SCREENING IN INSURANCE MARKETS
WITH ADVERSE SELECTION AND BACKGROUND RISK

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Abstract

Background risk increases the risk aversion of vulnerable decision makers and may thereby influence the performance of insurance markets encumbered by adverse selection. When insurance applicants cannot be categorized with respect to background risks, the prospects for existence of a pure strategy Nash screening equilibrium may worsen and cannot improve if some high-risk types are free of background risk. However, if all high risks have background risk, then prospects for existence improve provided low-risk types are only weakly vulnerable. Verifiable background risks can cause insurance markets to close when all individuals would be insured if categorization with respect to background risk were prohibited.

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I. Introduction

The performance of insurance markets contending with adverse selection can be affected by the presence of background risks. Insurance applicants, better aware of their risks of loss than insurers, as in the seminal model of adverse selection developed by Rothschild and Stiglitz (1976), may in addition possess independent background risks, such as those associated with uninsured income or health risks. Background risks increase the degree of risk aversion for decision makers who are risk vulnerable, in the sense of Gollier and Pratt (1996), thereby altering the attraction of potential defections from the Nash equilibrium and, through this avenue, influencing the performance of insurance markets encumbered by adverse selection.

Examples of background risk include randomness in portfolio or entrepreneurial incomes, or in wage income arising from uninsurable stochastic shifts in demands for labor skills or from incentive provisions in labor contracts. Typically, stochastic health care expenditures are not fully insured and present another source of background risk. While these background risks may not be observable by the insurer, others may be, as when an auto insurer, knowing the collision insurance deductible of an individual also buying liability coverage, is privy to some information about background risks held by the individual seeking liability coverage.

We assume that insurance markets attain the pure strategy Nash screening equilibrium whenever it exists, and otherwise remain closed with losses going wholly uninsured.[1] As in the Rothschild-Stiglitz model, existence of equilibrium and the extent of insurance coverage turn on whether the proportion of high-risk types in the applicant pool is at or above a critical value. The introduction of any fair or unfair background risk necessarily reduces expected utility since individuals are risk averse, but would nonetheless have no effect on insurance markets if individuals were invulnerable, which would be the case if, for example, they were to exhibit constant absolute risk aversion.[2] We assume that all individuals are vulnerable, but allow for heterogeneity by not requiring that all individuals hold background risk.[3] Our findings concerning the effects of background risk on the extent of insurance coverage can be summarized as follows.

When background risk is unobservable, its introduction may worsen, but never improves the prospects for existence of equilibrium, provided some high-risk types are among those free of background risk. Its presence worsens prospects for existence when the proportion of high risks without background risk is less than the proportion of low risks with it, so that an insurance pool attracting just these individuals would be profitable, having a disproportionate share of the low risks. In these instances, innovations that create opportunities to insure background risks, such as the introduction of policies that cover Medicare deductibles in the U.S., are socially valuable insofar as they open some markets that would otherwise be closed by adverse selection, while extending insurance coverage to previously uninsurable background risk.

However, if all high-risk types are exposed to background risk, then prospects for existence necessarily improve if no low risks are exposed, and may improve even if all low risks are. When all high risks have background risk, the incentive compatible, breakeven contract for low risks has a smaller deductible, which is valuable to them. More importantly, it is more difficult to attract low risks to a defecting insurance pool, so prospects for existence improve. In addition to this "deductible" effect, however, an opposing "vulnerability" effect arises as background risk makes vulnerable low-risk applicants easier to attract to a defecting pool. When this vulnerability effect is smaller than the deductible effect, prospects for existence of equilibrium improve. Ceteris paribus, greater risk aversion enhances the deductible effect and hence the prospects for existence. Nonetheless, if the vulnerability effect is strong enough, then low-risks with background risk can be attracted to a profitable defecting contract, and the pure strategy Nash equilibrium fails to exist.

The opportunity to verify and contractually exploit information on background risk, exemplified by the use of credit ratings to categorize insurance applicants with respect to their background risks, is potentially socially valuable, but its actual value may be negative when corrective taxes are not exploited to maintain equilibrium.[4] The market outcome depends on the distribution of background risk in the population. If its distribution is uniform, then there are no consequences for those without background risk, but prospects for existence of equilibrium worsen for those categorized with background risk if the vulnerability effect is strong enough to offset the deductible effect. On the other hand, if a higher proportion of high risks than low risks holds background risk, then prospects for existence necessarily worsen for those without it, but defecting contracts are not as profitable for those with background risk and for these applicants the pure strategy Nash equilibrium is sustained in a wider class of environments. Nonetheless, it is possible that insurance markets would close if insurers were free to categorize individuals on the basis of background risk, even though all individuals would be insured if such categorization were prohibited.

Previous studies of adverse selection in insurance markets with risk aversion as hidden knowledge have focused on optimal contracting. Arnott and Stiglitz (1988) explore the desirability of introducing *ex post* randomization, Landsberger and Meilijson (1994, 1999) consider monopolistic and break-even contracts, and Smart (2000) investigates the implications of "double crossing" indifference curves that can arise when insurance applicants differ with respect to their hidden knowledge of both risk and risk aversion. We, in contrast, are concerned with the existence of equilibrium in markets where the "single crossing" of indifference curves is maintained. Moreover, differences in risk aversion are not immutable, as in previous studies, but arise from the presence of background risks. Our model thus offers insights regarding the social value of innovations that extend coverage to previously uninsurable risks or that allow insurers to categorize applicants on the basis of exposure to background risks.

In the next section, we set out the Rothschild-Stiglitz model of an insurance market with adverse selection and characterize the critical proportion of high risks that must be equalled or exceeded for equilibrium to exist. In section III, we introduce background risk and analyze its effect on this critical proportion, first when the background risk is unobservable, and then when insurers can categorize individuals according to their exposure to background risks. In section IV, we conclude with a discussion of our assumption that all individuals have the same degree of risk aversion in the absence of background risk.

II. An Insurance Market with Adverse Selection

In the pure strategy Nash screening equilibrium of the Rothschild-Stiglitz insurance market, high risk H-types receive full insurance for the loss D, resulting in expected profit

$$\pi^H = \alpha^H - p^H D$$

and wealth for H-types

$$W^H = W^0 - \alpha^H = W^0 - \pi^H - p^H D,$$

where W^0 is the endowed wealth, p is the probability of the loss occurring, and α is the insurance premium. Low risk L-types receive a contract with a deductible S resulting in wealth

$$W_1^L = W^0 - \alpha^L$$

when the loss does not occur and

$$W_2^L = W^0 - \alpha^L - S = W_1^L - S$$

when it does, and yielding expected profit

$$\begin{aligned}\pi^L &= \alpha^L - p^L(D - S)\\ &= W^0 - W_1^L - p^L D + p^L(W_1^L - W_2^L).\end{aligned}$$

Incentive compatibility is a binding constraint for H-types, so

$$U(W^H) = (1 - p^H)U(W_1^L) + p^H U(W_2^L)\,, \qquad (1)$$

where $U(\cdot)$ is the common von Neumann-Morgenstern utility function, which is assumed to be risk averse and vulnerable. Expected profit must equal zero while allowing for cross-subsidization, satisfying the weak zero-profit constraint

$$lp^{H} + (1 - l)p^{L} = 0\,, \tag{2}$$

where l is the proportion of H-types in the population. In the pure strategy Nash equilibrium, the contracts break even individually and satisfy the strong zero-profit constraints $p^{H} = 0 = p^{L}$.

Figure 1 depicts the equilibrium with H-types along indifference curve U^{H} receiving full and fair insurance at H^{*}, and L-types along indifference curve U^{L} bearing a deductible at *A*. Competition for H-types ensures that they receive full and fair insurance while competition for L-types dictates the smallest deductible consistent with the incentive constraint (1) and the strong zero-profit constraint. Competition causes the equilibrium to unravel if the proportion of H-types is small enough to admit a profitable defection.[5] This possibility is ruled out in Figure 1.

Point *F* represents the first-best compulsory pooling contract, which lies closer to H^{*} along the 45-degree line as l increases. The locus *FA* depicts wealth positions for L-type contracts that pair with H-type contracts on the 45-degree line while satisfying both the incentive constraint (1) and the weak zero-profit constraint (2).[6] The existence of equilibrium turns on the slope of this locus at point *A* relative to the marginal rate of substitution for L-types at that point. The Figure depicts the case in which l equals the critical value l^{*} such that these two slopes are equal and equilibrium is just about to fail. If l were any smaller, then a portion of locus *FA* would lie above the L-type indifference curve passing through point *A* and a profitable pair of defecting, cross-subsidized contracts would attract both risk types away from the Nash equilibrium causing the market to close with the loss retained by all individuals at the endowment point $E \equiv (W^{0}, W^{0} - D)$. On the other hand, the pure strategy Nash screening equilibrium exists if l is greater than or equal to l^{*}.

To characterize the critical proportion of H-types, we first determine the slope of the locus *FA* by totally differentiating equations (1) and (2) with respect to W_1^L, W_2^L, and $\boldsymbol{p}^H$, and solving for $-dW_2^L / dW_1^L$. We obtain

$$\begin{aligned} r_U(l) \equiv [\, l(1-p^H)U_2' + (1-l)(1-p^L)U_H' \,] \\ /[\, lp^H U_1' + (1-l)\, p^L U_H' \,] \end{aligned} \tag{3}$$

as the slope of locus *FA*, where primes denote derivatives and subscripts on $U(\cdot)$ refer to the alternative wealth levels.[7] At point *A*, the slope $r_U(l)$ equals the L-type marginal rate of substitution for $U(\cdot)$,

$$MRS_U^L \equiv (1-p^L)U'(W_1^L)/p^L U'(W_2^L)\,, \tag{4}$$

when l equals the critical value l^*. To investigate the effect of background risk on the extent of insurance coverage, we shall suppose this to be the case so that existence is just about to fail in the absence of background risk.

III. An Insurance Market with Adverse Selection and Background Risk

To introduce background risk, we add the random variable e to each individual's wealth, and assume that e is uncorrelated across individuals, uncorrelated with the loss *D*, and has a nonpositive expected value. Figure 2 illustrates the effect of introducing background risk on an H-type applicant. The indifference curve labeled U^H refers to an H-type in the absence of background risk with utility function $U(\cdot)$. The curve labeled V^H refers to the same individual in the presence of background risk, so that in place of $U(\cdot)$ the utility function is

$$V(W) \equiv E[U(W+e)],$$

where $E[\cdot]$ denotes the expectation operator. A vulnerable decision maker is depicted, with background risk increasing risk aversion and contracting the acceptance set as shown. As a consequence, when all H-types possess background risk, the incentive compatible, breakeven L-type contract changes from *A* to A', which has a lower deductible. As a result of this "deductible" effect it is less costly for L-types to separate themselves from H-types by accepting the deductible contract and therefore l^* declines, expanding the set of markets in which the pure strategy Nash equilibrium exists.

Figure 3 illustrates the effect of background risk on an L-type applicant. At point *A*, the L-type indifference curve becomes flatter and cuts below locus *FA*. As a result of this "vulnerability" effect it is more costly for L-types to separate from H-types by accepting the deductible contract and l^* increases, contracting the set of markets in which the pure strategy Nash equilibrium exists.

A. Unobservable Background Risk

When insurers cannot verify background risks, or are otherwise prohibited from using information on such risks in designing insurance contracts, its distribution in the population is the critical factor that determines whether the deductible effect or the vulnerability effect has the deciding influence on equilibrium.[8] Let m^t denote the proportion of t-types with background risk. The pure strategy Nash screening equilibrium is now potentially broken not only by insurance pools that attract everyone, but also by insurance pools that attract L-types with background risk and H-types without it (type 1 insurance pools), and those that attract L-types with background risk and all H-types (type 2 insurance pools). Figure 4 illustrates examples of type 1 and type 2 insurance pools.[9] Since the former has a smaller proportion of H-types than the latter, if a type 2 insurance pool breaks the equilibrium, then a type 1 pool does so as well, but not vice versa. We therefore focus on type 1, and distinguish between cases in which m^H is less than one rather than equal to one.

1. $m^H < 1$. When m^H is less than one, incentive constraint (1) must still be satisfied because there are H-types without background risk. The zero-profit condition for defecting contracts is now

$$jp^H + (1 - j)p^L = 0 \tag{2´}$$

in place of (2), where the proportion of H-types is

$$j \equiv (1 - m^H)\, l^* / [(1 - m^H)\, l^* + m^L (1 - l^*)]\,. \tag{2´´}$$

Using (2´) in place of (2) yields as the slope of the locus *FA* for type1 insurance pools the expression on the right-hand side of (3) with j replacing l. On the other hand, since individuals are vulnerable, with partial coverage, MRS^L is lower for L-types with background risk, that is,

$$MRS_V^L \equiv (1 - p^L)V'(W_1^L) / \, p^L V'(W_2^L) \tag{4´}$$

is less than MRS_U^L given in (4) whenever W_1^L exceeds W_2^L.

Recall that, at point *A*, $r_U(l^*)$ equals MRS_U^L, and that r decreases with increases in l. Also, point *A* does not change with the introduction of background risk when m^H is less than one. Hence, the introduction of background risk breaks the pure strategy Nash screening equilibrium if and only if, at point *A*, MRS_V^L is less than $r_U(j)$.

Since, by assumption, the single crossing property continues to hold, we have

$$MRS_V^L > (1 - p^H)U'(W_1^L) / \, p^H U'(W_2^L) \tag{5}$$

at point *A*. It follows that, as j approaches one, $r_U(j)$ decreases and approaches the right-hand side of (5). Hence, there is a critical value $j^* \in (l^*, 1)$ such that the equilibrium continues to exist if and only if $j \geq j^*$. Definition (2´´) for j implies that a necessary condition for this inequality is $j > l^*$ or, equivalently,

$$1 - m^H > m^L.$$

It follows that, whenever the proportion of H-types with background risk, m^H, exceeds the proportion of L-types without it, $(1 - m^L)$, the introduction of background risk closes the insurance market.

2. $m^H = 1$. In contrast with these environments where m^H is less than one and the equilibrium L-type contract is unaffected by the introduction of background risk, in environments where all H-types possess background risk, the equilibrium L-type contract is affected by its presence. Since all H-types are more risk averse, incentive constraint (1) is no longer relevant and in its place we have

$$V(W^H) = (1 - p^H)V(W_1^L) + p^H V(W_2^L). \qquad (1')$$

This is a weaker constraint since $V(\cdot)$ is more risk averse than $U(\cdot)$, and therefore the equilibrium L-type deductible is lower.

The implications of unobservable background risk for the locus *FA* are illustrated in Figure 5. The locus rotates upward to *FA´* as shown. In addition, the value of MRS_U^L is greater at *A´* than at *A*. As a consequence, if no L-types possess background risk, then the greater risk aversion of H-types improves prospects for existence and the critical value for l is lower.

If any L-types also possess background risk, then type 2 insurance pools could break the equilibrium at (H^*, A'). When m^L is less than one, the proportion of H-types in type 2 pools exceeds l^* and the corresponding point *F* for these pools is lower along the 45-degree line, and the relevant locus *FA* is now *F´A´* as shown in Figure 2. When m^L also equals one, *F´* coincides with F. If, in that instance, at point *A´*, MRS_V^L exceeds the slope of the *FA´* locus $r_V(l^*)$ obtained from (3) with $V'(\cdot)$ replacing $U'(\cdot)$, then prospects for existence improve. The opposite is true when MRS_V^L is less than $r_V(l^*)$, and in these instances, a critical value for m^L

exists such that prospects worsen or improve as m^L exceeds or falls short of the critical value at which the slope of the locus *F´A´* equals MRS_V^L at point *A´*.

In the next section, we further explore the case in which all individuals have background risk by assuming that insurers can categorize on that basis.

B. Observable Background Risk

We now suppose that insurers can verify and use information about background risk in contracting. In this event, individuals are categorized. To see this, notice that when individuals are not categorized, there exists a contract such as the type 1 insurance pool in Figure 4 that attracts only L-types with background risk and earns positive profit, since H-types without background risk can be identified and prevented from purchasing this contract. Hence, an equilibrium without categorization cannot be sustained.

If $m^H = m^L$, then the existence of equilibrium is unaffected for those without background risk.[10] For those with background risk, however, the relevant incentive constraint is (1´), point *A* changes to point *A´* as in Figure 5, and the locus *FA* rotates upward to *FA´*. Let l' denote the critical proportion of H-types such that, at point *A´*,

$$\Delta \equiv MRS_V^L - r_V(l)$$

equals zero and existence is just about to fail. To study the effect of background risk in this market, we replace e with xe for a nonnegative scalar x initially set equal to zero and increase x to determine how l' must change to maintain $\Delta = 0$.[11]

As x increases, point *A´* moves up the L-type fair-odds line. Maintaining $p^L = 0$ requires

$$dW_2^L = -(1 - p^L)dW_1^L / p^L,$$

while maintaining incentive compatibility requires

$$
\begin{aligned}
&\partial\{E[\varepsilon U'(W^H)] - (1-p^H)E[\varepsilon U'(W_1^L)] - p^H E[\varepsilon U'(W_2^L)]\}/\partial\varepsilon \cdot d\varepsilon \\
&\quad = (1-p^H)V'(W_1^L)dW_1^L + p^H V'(W_2^L)dW_2^L \\
&\quad = [(1-p^H)V'(W_1^L) - p^H(1-p^L)V'(W_2^L)/p^L]dW_1^L .
\end{aligned}
$$

Thus, to maintain $\Delta = 0$ we require that, with dW_1^L satisfying this relation,

$$(\partial\Delta/\partial\lambda)d\lambda' = -(\partial\Delta/\partial\xi)d\xi - [(\partial\Delta/\partial W_1^L) - (1-p^L)(\partial\Delta/\partial W_2^L)/p^L]dW_1^L .$$

Since $\partial\Delta/\partial\lambda$ is positive,[12] $d\lambda'$ has the same sign as the right-hand side. The first term captures the vulnerability effect. As we shall see, $\partial\Delta/\partial\xi$ is negative, so the vulnerability effect of background risk on λ' is positive, worsening prospects for existence. The second term captures the deductible effect. This term is positive, enhancing prospects for existence as L-types are less easily attracted to a defecting pool. Hence, the sign of $d\lambda'$ depends on whether the vulnerability or the deductible effect dominates.

First, suppose individuals are invulnerable. In this case, $A \equiv A'$ and $dW_1^L \equiv 0$, so there is no deductible effect. However, there is also no vulnerability effect. To verify this, write $\Delta = N/K$ with

$$
\begin{aligned}
N = &(V_1'/V_2')[(1-p^L)p^H - (1-p^H)p^L](1/p^L p^H) \\
&- (1-p^L)(1-\lambda)V_H'(1-V_1'/V_2')/p^H \lambda V_1'
\end{aligned}
$$

and

$$K = 1 + p^L(1-\lambda)V_H'/p^H \lambda V_1',$$

so that, given $\Delta = 0$,

$$\partial\Delta/\partial\xi = (\partial N/\partial\xi)(1/K).$$

Since $K > 0$, $\partial\Delta/\partial\xi$ has the same sign as

$$\partial N/\partial\xi = T_1[\partial(V_H'/V_1'/\partial\xi] + T_2[\partial(V_1'/V_2')/\partial\xi],$$

where

$$T_1 = -(1-p^L)(1-\lambda)(1-V_1'/V_2')/p^L p^H \lambda$$

is negative and

$$T_2 = [(1-p^L)/p^L] - [(1-p^H)/p^H] + (1-p^L)(1-\boldsymbol{l})V_H'/p^L p^H \boldsymbol{l} V_2'$$

is positive. For invulnerable individuals, marginal rates of substitution are unaffected by background risk, and therefore $\partial(V_1'/V_2')/\partial \boldsymbol{x} = 0 = \partial(V_H'/V_1')/\partial \boldsymbol{x}$, so that $\partial\Delta/\partial \boldsymbol{x}$ equals zero as well.

When individuals are vulnerable, marginal rates of substitution increase (decrease) whenever W_1 is less (greater) than W_2. Hence, we have

$$\partial(V_1'/V_2')/\partial \boldsymbol{x} < 0$$

since W_1^L is greater than W_2^L, while

$$\partial(V_H'/V_1')/\partial \boldsymbol{x} > 0$$

since W^H is less than W_1^L. It follows that $\partial\Delta/\partial \boldsymbol{x}$ is negative, so the vulnerability effect is positive, tending to worsen prospects for existence. Ceteris paribus, the vulnerability effect is stronger the greater the degree of either temperance or prudence.[13]

The deductible effect, which improves prospects for existence, is the product of two components. First, a breakeven change in (W_1^L, W_2^L) influences Δ, and second, W_1^L declines with background risk. To evaluate the first component, observe that

$$\partial\Delta/\partial W_1^L = \{[(1-p^L)/p^L V_2'] - (1-p^H)/K\} \cdot V_1''$$

is negative, while

$$\partial\Delta/\partial W_2^L = [(Np^H/K^2) - (1-p^L)V_1'/p^L(V_2')^2] \cdot V_2''$$

is positive. It follows that the first component of the deductible effect is also negative. Hence, the deductible effect of background risk on $\boldsymbol{l}'$ is negative, and when it dominates the vulnerability effect, an increase in background risk reduces $\boldsymbol{l}'$, improving the prospects for existence and extending insurance coverage.

Notice that both $\partial\Delta / \partial W_1^L$ and $\partial\Delta / \partial W_2^L$ are greater in absolute value as risk aversion increases,[14] ceteris paribus, which strengthens the deductible effect. Hence, the deductible effect dominates when the index of absolute risk aversion, $-U'' / U'$, is relatively high for a given degree of vulnerability, and prospects for existence improve for those categorized with background risk. Conversely, for the same degree of vulnerability but a relatively low index of risk aversion, the insurance market closes for those categorized with background risk.

IV. Conclusions

Insurance applicants may possess uninsurable, background risks that increase the risk aversion of vulnerable individuals. Whether observable or not, these background risks can influence the performance of insurance markets by affecting the extent of insurance coverage. In particular, if the proportion of high risks with background risk is less than one but greater that the proportion of low risks without it, then unobservable background risk closes some insurance markets. On the other hand, if insurers can categorize applicants with respect to background risk, then some insurance markets may open for both those with and those without background risk.

It follows that successful efforts to open markets for insuring background risks may also have implications for the performance of preexisting markets. When the introduction of background risks would enhance prospects for existence of equilibrium, extending insurance coverage to those risks has a positive social value insofar as previously uninsurable risks are now covered, but also has a countervailing negative social value in that some insurance markets may close as a result.

Finally, in the absence of background risk, the assumption that every insurance applicant has the same von Neumann-Morgenstern utility function $U(\cdot)$ can be rationalized by assuming that insurers categorize on the basis of some observed traits or behaviors that reveal the degree of risk aversion. If such categorization is practicable and some applicants possess background risk, then the market corresponds to the case we have analyzed in which insurers can categorize applicants on the basis of verifiable background risk. On the other hand, if insurers cannot effectively categorized on the basis of risk aversion, then the assumption that everyone has utility function $U(\cdot)$ can be relaxed at the expense of increased complexity. As long as the single-crossing property continues to hold, however, our qualitative results would be unaffected.

Footnotes

[1] Alternatively, we could assume that the market, rather than closing, attains a pooling equilibrium sustained by the non-Nash "anticipatory" behavior suggested by Wilson (1977) or as the strategically stable equilibrium of the three-stage game introduced by Grossman (1979) and Hellwig (1987). In each case, the market outcome is inefficient when the pure strategy Nash equilibrium fails to exist.

[2] Gollier and Pratt show that a decision maker is risk vulnerable, and therefore becomes more risk averse when any fair or unfair background risk is introduced, if and only if both the indexes of prudence $(P \equiv -U'''/U'')$ and temperance $(T \equiv -U''''/U''')$ exceed the index of risk aversion $(R \equiv -U''/U')$. It is easy to verify that, with constant absolute risk aversion, $P = R = T$, so this decision maker is invulnerable.

[3] Although we have cast the problem in terms of the presence or absence of background risk, the analysis applies equally to the general case in which individuals differ in the extent of their exposure to background risks.

[4] Crocker and Snow (1985) show that a system of taxes and subsidies can be assessed against insurance contracts to implement any cross-subsidization needed to ensure existence of a pure strategy Nash equilibrium in the Rothschild-Stiglitz model.

[5] In the pure strategy Nash screening equilibrium, insurers offer a menu of premium-deductible pairs from which insurance applicants choose their most preferred option, and no profitable alternative menu exists. Although Rothschild and Stiglitz emphasized pooling contracts as potentially profitable defections, a pair of contracts in which losses generated by the H-type contract are offset by profits earned on the L-type contract is also a potentially profitable defection, as discussed by Engers (1987). When the Nash equilibrium exists, the outcome corresponds to the Pareto dominant member of the family of contracts that break even individually and satisfy the incentive constraint (1), as shown by Riley (1979).

[6] See Crocker and Snow (1985) and Dionne and Fombaron (1996) for the characterization of this locus.

[7] Equation (2) implies $l d\mathbf{p}^H/(1-l) = (1-p^L)dW_1^L + p^L dW_2^L$ and equation (1) implies $-U'_H d\mathbf{p}^H = (1-p^H U'_1 dW_1^L + p^H U'_2 dW_2^L$. Substituting for $d\mathbf{p}^H$ from the former into the latter and rearranging terms yields equation (3).

[8] We confine attention to situations in which the single crossing of indifference curves continues to hold even as individuals differ in their aversion to risk bearing.

[9] Note that an insurance pool may consist of a pooling contract such as those illustrated in Figure 4, in which both H- and L-types choose the same contract, or a separating pair of contracts, in which the two types choose different contracts.

[10] With $m^H > (<)\ m^L$, prospects for existence are worse (better) in the category without background risk than when $m^H = m^L$.

[11] When $x = 0$, $l' = l^*$ and, at point $A' = A$, $\Delta = 0$. The change $dx > 0$ then introduces a small background risk.

[12] In particular, $\partial\Delta / \partial l$ can be written as

$$-[(1 - p^L) V_H' (1 - V_1'/V_2') / p^H V_1'](1/l^2)/K,$$

where K is positive. This expression is positive since W_1^L exceeds W_2^L.

[13] Keenan and Snow (2002) show that the introduction of a small fair background risk leads to a greater increase in risk aversion for a decision maker with a higher index of vulnerability as measured by $(T - R)PR$.

[14] To see this, note that the term multiplying V'' is negative (positive) in the expression for $\partial\Delta / \partial W_1^L$ $(\partial\Delta / \partial W_2^L)$, so that a higher index of risk aversion $-V''/V'$, ceteris paribus, results in a more negative (positive) value for $\partial\Delta / \partial W_1^L$ $(\partial\Delta / \partial W_2^L)$.

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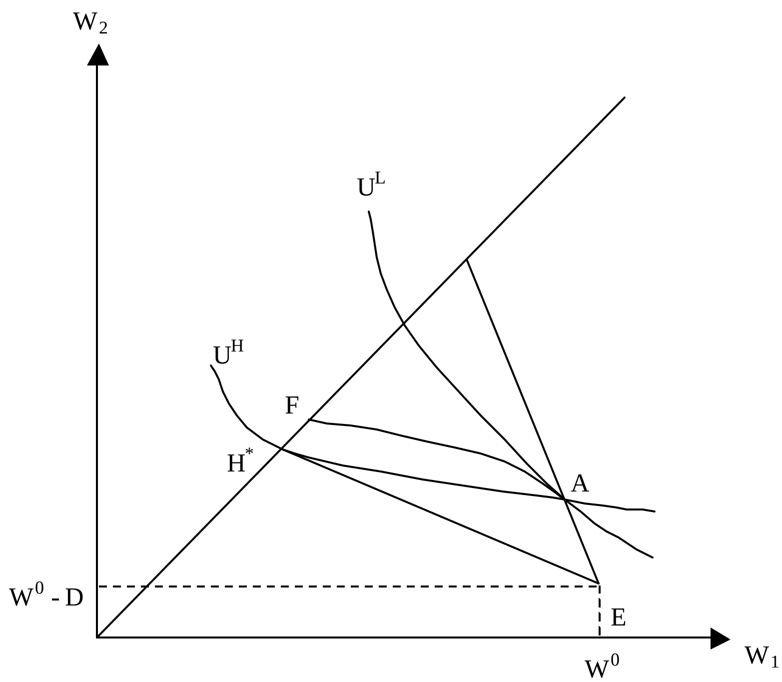


Figure 1

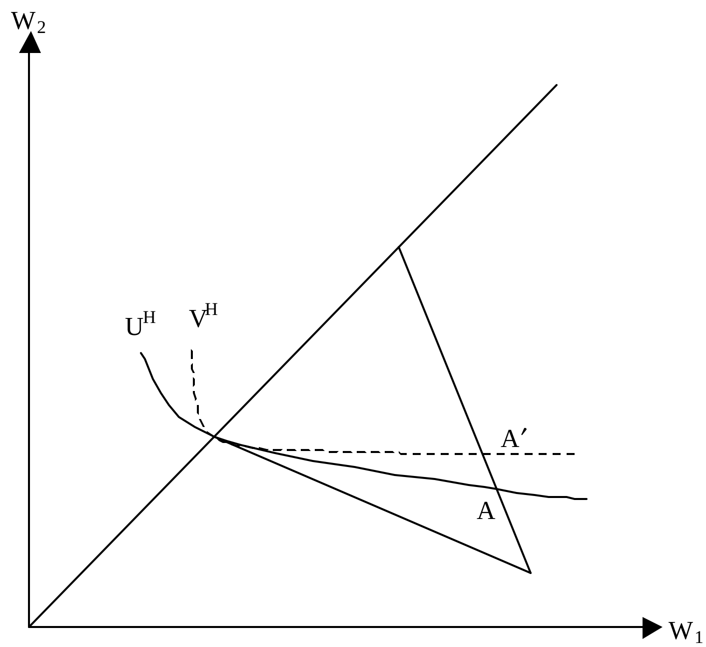


Figure 2

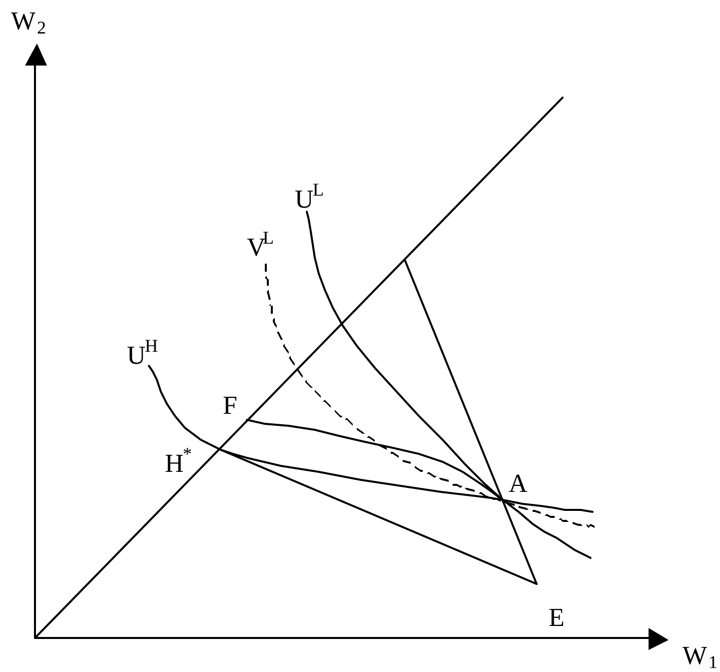
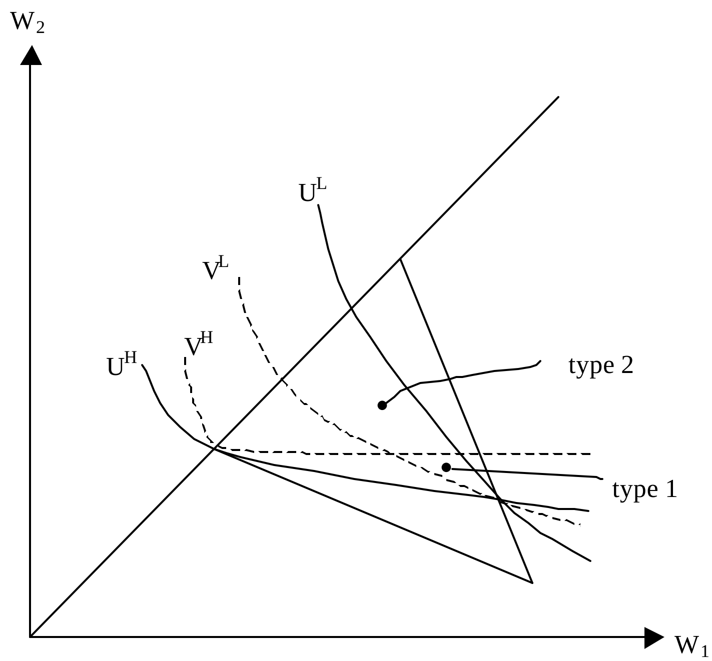


Figure 3



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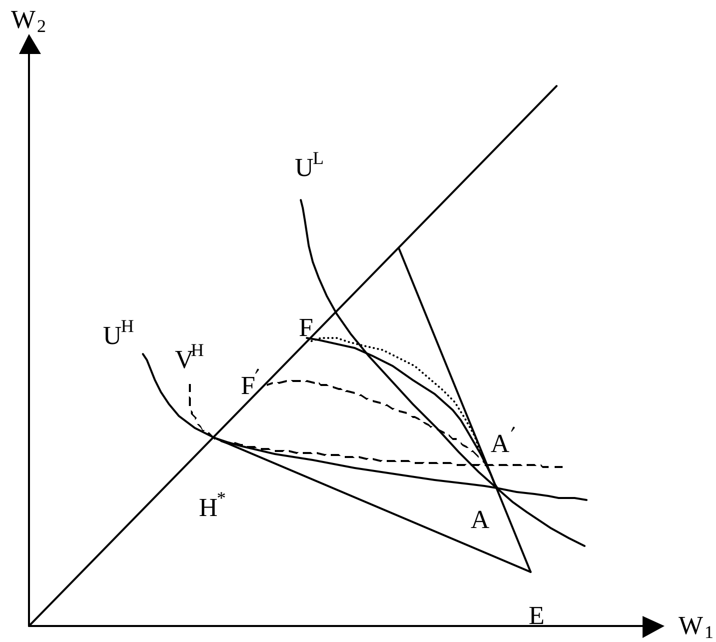

Figure 5