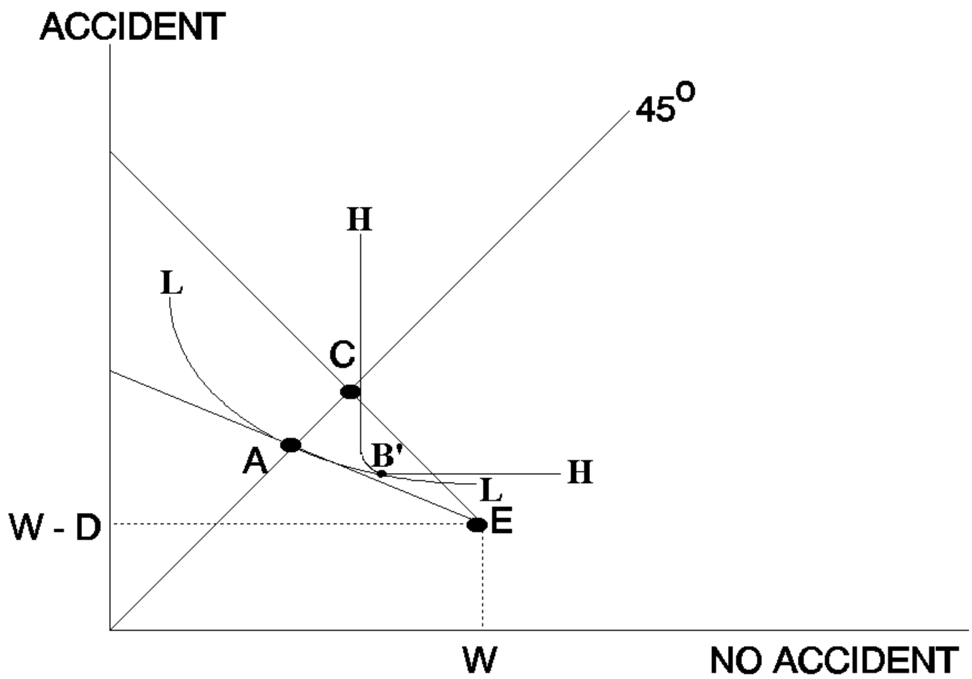


Figure 2.

A positive-profit equilibrium: This figure differs from Figure 1 in that we now allow low-riskers and high-riskers to have different utility functions. It is then possible to have the configuration of indifference curves pictured here. There can then be an equilibrium in which consumers are given a choice between the contracts A and B', and insurance companies earn positive profits.

3) *No equilibrium.* In the configuration of Figure 1 or Figure 2, it is possible that an appropriately designed contract can lure both low and high riskers and earn positive profits; in this case there is no equilibrium.

Note that in Rothschild and Stiglitz only 1) and 3) can hold; 2) is (implicitly) ruled out as a consequence of their assumption that both groups have identical tastes.

I take case 3) to be relatively uninteresting and will not dwell on it. Regarding cases 1) and 2), the analyses are similar; therefore I will concentrate on 1) to avoid repetitiveness, leaving it to the reader to modify the arguments so that they can be applied to case 2). Therefore, for the remainder of the paper, *we assume the existence of a zero-profit equilibrium* a la 1) above.

2. Propitious Selection

2.1 Differing Risk Aversion. As a benchmark, consider the model of Section 1 with the additional assumption that both groups have identical tastes. (This is exactly the adverse selection model of Rothschild and Stiglitz).

Now perturb the model by replacing the high-riskers' utility function with one that exhibits less risk aversion at every point. (Thus in this section the high-riskers differ *exogenously* from the low riskers *both* in their propensity for accidents *and* in their tastes. Later, in Section 5, we will continue to take tastes as exogenous, but will allow the propensity for accidents to arise endogenously from choices of precautionary measures.)

The analysis remains identical to that of Figure 1. (As per section 1, I assume the existence of a zero-profit equilibrium.) The only change is that the pictured high-risk indifference curve must now be more nearly linear, since high-riskers are now less risk averse.) It follows intuitively from this observation, and rigorously from Theorem 1 of Pratt (1964), that point B, where the indifference curve crosses the segment EC, must now lie closer to E than before. Since low-riskers would prefer to be as close as possible to C along this segment, they must be worse off in the new equilibrium. High-riskers remain fully insured as they were before.

Clearly the more risk-averse we make the high-riskers, the worse off the low-riskers will be. The less risk averse they are, the more nearly linear the indifference curve will be and the closer point B moves to point E.

Similarly, if the high-risk group is exogenously *more* risk averse than the low risk group, then point B shifts closer to C and low riskers are *better* off.

We have shown the following: Given p and q (the low-risk and high-risk accident probabilities) and given the tastes of the low-risk population, low-riskers benefit in equilibrium from risk-aversion by high riskers.

In terms of the numbered statements in the introduction, we have shown that as long as high-riskers have some positive degree of risk aversion, 1) is false and $1'$) is true.

2.2 Risk Neutrality. Suppose that the low-risk group is risk-averse and the high-risk group is (exogenously) risk-neutral. In this case, no low-risk insurance at all can be available in equilibrium.

Figure 1 is again the relevant picture, except that the high- risk indifference curve is now perfectly linear and corresponds with the segment AE. Points B and E coincide and the equilibrium requires that low-risk individuals remain at their endowment point, purchasing no insurance.

The point here is that the opportunity to purchase actuarially fair insurance is worth exactly zero to the risk- neutral parties. If any contract at all is offered for sale above the segment AE, then they will happily give up their full-insurance option to purchase it. Thus no such contract can be offered and the low-risk insurance market disappears completely.

2.3. Risk Preference. Risk-preferrers might want to purchase negative amounts of insurance (so that they receive additional income in the event that no accident occurs). I assume this is impossible because it would eliminate the incentive to report accidents. Thus I will consider only insurance contracts that are issued in positive quantities.

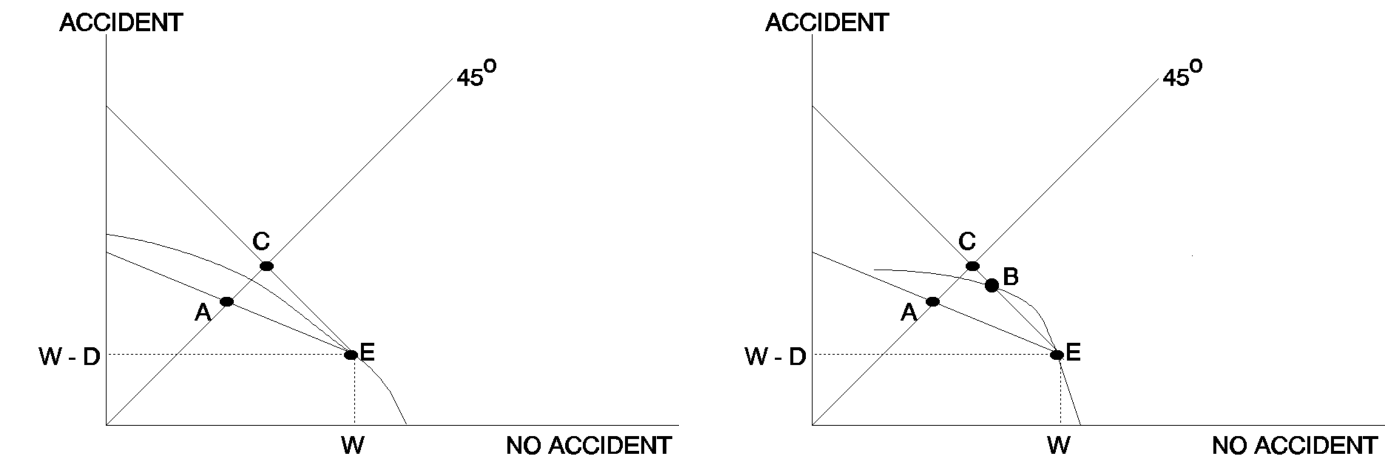
If the high-riskers are (exogenously) risk-preferring, their indifference curves are concave. The three panels of Figure 3 show three possible configurations. Here the points A, C and E, and the budget lines, are as in Figure 1. In Panel A (a small amount of risk preference) there can be no low-risk insurance offered. In Panel B (a middling amount of risk preference) partial low-risk insurance is offered. (Low-riskers are able to move to point B.) Only in Panel C (a great deal of risk preference) can the low-risk group be fully insured.

2.4. Summary.

Figure 4 shows the welfare consequences for low-risk buyers when high-risk buyers have varying degrees of risk preference. The point labeled AS on the horizontal scale represents the situation where high-risker's risk preference is the same as low-risker's risk preference; in other words the two groups have identical tastes. This is the classical Rothschild-Stiglitz adverse selection case.

3. Welfare Analysis

We would like to make a welfare comparison between the Rothshcild-Stiglitz world where high-riskers have the same tastes as low-riskers, and the world of propitious selection where high-riskers have different tastes. Clearly, because tastes differ across these worlds,



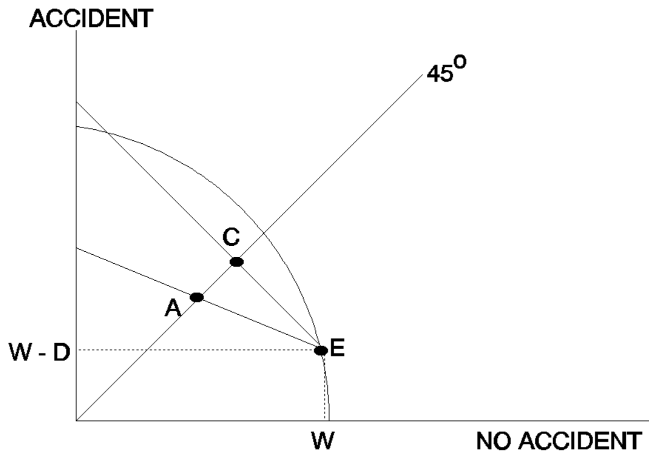


Figure 3.

Risk preference: If high-riskers are risk-preferring, their indifference curves might lie in any of the three pictured configurations. In panel A (a small amount of risk preference) there can be no low-risk insurance offered. In panel B (a middling amount of risk-preference) partial low-risk insurance is offered. In panel C (a great deal of risk preference) the low-risk group can be fully insured.

the usual Pareto criterion can not be applied. However, we can note that in equilibrium the high-risk population is always fully insured, so that it seems at least somewhat natural to confine one's welfare analysis to the low-risk population, whose tastes *can* be held constant.

The natural question is: Suppose that you are a low-risk individual. Would you prefer to live in a world where high- risk inidividuals are *less* risk averse than you are, or in a world where high risk individuals are *more* risk averse than you are? The answer derived in Section 2 is unambiguous: By this criterion, risk aversion by high risk individuals is desirable.

In this section, we will analyze the welfare properties of insurance markets from a different point of view, by showing that when high-risk individuals exhibit low risk aversion,

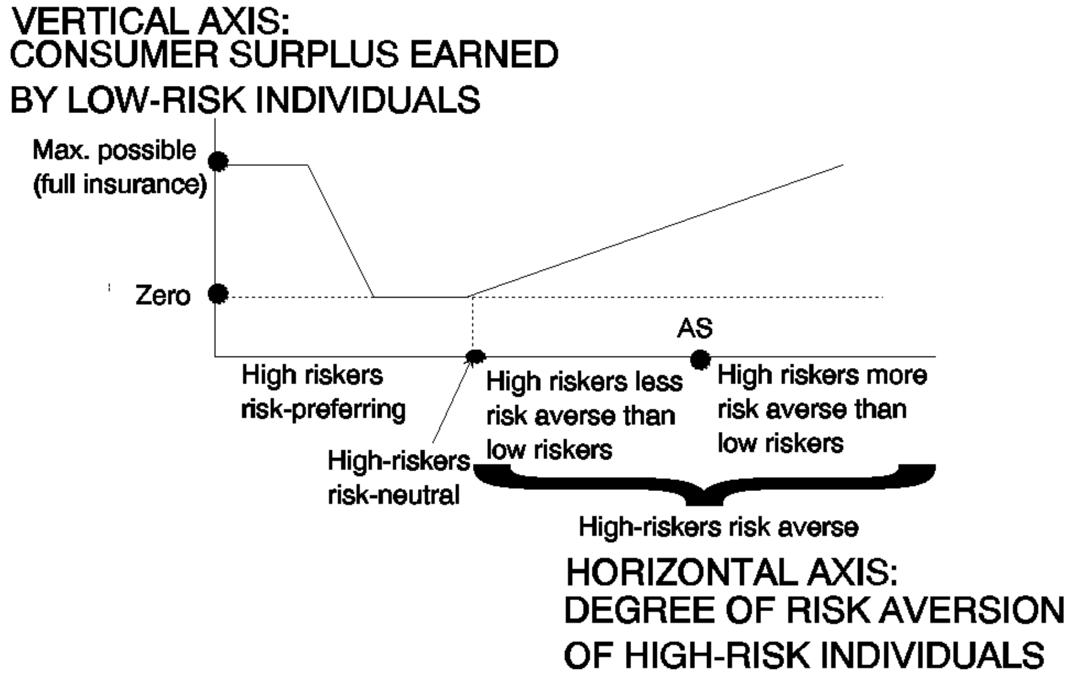


Figure 4.

At point AS, high-risk and low-risk individuals have identical tastes as in the classical adverse selection model. At points between the risk-neutral point and AS, those who have the highest accident risk also have the highest tolerance for risk. According to the "propitious selection" story, this is both a reasonable expectation and a good thing for low-riskers; the present paper argues that on the contrary, it is neither a reasonable expectation *nor* a good thing for low-riskers. The graph illustrates the second of these points, showing that low riskers are better off to the *right* of point AS, where those with high accident probabilities have a *lower* tolerance for risk. (The graph is highly stylized; the curve has increasing and decreasing segments as shown, but it need not be linear within those segments.

equilibria are less likely to be constrained-Pareto-efficient (with appropriate break-even constraints) than are adverse selection equilibria. I thank Eric Bond for suggesting that I investigate this question. This will give an additional sense in which risk aversion by high risk individuals is desirable.

Rothschild and Stiglitz (1976) point out that adverse selection equilibria can be inefficient in the following sense: We can envision a single insurance company offering two different contracts, one to high-riskers and one to low- riskers, which jointly break even though the high-risk contract loses money; that is, the low-riskers effectively subsidize the high-riskers. Such subsidies can not exist in competitive equilibrium, yet they can be Pareto improvements over competitive equilibrium. Rothschild and Stiglitz give a condition for competitive equilirium to be efficient in the sense that no such Pareto improvement is possible.

Continue to let p and q represent the low-risk and high- risk accident probabilities; let γ represent the fraction of the population that is high-risk, and let U be the utility function shared by all. Then the Rothschild- Stiglitz condition for efficiency is

$$\frac{\gamma(q-p)}{p(1-p)} > \frac{U'(Y)\big(U'(Z)-U'(X)\big)}{U'(X)U'(Z)} \tag{1}$$

where X and Z are the incomes of low-risk individuals in the two states of the world and Y is the income of the (fully insured) high-risk individuals, at the appropriately constrained optimum.

Rothschild and Stiglitz describe the derivation of this inequality as "straightforward but tedious". To generalize to the case where low-risk and high-risk individuals have different utility functions U and V is equally straightforward, but thanks to the advent of modern symbolic computation packages, no longer tedious. The generalized inequality is

$$\frac{\gamma\big(q(1-p)V'(Z)U'(X)-p(1-q)U'(Z)V'(X)\big)}{p(1-p)} > V'(Y)\big(U'(Z)-U'(X)\big) \tag{2}$$

which reduces to (1) in the adverse selection case $U=V$.

The case where high-riskers are less risk averse is the one where V is more nearly linear than U; to save notation I will restrict to the case where V is perfectly linear, so that V' is constant. Then (2) becomes

$$\frac{\gamma\big(q(1-p)-p(1-q)\frac{U'(Z)}{U'(X)}\big)}{p(1-p)} > \frac{U'(Z)-U'(X)}{U'(X)} \tag{3}$$

It is an easy exercise in algebra (using $U'(Z)>U'(X)$ and $U'(Z)>U'(Y)$, both of which must hold at the optimum) to show that (3) always implies (1). In other words, the condition for equilibrium to be efficient becomes more difficult to satisfy when high-riskers are less risk averse. Roughly, this says that high risk aversion by high riskers makes equilibria *more* likely to be efficient . This desirable feature of risk aversion by the high-risk population is *in addition* to the desirable features derived in Section 2.

4. Voluntary Precautions

In the preceding two sections, I have taken the accident probabilities p and $q > p$ to be exogenous. In this section I will replace that assumption with a model that allows individuals to choose their accident probabilities via voluntary but costly precautions. I will show that in equilibrium, the group that chooses the higher accident probability must always be the less risk averse of the two groups.

Continue to assume just two risk classes with probabilities of accident p and $q > p$. Everyone is endowed with accident probability q, but can buy it down to p for a fixed cost C. As in earlier sections, everyone is endowed with wealth W and $W - D$ in the two states of the world "no accident" and "accident".

This setup raises issues of moral hazard that are well understood but not terribly germane to the present discussion. It is possible that members of the low-risk group, after purchasing insurance, lose their incentive to take precautions. In that case, we have only one risk group and the selection problems disappear. Therefore I *assume* that the magnitude of C is sufficiently low that when low-riskers are permitted to purchase an equilbrium quantity of insurance, they continue to take precautions. High-riskers, who are fully insured in equilibrium, will continue not to take precautions.

In equilbrium, high-riskers are fully insured at actuarially fair rates and have certain wealth of $W - qD$ in either state of the world. Low-riskers are partly insured at actuarially fair rates, and have wealth of either $W - C - s$ (in the no- accident state) or $W - C - t$ (in the accident state) where C is the cost of precautions and (s, t) satisfies $(1-p)s + pt = pD$. The exact values of s and t are determined as in Figure 1; in particular they fall between 0 and D.

Now suppose that there are two classes of individuals, with utility functions U and V. Suppose also that U exhibits greater risk aversion at every level of wealth than V does. It follows from Theorem 1 of Pratt that we can write $U = k \circ V$ for some increasing concave function k.

I claim that in any separating equilibrium, it is the less risk averse group that takes precautions. To see this, suppose the contrary. That is, assume that in equilibrium those with utility function U take precautions and those with utility function V do not. The incentive compatibility constraints are

$$(1-p)U(W-C-s)+pU(W-C-t)>U(W-qD) \tag{4}$$

$$V(W-qD)>(1-p)V(W-C-s)+pV(W-C-t) \tag{5}$$

But applying the increasing concave function k to both sides of (4) and using Jensen's inequality, we contradict (5). Thus the claim is proved.

In terms of the statements in the introduction, this means that contrary to the "natural intuition" of Hemenway, 1) never holds, and $1'$) is true.

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