Mitigating adverse selection through multi-peril insurance policies

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Abstract

The objective of this paper is to pursue an intuitive idea: For a consumer who is an unfavorable health risk but a "better" risk as a driver, would a multi-peril policy not be associated with a reduced selection effort on the part of the insurer? If this intuition should be confirmed, it could serve to mitigate the decade-long concern with risk selection both in the economic literature and by policy makers. A two-perils model is developed in which consumers deploy effort in search of a policy offering them most coverage at the going premium while insurers deploy effort designed to stave off unfavorable risks. Two types of Nash equilibria are compared, one in which the insurer is confronted with high-risk and low-risk types as usual and another one, where both types are a "better" risk with regard to a second peril. The difference in selection effort directed at high-risk and low-risk types is indeed found to be reduced in the second case.

Keywords: Adverse selection; Risk selection; Consumer search effort; Insurer selection effort

Acknowledgment: …….

1 Introduction and motivation

For several decades, adverse selection in competitive insurance markets has been an issue for insurance companies (ICs henceforth), economists, and policy makers. ICs have been afraid of losing their favorable risks to a competitor, as predicted by Rothschild and Stiglitz (1976), economists continue to analyze if and how equilibrium in insurance markets might dissolve [e.g. Wilson (1977), Engers and Fernandez (1987), Asheim and Nilssen (1996), and again Rothschild and Stiglitz (1997), and policy makers worry about unfavorable risks being discriminated against [e.g. Rosenbaum (2009), Avraham, Logue, and Schwarcz (2014), Petkantchin (2010)].

Yet there are two striking observations regarding this literature. The first is that in the age of multiline ICs, much of the analysis has revolved exclusively about one risk. However, Crocker and Snow (2011) note that many insurance contracts bundle several perils, often with differing deductibles[1]. They develop a model in which low-risk consumers can signal their type through their deductible choices and show that this may enhance the efficiency of self-sorting to a degree that the market approaches a stable Nash equilibrium. This result holds regardless of the intuitive argument that a multiline IC´s concern about adverse selection would be mitigated because a future expected loss in one line is likely to be balanced by an expected gain in the other.

The second observation is that consumers are seen as seeking out a policy without deploying costly search effort, while ICs undertake risk selection effort that is costless. Ever since Rothschild and Stiglitz (1976), low-risk consumers have been implicitly assumed to find the contract suiting them without deploying effort. Yet the Internet is replete with website offering advice on how to choose an insurance policy (e.g. https://insuranceadviser.net/consumer-advice, https://car-advice/a26553500/how-to-reduce-car-insurance/, https://www.usa.gov/insurance). On the part of the IC, the implementation of separating contracts designed to stave off adverse selection also entails costly effort. Attracting high-risk types is relatively easy: All it takes is to offer a policy with a relatively high degree of coverage at a high premium. However, the IC also needs to launch a contract with limited coverage but a low premium to attract low-risk types. In this, it faces two challenges, viz. to prevent high-risk types from infiltrating this contract also through renegotiation [see e.g. Dionne and Doherty (1994)] and to prevent a competitor from siphoning off its low-risk types through clever contract design. While in

[1] Among the ten leading US insurance companies, all have at least two lines of business (typically, auto and homeowners´); Geico (owned by Berkshire Hathaway) even features no fewer than 12. (https://www.thetruthaboutinsurance.com/ and the pertinent company websites, accessed 26 Aug 2020).

the model of Crocker and Snow (2011), the self-sorting of risks achieves this at no cost, many firms offer advice on developing and marketing insurance policies in the Internet (see e.g. https://bizfluent.com/about-6629092-role-marketing-insurance.html, https://innovalue.de/en/expertise/projects/maklerstrategie.php, https://wiki.scn.sap.com/wiki/display/ESpackages/Insurance+Policy+Issuing+and+Underwriting). Evidently, risk selection is a costly activity.

Against this background, the present contribution introduces costly effort on both sides of the market. Consumers need to deploy search effort to identify the policy offering them the highest coverage for the given premium, while ICs set their risk selection effort as to maximize expected profit. Accordingly, in Section 2 Nash equilibria are derived in efforts space to model the interaction of high-risk and low-risk consumers with an IC. These equilibria can be shown to be less far apart in efforts space if risk types are a "better" risk w.r.t. to a second peril than when this is not the case. In addition, the equilibrium characterizing the IC´s interaction with the high-risk type involves reduced risk selection effort compared with a single-risk policy. In Section 3, these results are projected into the familiar wealth levels space, where the rationing constraint inherent in separating equilibria is taken into account. A conclusion and outlook follows in Section 4.

2 Modelling the interaction between consumers and insurers in the presence of a two-perils policy

In this section, a simple game-theoretic model is developed to determine Nash equilibria for unfavorable ("high" henceforth) and favorable ("low") risk types in efforts space (for the projection into conventional wealth levels space, see Section 3). Starting in efforts space takes account of costly consumer search, which is implicit in the received literature on adverse selection. It also permits to integrate risk selection effort on the part of the IC (developing contract variants is a costly activity, as argued in Section 1). In the present model, search effort and risk selection effort are the decision variables controlled by the respective players.

2.1 Consumers

Consumers are seen as expected utility maximizers who undertake search effort for securing maximum amounts of coverage $I^H\left(I^L\right)$ and $J^H\left(J^L\right)$ for both risks at the going combined premium $P^H\left(P^L\right)$[2], which they view as exogenous,

[2] Premia are the outcome of the Nash equilibria, to be determined below.

$$EU_{c^H}^{H} = \rho^H \cdot \left(\rho^H \Delta\right) \upsilon^H \left[W_0 + I^H\left(c^H, e\right) - K - L - P^H\right]$$
$$+\left(1-\rho^H\right) \cdot \left(\rho^H \Delta\right) \upsilon^H \left[W_0 + I^H\left(c^H, e\right) - K - P^H\right]$$
$$+\rho^H \cdot \left(1-\rho^H \Delta\right) \upsilon^H \left[W_0 + J^H\left(c^H, e\right) - L - P^H\right]$$
$$+\left(1-\rho^H\right) \cdot \left(1-\rho^H \Delta\right) \upsilon^H \left[W_0 - P^H\right] - c^H, \text{ with}$$
$$P^H = 2\bar{\rho}\left(1+\lambda^H(e)\right); \qquad (1a)$$

$$EU_{c^L}^{L} = \rho^L \left(\rho^L \Delta\right) \upsilon^L \left[W_0 + I^L\left(c^L, e\right) - K - L - P^L\right]$$
$$+\left(1-\rho^L\right)\left(\rho^L \Delta\right) \upsilon^H \left[W_0 + I^H\left(c^L, e\right) - K - P^L\right]$$
$$+\rho^L \left(1-\rho^L \Delta\right) \upsilon^L \left[W_0 + J^H\left(c^L, e\right) - L - P^L\right]$$
$$+\left(1-\rho^L\right)\left(1-\rho^L \Delta\right) \upsilon^L \left[W_0 - P^L\right] - c^L, \text{with}$$
$$P^L = 2\bar{\rho}\left(1+\lambda^L(e)\right). \qquad (1b)$$

Here, EU^H (EU^L) denotes expected utility of the high (low) risk type, with superscripts H and L not explained separately below unless necessary. Thus, υ^H is the VNM risk utility function with $\upsilon^{H\prime} > 0$ and $\upsilon^{H\prime\prime} < 0$ $\left(\upsilon^{L\prime} > 0 \text{ and } \upsilon^{L\prime\prime} < 0\right)$. Both risk types are exposed to a second peril with a lower probability given by $\rho^H = \rho^H \Delta$ and $\rho^L = \rho^L \Delta$, respectively, with $0 < \Delta < 1$ indicating that both of them are "better risks" in this regard. However, the common value of Δ (which is public information) leaves their ordering unchanged in the sense of a single-crossing property[3]. Next, W_0 is exogenous initial wealth, $I^H\left(c^H, e\right)$ the amount of coverage which depends on both consumer´s search effort with $\partial I^H / \partial c^H > \partial I^L / \partial c^L > 0$ and $\partial^2 I^H / \partial c^{H2} < 0, \partial^2 I^L / \partial c^{L2} < 0$ as well as insurer´s selection effort with $\partial I^H / \partial e < 0, \partial J^H / \partial e < 0$ and $\partial I^L / \partial e < 0, \partial J^L / \partial e < 0$ because regardless of risk type consumers are burdened by providing additional information to the IC[4]. Finally, K and L denote the two losses.

[3] If only the high-risk types were to benefit from a $\Delta < 1$, this information would be private, and a consumer showing interest in covering a second peril would be classified as a high risk -type, rendering a two-perils policy unattractive to begin with.

[4] Selection effort e is set at a common value for both high- and low-risk types, reflecting the assumption that the IC cannot distinguish between them and has to rely on separating contracts.

In view of the information asymmetry, the premium covers the two risks based on a population average value $\bar{\rho}$ with loadings that increase with selection effort $\lambda^H(e)$ and $\lambda^L(e) < \lambda^H(e)$ which reflect separating contracts.

The first-order conditions for an interior optimum are given by

$$
\begin{aligned}
\frac{dEU^H}{dc^H} &= \rho^H \cdot \left(\rho^H \Delta\right) \upsilon^{H\prime}\left[W_0 + I^H\left(c^H, e\right) - K - L - P^H(e)\right] \frac{\partial I^H}{\partial c^H} \\
&\quad + \left(1-\rho^H\right)\left(\rho^H \Delta\right) \upsilon^{H\prime}\left[W_0 + I^H\left(c^H, e\right) - K - P^H(e)\right] \frac{\partial I^H}{\partial c^H} \\
&\quad + \rho^H\left(1-\rho^H \Delta\right) \upsilon^{H\prime}\left[W_0 + J^H\left(c^H, e\right) - L - P^H(e)\right] \frac{\partial J^H}{\partial c^H} \\
&\quad + \left(1-\rho^H\right)\left(1-\rho^H \Delta\right) \upsilon^{H\prime}\left[W_0 - P^H(e)\right] \frac{\partial J^H}{\partial c^H} - 1 = 0; \qquad \text{(2a)}
\end{aligned}
$$

$$
\begin{aligned}
\frac{dEU^L}{dc^L} &= \rho^L \cdot \left(\rho^L \Delta\right) \upsilon^{L\prime}\left[W_0 + I^H\left(c^H, e\right) - K - L - P^L(e)\right] \frac{\partial I^L}{\partial c^H} \\
&\quad + \left(1-\rho^L\right)\left(\rho^L \Delta\right) \upsilon^{L\prime}\left[W_0 + I^L\left(c^L, e\right) - K - P^L(e)\right] \frac{\partial I^L}{\partial c^L} \\
&\quad + \rho^L\left(1-\rho^L \Delta\right) \upsilon^{L\prime}\left[W_0 + J^H\left(c^H, e\right) - L - P^L(e)\right] \frac{\partial J^H}{\partial c^H} \\
&\quad + \left(1-\rho^L\right)\left(1-\rho^L \Delta\right) \upsilon^{L\prime}\left[W_0 - P^L(e)\right] \frac{\partial J^L}{\partial c^L} - 1 = 0. \qquad \text{(2b)}
\end{aligned}
$$

Because the first four terms are positive, the existence of interior solutions may be assumed. Note that unless the derivatives of the $\upsilon(\cdot)$, $I(c,e)$, and $J(c,e)$ functions differ substantially between risk types (for which there is no apparent reason), the high-risk types are predicted to undertake more effort than the low ones since $\rho^H > \rho^L$ and

$$
\begin{aligned}
&\rho^H \cdot \left(\rho^H \Delta\right) + \left(1-\rho^H\right)\left(\rho^H \Delta\right) + \rho^H\left(1-\rho^H \Delta\right) + \left(1-\rho^H\right)\left(1-\rho^H \Delta\right) \\
&-\left\{\rho^L \cdot \left(\rho^L \Delta\right) + \left(1-\rho^L\right)\left(\rho^L \Delta\right) + \rho^L\left(1-\rho^L \Delta\right) + \left(1-\rho^L\right)\left(1-\rho^L \Delta\right)\right\} \\
&= \left(\rho^{H2} - \rho^{L2}\right)\Delta + \left(\rho^H - \rho^L\right)\Delta - \left(\rho^{H2} - \rho^{L2}\right)\Delta + \left(\rho^H - \rho^L\right)\Delta \\
&\quad - 2\left(\rho^H - \rho^L\right)\Delta + \left(\rho^{H2} - \rho^{L2}\right)\Delta \\
&= \left(\rho^{H2} - \rho^{L2}\right)\Delta > 0, \qquad \text{(3)}
\end{aligned}
$$

indicating that the marginal benefit of search is higher for them. This also implies that at a given value of selection effort *e*, consumer search by high-risk types is at least as large as that by low-risk types (see Figure 1 below).

The derivation of the reaction functions displayed in Figure 1 is relegated to Appendix A, where the one pertaining to the high-risk type is found to be of ambiguous slope while the one pertaining to the low-risk type has a negative slope. The two type-specific reaction functions are shown in Figure 1 for the case of negative slopes (in Appendix C, it is shown that a positive slope leads to the same predictions as exhibited in Figure 2). As argued below eq. (A.4) of Appendix A, there is no reason for them to have differing slopes[5]. Finally, note that "more marked" in the text below eq. (A.7) means that a decrease in $\varDelta$ causes the reaction function of the high-risk type to rotate in more strongly than the one of the low-risk type.

2.2 Insurers

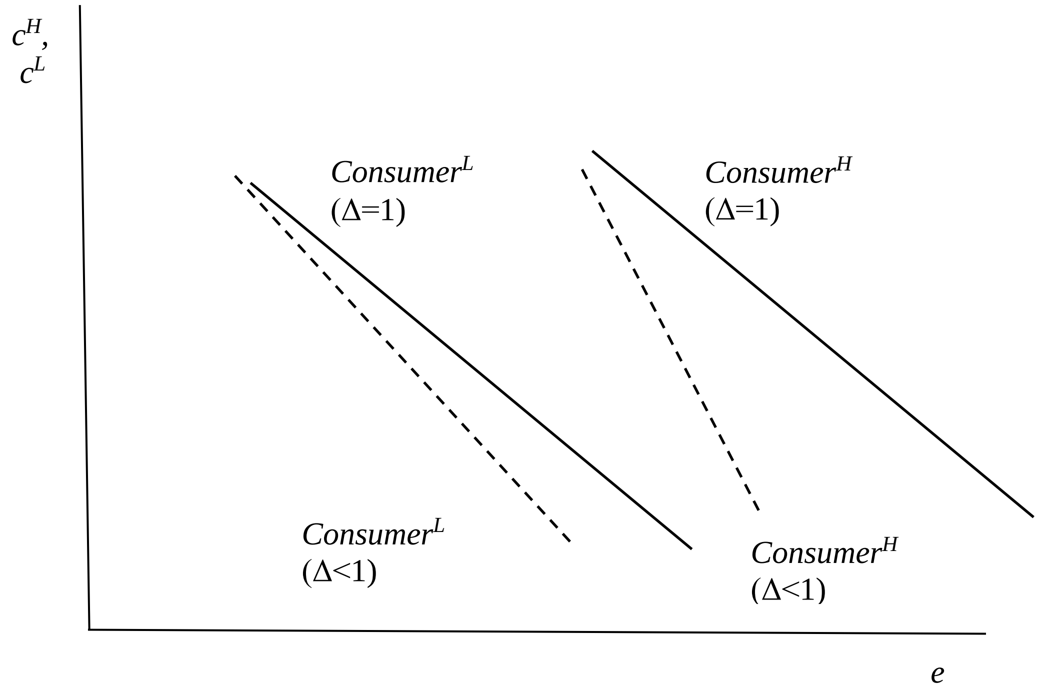
Insurers are viewed as expected profit maximizers,

$$\underset{e}{E\varPi} = \pi(e)\left[P^H(e) - I^H(c^H, e) - J^H(c^H, e)\right] + (1-\pi(e))\left[P^L(e) - I^L(c^L, e) - J^L(c^H, e)\right] - e. \qquad (4)$$

Here, $E\varPi$ denotes expected profit, $\pi(e)$, the probability of enrolling a high-risk type depending on risk selection effort e (at unit cost of one, also comprising administrative expense for simplicity) with $\partial\pi/\partial e < 0$ and $\partial\pi^2/\partial e^2 > 0$ indicating decreasing marginal effectiveness, P^H premium income from a high-risk type which depends positively on selection effort *e* through the loading $\lambda^H(e)$, and covered losses $I^H(c^H, e)$ and $J^H(c^H, e)$ which depend positively on consumer search effort and but negatively on the IC´s selection effort, as in Section 2.1. The first-order condition for an interior optimum reads,

[5] The reaction functions in Figure 1 are drawn as straight lines since nothing can be said about the third derivatives of the functions $I^H(c^H, e), J^H(c^H, e),$ and $I^L(c^L, e), J^L(c^L, e)$.

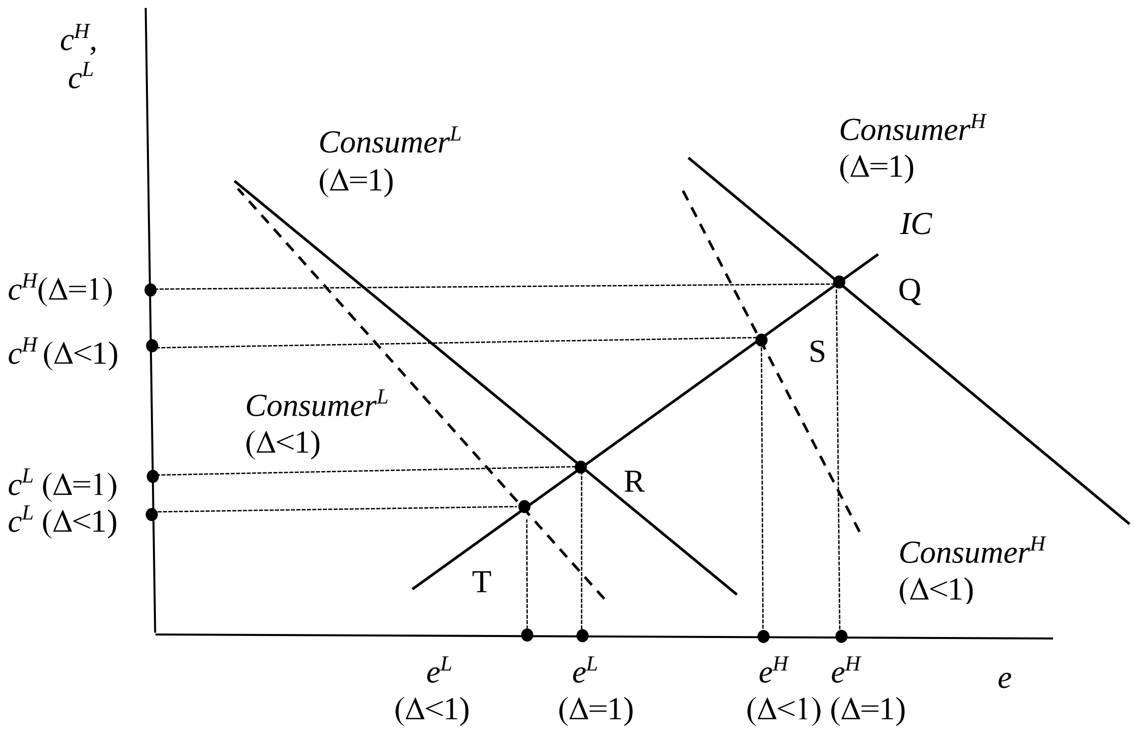
Figure 1. Reaction functions when consumers are "better" risks w.r.t. a second peril (downward-sloping case)



$$\frac{dE\Pi}{de} = \partial\pi/\partial e \cdot \left[P^H(e) - I^H - J^H\right] + \pi(e)\left[\frac{\partial P^H}{\partial e} - \frac{\partial I^H\left(c^H, e\right)}{\partial e} - \frac{\partial J^H\left(c^H, e\right)}{\partial e}\right]$$
$$-\partial\pi/\partial e \cdot \left[P^L(e) - I^L - J^L\right] + \left(1 - \pi(e)\right)\left[\frac{\partial P^L}{\partial e} - \frac{\partial I^L\left(c^L, e\right)}{\partial e} - \frac{\partial J^L\left(c^L, e\right)}{\partial e}\right] - 1$$
$$= 0. \quad (5)$$

The first term is positive due to $\partial\pi/\partial e < 0$ combined with the fact that benefits paid exceed the current premium; the second is positive as well (since $\partial P^H/\partial e = \left(\partial P/\partial\lambda\right) \cdot \left(\partial\lambda/\partial e\right) > 0$, $\partial I^H\left(c^H, e\right)/\partial e < 0$, $\partial J^H\left(c^H, e\right)/\partial e < 0$); the third is negative, and the fourth again positive. In all, overall marginal benefit almost certainly covers marginal cost, ensuring an interior solution.

Figure 2. Reaction functions of consumers (both negatively sloped), the IC, and Nash equilibria



The derivation of the IC´s reaction functions is relegated to Appendix B. Note that while there is only one decision variable e, in principle the functions depend on whether the IC is dealing with a high-risk or a low-risk type. However, the pertinent eqs. (B.1) and (B.2) cannot be distinguished without further assumptions; therefore, only one IC reaction function is entered in Figure 2.

Nash equilibrium Q obtains if the IC is confronted with a high-risk type w.r.t. both perils (Δ=1) who spends great deal of search effort (c^H). The resulting risk selection effort e^H is comparatively high, which is intuitive. Equilibrium R results if the consumer is a low-risk type who is confronted with substantially lower selection effort e^L and spends little search effort, still with Δ=1. With Δ<1, the equilibrium for the high-risk type moves to point S, with a lower search effort as well as risk selection effort. The same holds for the low-risk type, with transition from R to T. However, the reduction in risk selection effort is greater for the high-risk type [from e^H (Δ=1) to e^H Δ<1)] than for the low-risk one [from e^L (Δ=1) to e^L Δ<1)]. Therefore, the difference between the two levels [e^H (Δ<1) vs. e^L Δ<1)] diminishes, as shown in Appendix C.

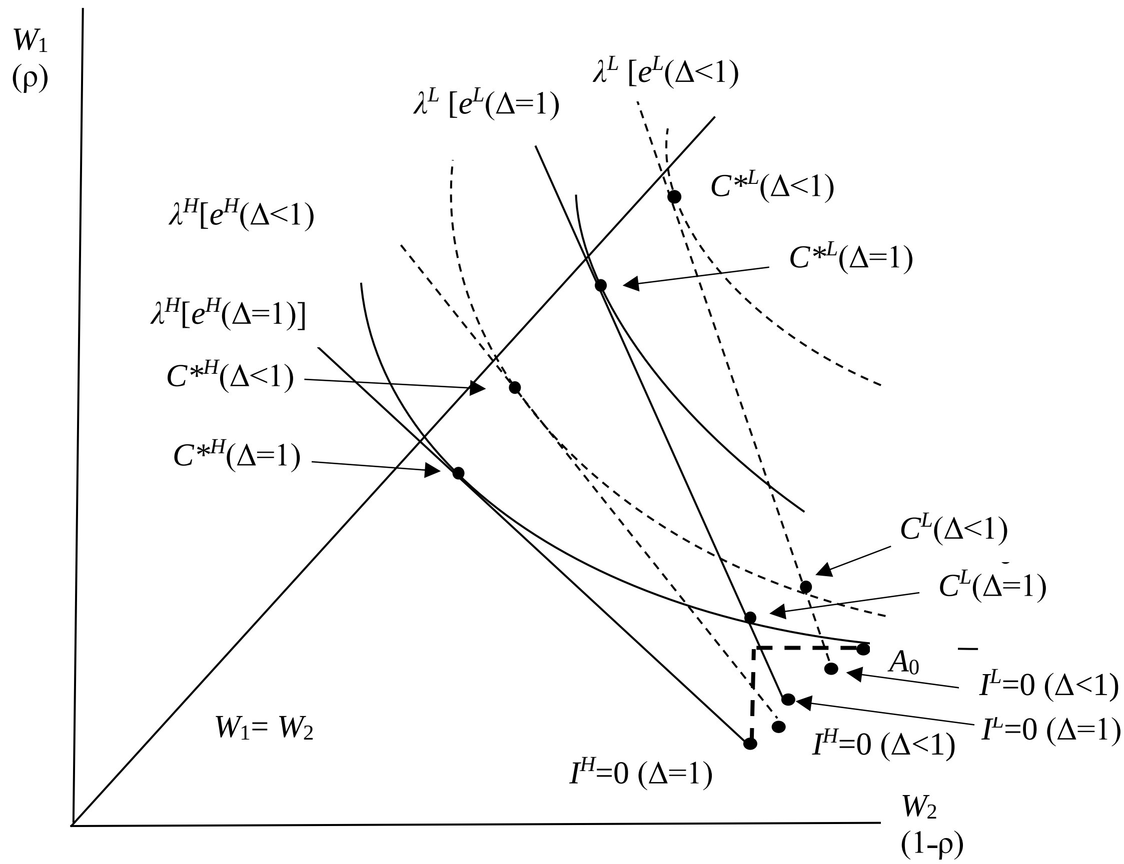
Conclusion 1. The interaction of consumers searching for maximum coverage given the premium and the risk-selecting insurer is predicted to result in a separating Nash equilibrium (if it exists) characterized by high consumer search and selection effort if the insurer is confronted with a high-risk type and low consumer search and selection effort if confronted with a low-risk type. These differences (in risk selection effort in particular, benefiting the high-risk type) decrease in case of a multi-peril policy if both consumer types are “better” risks with regard to one peril.

3 Projecting results from efforts space into wealth levels space

The Nash equilibria of Figure 2 can be projected into conventional (W_1, W_2)-space. For simplicity, the insurance lines pertaining to fair premiums are not shown in Figure 3 since the IC´s risk selection effort calls for a loading at any rate. According to Conclusion 1, the IC deploys relatively much risk selection effort when being confronted with a high-risk type. This results in a high loading that causes a reduction of optimal coverage; on the other hand, high-risk types are particularly keen to obtain a high degree of coverage. The location of their optimum C^{*H} in Figure 3 depends on the parameters appearing in eq. (2a) about which little is known, in particular $\upsilon^{H\prime}\left[W_0 + I^H\left(c^H, e\right) - K - L - P^H\left(e\right)\right]$, $\partial I^H / \partial c^H$, $\partial J^H / \partial c^H$, and $\partial \lambda^H / \partial e$. These efforts may even drive up the loading to such a high value that the endowment point A_0 dominates all points on the insurance line labelled $\lambda^H[e^H(\Delta=1)]$, causing high-risk types to go without insurance coverage altogether. The outcome is an extreme case of separating equilibrium, not to be analyzed any further.

In Figure 2, both the high-risk type and the IC are seen as exerting comparatively much search and risk selection effort, respectively. This has two effects. First, the origin of the insurance line $I^H=0$ ($\Delta=1$) shifts far away from the endowment point A_0 because much cost of search effort c^H has to be borne in both the loss and the no-loss state. Second, the loading $\lambda^H\left(e^H\right)$ is low, causing the insurance line $\lambda^H[e^H(\Delta=1)]$ to run rather flat. Now let there be a second peril where both consumer types are “better” risks ($\Delta<1$). This has three effects. First, since both types become “better” risks with a lowered overall probability of loss, their indifference curves run steeper (dashed). Second, according to Figure 2, a $\Delta<1$ is associated with a lower amount of consumer search c^H; therefore, the insurance line $I^H=0$ ($\Delta<1$) starts closer to point A_0 in Figure 3.Third, it has a steeper slope since the IC´s selection effort is also lower, resulting in the reduced proportional loading $\lambda^H[e^H(\Delta<1)$. In all, the high-risk type benefits from an increase in insurance coverage, indicated by the transition from $C^{*H}(\Delta=1)$ to $C^{*H}(\Delta<1)$.

Figure 3. Projecting Nash equilibria into (W_1, W_2)-space



Turning to the low-risk type, Figure 2 indicates that the multi-peril policy is associated with a reduced amount of consumer search as well. In the particular case shown, this reduction is less marked than for the high-risk type. Accordingly, the origin of the pertinent insurance line I^L=0 (Δ=1) from the endowment point A_0 in Figure 3 is less marked. Also, its slope does not increase as much [from λ^L [e^L(Δ=1) to λ^L [e^L(Δ<1) in Figure 3] as for the high-risk type because the reduction in the IC´s selection effort is not as great. Now the consumer optimum of the low-risk type moves from C^{*L}(Δ=1) to C^{*L}(Δ<1) in principle; however, the relaxation of the rationing constraint permits it to shift from C^L(Δ=1) to C^L(Δ<1) only. Still, the existence of a multi-peril policy where both consumer types are "better" risk w.r.t. second peril allows both of them to attain an increased amount of coverage, resulting in a Pareto improvement.

Conclusion 2. The projection of Nash equilibria from efforts space into wealth levels space shows that due to reduced consumer search and IC´s risk selection effort both risk types attain a higher degree of insurance coverage if they are "better" risks w.r.t. one peril and if a two-peril policy is available. In addition to this Pareto improvement, the high-risk types benefit from reduced risk selection to an even greater extent than the high-risk ones.

4 Summary and conclusion

The point of departure of this paper is an intuition: If consumers who are a "better" risk with regard to at least one peril were able to purchase a multi-peril policy, this could possibly mitigate the adverse selection problem for the insurer. In pursuing this intuition, a two-risk model is developed in which both high-risk and low-risk types deploy costly search effort to find the policy offering as much coverage as possible for the given premium. In its turn, the insurance company deploys costly effort designed to stave off high-risk types while attracting low-risk ones. If it exists, the separating Nash equilibrium in efforts space is associated with a high amount of consumer search effort combined with a high amount of risk selection effort if the uninformed insurer is confronted with a high-risk type. It combines a low amount of consumer search and of selection effort if the company is dealing with a low-risk type. In addition, if both risk types are "better" risks with regard to one peril, the Nash equilibrium shifts towards lower consumer search and risk selection efforts. Interestingly, the degree of reduction is especially marked if the insurer is confronted with a high-risk type. The reason is that the same reduction in the probability of loss for the second peril has a higher impact on the high-risk Nash equilibrium because of the higher overall probability of loss characterizing the high-risk type (Conclusion 1).

Next, these findings are projected into the more familiar wealth levels space which permits to depict the rationing constraint imposed on low-risk types for ensuring the sustainability of separating contracts. Here, the fact that both risk types are "better" risks with regard to one peril has three consequences. First, the slope of their indifference curves increases; second, the origin of their insurance lines does not move as far away from the endowment point reflecting less search effort; and third, the insurance lines have a higher slope reflecting a reduced loading due to less risk selection effort. Most importantly, Conclusion 1 is confirmed in that the second and the third change are more marked if the insurer is confronted with a high-risk type, who therefore benefits to a particularly high degree from the existence of a multi-peril policy. However, the low-risk type benefits as well thanks to a relaxation of the rationing constraint; therefore, multi-peril policies hold the promise of Pareto improvement (Conclusion 2).

There are several limitations to this analysis. First, using expected utility as the criterion governing choice under uncertainty has met with criticism. Concerning the demand for insurance, however, Bleichrodt and Schmidt (2009) have found that most predictions carry over from expected utility to its main alternatives, confirming Machina´s (1995) robustness result. Next, risk types may differ not only with regard to their probability of loss but also with regard to other characteristics, in particular risk aversion. Arguably, individuals become higher risks with age [at least in health and life insurance, see Halek and Eisenhauer (2001)]. Risk aversion thus correlates positively with high-risk status. Yet this would accentuate the finding that high-risk types [who feature a high value of $\upsilon^{H''}(.)$ in eq. (A.7)] would be exposed to even less risk selection effort than predicted in the context of a multi-peril policy. Third, the one-period model developed here cannot accommodate learning on both sides of the market. Experimental evidence suggests that consumers re-estimate the probability of loss in the wake of a loss occurrence (Dumm, Eckles, Nyce et al., 2020). Insurers update their risk assessment as well, applying experience rating e.g. in auto insurance. But this is unlikely to modify the findings presented here as long as consumers continue to be "better" risks with regard to at least one additional peril covered by a multi-peril policy. The final limitation is that – unlike - the contribution of Crocker and Snow (2011) -- this paper does not contain a proof that the Nash equilibrium derived in efforts space is sustainable; the pertinent condition is imposed as part of the transition to wealth levels space.

In conclusion, a multi-peril policy has the potential for Pareto improvement for consumers regardless of their risk type as long as they present a "better" risk with regard to a peril covered. If this finding should hold true, European regulation mandating the separation of life from nonlife insurance (EIOPA, 2020) does not necessarily have a favorable benefit-cost ratio. Whereas social insurance schemes almost by definition concern themselves with one risk exclusively, the separation of lines in private insurance dates from an era when regulators were afraid that reserves accumulated in life insurance would be misspent on nonlife insurance. But today´s capital markets can serve as institutions providing market discipline [see e.g. Deng, Leverty and Zanjani (2019) for banks; Epermanis and Harrington (2006), Halek and Eckles (2010), Eling and Schmit (2012), and Dent et al. (2017) for insurers]. An inefficient allocation of reserves likely would be reflected in the share price and/or in the market share of listed companies. Therefore, it may be time to reconsider regulation imposing the separation of lines which hamper the development of multi-peril policies.

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Appendix A: Consumers´reaction functions

In this Appendix, the reaction functions shown in Figure 1 are derived.

Let there be an exogenous shock $d\alpha > 0$, with $d\alpha$ symbolizing one of the changes to be specified below. In the case of eq. (2a) e.g., this gives rise to the comparative static equation (applying the implicit function theorem),

$$\frac{\partial^2 EU^H}{\partial c^{H2}} dc^H + \frac{\partial^2 EU^H}{\partial c^H \partial \alpha} d\alpha = 0$$

which can be solved to obtain

$$\frac{dc^H}{d\alpha} = -\frac{\partial^2 EU^H / \partial c^H \partial \alpha}{\partial^2 EU^H / \partial c^{H2}} \tag{A.1}$$

Since $\partial^2 EU^H / \partial c^{H2} < 0$ in a maximum, the sign of $dc^H / d\alpha$ is determined by the sign of the mixed second-order derivative, $\partial^2 EU^H / \partial c^H \partial \alpha$. In deriving the predictions below, any impact on $\partial^2 EU^H / \partial c^{H2}$ in eq. (A.1) is neglected because it must be minor, lest $\partial^2 EU^H / \partial c^{H2}$ change signs, turning a maximum into a minimum.

The first shock to be considered is an increase in IC’s general selection effort such that $d\alpha := de$. Applying eq. (A.1), one obtains from eq. (2a),

$$\frac{dc^H}{de} \propto \frac{\partial^2 EU^H}{\partial c^H \partial e} = \rho^{H2}\Delta\left[\upsilon^{H''}\left(\frac{\partial I^H}{\partial e}-\frac{\partial P^H}{\partial e}\right)\frac{\partial I^H}{\partial c^H}+\upsilon^{H'}\frac{\partial^2 I^H}{\partial c^H \partial e}\right]$$

$$+\left(\rho^H-\rho^{H2}\Delta\right)\left[\upsilon^{H''}\left(\frac{\partial I^H}{\partial e}-\frac{\partial P^H}{\partial e}\right)\frac{\partial I^H}{\partial c^H}+\upsilon^{H'}\frac{\partial^2 I^H}{\partial c^H \partial e}\right]$$

$$+\left(\rho^H-\rho^{H2}\Delta\right)\left[\upsilon^{H''}\left(\frac{\partial J^H}{\partial e}-\frac{\partial P^H}{\partial e}\right)\frac{\partial J^H}{\partial c^H}+\upsilon^{H'}\frac{\partial^2 J^H}{\partial c^H \partial e}\right]$$

$$+\left(1-\rho^H-\rho^H\Delta+\rho^{H2}\Delta\right)\left[\upsilon^{H''}\left(\frac{\partial J^H}{\partial e}-\frac{\partial P^H}{\partial e}\right)\frac{\partial J^H}{\partial c^H}+\upsilon^{H'}\frac{\partial^2 J^H}{\partial c^H \partial e}\right]$$

$$> 0 \text{ if } \upsilon^{H''}\left(\frac{\partial J^H}{\partial e}-\frac{\partial P^H}{\partial e}\right)\frac{\partial J^H}{\partial c^H}+\upsilon^{H'}\frac{\partial^2 J^H}{\partial c^H \partial e} > 0;$$

$$< 0 \text{ if } \upsilon^{H''}\left(\frac{\partial J^H}{\partial e}-\frac{\partial P^H}{\partial e}\right)\frac{\partial J^H}{\partial c^H}+\upsilon^{H'}\frac{\partial^2 J^H}{\partial c^H \partial e} < 0. \qquad \text{(A.3)}$$

Although $\upsilon^{H'}$ and $\upsilon^{H''}$ have to be evaluated at different values of their arguments, they are unlikely to differ much. Also, all multipliers involving ρ^H and Δ are positive. Therefore, it suffices to examine one of the four bracketed terms, e.g. the first one, $\upsilon^{H''}\left(\frac{\partial I^H}{\partial e}-\frac{\partial P^H}{\partial e}\right)\frac{\partial I^H}{\partial c^H}+\upsilon^{H'}\frac{\partial^2 I^H}{\partial c^H \partial e}$. The first term is positive since with $\partial I^H / \partial e < 0$ and

$\partial P^H / \partial e = 2\bar{\rho}\cdot\partial\lambda^H / \partial e > 0$ by eq. (1a), the parenthesis is negative whereas $\upsilon^{H''} < 0$. As to the second term, additional selection effort by the IC arguably counteracts the effectiveness of consumers´ search effort. They are made to provide additional information, which burdens them with additional transaction cost when searching for a favorable policy. Therefore $\partial^2 I^H / \partial c^H \partial e$ is negative, rendering the second term negative. This makes the sign of eq. (A.3) ambiguous (however, this is without consequence for the displacement of Nash equilibria, as shown in Appendix C).

Developments for the low-risk type are exactly the same. Therefore,

$$\frac{dc^L}{de} > 0 \text{ if } \upsilon^{L''}\left(\frac{\partial J^L}{\partial e}-\frac{\partial P^L}{\partial e}\right)\frac{\partial J^L}{\partial c^L}+\upsilon^{L'}\frac{\partial^2 J^L}{\partial c^L \partial e} > 0;$$
$$< 0 \text{ if } \upsilon^{H''}\left(\frac{\partial J^L}{\partial e}-\frac{\partial P^L}{\partial e}\right)\frac{\partial J^L}{\partial c^L}+\upsilon^{H'}\frac{\partial^2 J^L}{\partial c^L \partial e} < 0; \qquad \text{(A.4)}$$

however, this ambiguity is again without consequence for the displacement of Nash equilibria (see Appendix C).

As an approximation, the slope of the reaction function pertaining to the high-risk type is the same (in absolute value) as that pertaining to the low-risk type. To see this, it suffices to evaluate the derivative of the sums Σ^H in eq. (A.4) and Σ^L (not shown but analogous) of the probability multipliers w.r.t. ρ^H and ρ^L, respectively, with the result

$$\frac{\partial \Sigma^H}{\partial \rho^H} = 2\rho^H - 2\rho^H - 2\rho^H - 1 + 2\rho^H = -1$$
$$= \frac{\partial \Sigma^L}{\partial \rho^L} = 2\rho^L - 2\rho^L - 2\rho^L - 1 + 2\rho^L. \qquad \text{(A.5)}$$

Accordingly, the two type-specific reaction functions are drawn parallel in Figure 1. Note however that this equality does not preclude a differential effect of a change in Δ. Indeed, for the high-risk type, one obtains

$$\frac{d}{d\Delta}\left[\frac{dc^H}{de}\right] \propto \rho^{H2}\left[\upsilon^{H''}\left(\frac{\partial I^H}{\partial e}-\frac{\partial P^H}{\partial e}\right)\frac{\partial I^H}{\partial c^H}+\upsilon^{H'}\frac{\partial^2 I^H}{\partial c^H \partial e}\right]$$
$$-\rho^{H2}\left[\upsilon^{H''}\left(\frac{\partial I^H}{\partial e}-\frac{\partial P^H}{\partial e}\right)\frac{\partial I^H}{\partial c^H}+\upsilon^{H'}\frac{\partial^2 I^H}{\partial c^H \partial e}\right]$$
$$-\rho^{H2}\left[\upsilon^{H''}\left(\frac{\partial J^H}{\partial e}-\frac{\partial P^H}{\partial e}\right)\frac{\partial J^H}{\partial c^H}+\upsilon^{H'}\frac{\partial^2 J^H}{\partial c^H \partial e}\right]$$
$$-\left(\rho^H - \rho^{H2}\right)\left[\upsilon^{H''}\left(\frac{\partial J^H}{\partial e}-\frac{\partial P^H}{\partial e}\right)\frac{\partial J^H}{\partial c^H}+\upsilon^{H'}\frac{\partial^2 J^H}{\partial c^H \partial e}\right]. \qquad \text{(A.6)}$$

Neglecting again the fact that the utility terms depend on the value of their arguments, one sees that the first two terms of eq. (A.6) cancel, while the third and fourth boil down to

$$\frac{d}{d\Delta}\left[\frac{dc^H}{de}\right] \propto -\rho^H\left[\upsilon^{H''}\left(\frac{\partial J^H}{\partial e}-\frac{\partial P^H}{\partial e}\right)\frac{\partial J^H}{\partial c^H}+\upsilon^{H'}\frac{\partial^2 J^H}{\partial c^H \partial e}\right]$$

$$< 0 \text{ if } \upsilon^{H''}\left(\frac{\partial J^H}{\partial e}-\frac{\partial P^H}{\partial e}\right)\frac{\partial J^H}{\partial c^H}+\upsilon^{H'}\frac{\partial^2 J^H}{\partial c^H \partial e} > 0, \text{ i.e. if } \frac{dc^H}{de} > 0;$$

$$> 0 \text{ if } \upsilon^{H''}\left(\frac{\partial J^H}{\partial e}-\frac{\partial P^H}{\partial e}\right)\frac{\partial J^H}{\partial c^H}+\upsilon^{H'}\frac{\partial^2 J^H}{\partial c^H \partial e} < 0, \text{ i.e. if } \frac{dc^H}{de} < 0 \qquad \text{(A.7)}$$

in view of eq. (A.3). Therefore, with increasing Δ the slope of the reaction function pertaining to the high-risk type decreases if it is positive but goes towards zero if it is negative. Conversely, with *de*creasing Δ this slope increases if it is positive but becomes more markedly negative if it is negative, the case shown in Figure 1.

A fully analogous development yields for the low-risk type

$$\frac{d}{d\Delta}\left[\frac{dc^L}{de}\right] \propto -\rho^L\left[\upsilon^{H''}\left(\frac{\partial J^L}{\partial e}-\frac{\partial P^L}{\partial e}\right)\frac{\partial J^L}{\partial c^L}+\upsilon^{L'}\frac{\partial^2 J^L}{\partial c^L \partial e}\right]$$

$$< 0 \text{ if } \upsilon^{L''}\left(\frac{\partial J^L}{\partial e}-\frac{\partial P^L}{\partial e}\right)\frac{\partial J^L}{\partial c^H}+\upsilon^{L'}\frac{\partial^2 J^L}{\partial c^L \partial e} > 0, \text{ i.e. if } \frac{dc^L}{de} > 0;$$

$$> 0 \text{ if } \upsilon^{L''}\left(\frac{\partial J^L}{\partial e}-\frac{\partial P^L}{\partial e}\right)\frac{\partial J^L}{\partial c^L}+\upsilon^{L'}\frac{\partial^2 J^L}{\partial c^L \partial e} < 0, \text{ i.e. if } \frac{dc^L}{de} < 0 \qquad \text{(A.8)}$$

in view of eq. (A.4). Therefore, with a *de*creasing value of Δ the reaction function of the low-risk type also becomes steeper both if it slope is positive and negative.

As to the type-specific size of effects, the brackets in eqs. (A.5) and (A.6) arguably differ relatively little, rendering the fact that $\rho^H > \rho^L$ decisive. A decreasing value of Δ thus has a more marked effect on the slope of the reaction function of the high-risk type than that of the low-risk type, as drawn in Figure 1.

Appendix B: The IC´s reaction function

This Appendix is devoted to deriving the IC´s reaction functions shown in Figure 2. Let the optimum of eq. (5) be disturbed by an increase in consumers' search effort. Setting first $d\alpha := dc^H$, one obtains the solution to the comparative-static equation, in analogy to eq. (A.1),

$$\frac{de}{dc^H} \propto \frac{\partial^2 E\Pi}{\partial e \partial c^H} = \partial\pi / \partial e \cdot \left[-\frac{\partial I^H}{\partial c^H} - \frac{\partial J^H}{\partial c^H} \right] + \pi(e) \left[-\frac{\partial^2 I^H}{\partial e \partial c^H} - \frac{\partial^2 J^H}{\partial e \partial c^H} \right] > 0 \qquad \text{(B.1)}$$

because $\partial^2 I^H / \partial e \partial c^H = \partial^2 I^H / \partial c^H \partial e < 0, \partial^2 J^H / \partial e \partial c^H = \partial^2 J^H / \partial c^H \partial e < 0$ (recalling that the IC´s selection effort lowers the effectiveness of consumer search effort). Therefore, the reaction function has a positive slope when the IC is interacting with a high-risk type.

Next, with $d\alpha := dc^L$ one obtains

$$\frac{de}{dc^H} \propto \frac{\partial^2 E\Pi}{\partial e \partial c^L} = \partial\pi / \partial e \cdot \left[-\frac{\partial I^L}{\partial c^L} - \frac{\partial J^L}{\partial c^L} \right] + \pi(e) \left[-\frac{\partial^2 I^H}{\partial e \partial c^H} - \frac{\partial^2 J^H}{\partial e \partial c^H} \right] > 0; \qquad \text{(B.2)}$$

the reaction function has a positive slope as well. Since nothing can be said about the bracketed terms in eqs. (B.1) and (B.2) without further assumptions, only one reaction function appears in Figure 2. However, due to the type-specific consumer reaction functions derived in Appendix A, there are two Nash equilibria giving rise to two levels of risk selection effort, e^H and e^L, respectively.

Appendix C: Evaluation of changes in IC´s selection effort

In this Appendix, the effects of a decrease in Δ on the difference in the IC´s levels of risk selection effort e^H and e^L are derived. The starting point are the two Nash equilibria defined by the FOCs (where $e^H \neq e^L$ in general as a result of the interaction with the two consumer types),

$$\frac{dEU^H}{dc^H} - \frac{dE\Pi}{de^H} = 0, \frac{dEU^L}{dc^L} - \frac{dE\Pi}{de^L} = 0. \qquad \text{(C.1)}$$

Recalling that the FOCs in eqs. (2a) and (2b) depend on the insurer´s selection effort and changing notation slightly, one obtains the two comparative-static equations

$$\begin{bmatrix} \frac{\partial^2 EU^H}{\partial e^{H2}} - \frac{\partial^2 E\Pi}{\partial e^{H2}} & \frac{\partial^2 EU^H}{\partial e^H \partial e^L} - \frac{\partial^2 E\Pi}{\partial e^H \partial e^L} \\ \frac{\partial^2 EU^L}{\partial e^L \partial e^H} - \frac{\partial^2 E\Pi}{\partial e^L \partial e^H} & \frac{\partial^2 EU^L}{\partial e^{L2}} - \frac{\partial^2 E\Pi}{\partial e^{L2}} \end{bmatrix} \begin{bmatrix} de^H \\ de^L \end{bmatrix} + \begin{bmatrix} \frac{\partial^2 EU^H}{\partial e^H \partial \Delta} - \frac{\partial^2 E\Pi}{\partial e^H \partial \Delta} \\ \frac{\partial^2 EU^L}{\partial e^L \partial \Delta} - \frac{\partial^2 E\Pi}{\partial e^L \partial \Delta} \end{bmatrix} d\Delta = \begin{bmatrix} 0 \\ 0 \end{bmatrix}. \qquad \text{(C.2)}$$

With $\Omega > 0$ denoting the determinant of the negative definite Hessian of rank two (both agents are maximizing), Cramer´s rule yields the solutions,

$$\frac{de^H}{d\Delta} = \frac{-1}{\Omega} \begin{vmatrix} \frac{\partial^2 EU^H}{\partial e^H \partial \Delta} - \frac{\partial^2 E\Pi}{\partial e^H \partial \Delta} & \frac{\partial^2 EU^H}{\partial e^H \partial e^L} - \frac{\partial^2 E\Pi}{\partial e^H \partial e^L} \\ \frac{\partial^2 EU^L}{\partial e^L \partial \Delta} - \frac{\partial^2 E\Pi}{\partial e^L \partial \Delta} & \frac{\partial^2 EU^H}{\partial e^{L2}} - \frac{\partial^2 E\Pi}{\partial e^{L2}} \end{vmatrix} \qquad \text{(C.3)}$$

and

$$\frac{de^L}{d\Delta} = \frac{-1}{\Omega} \begin{vmatrix} \frac{\partial^2 EU^H}{\partial e^{H2}} - \frac{\partial^2 E\Pi}{\partial e^{H2}} & \frac{\partial^2 EU^H}{\partial e^H \partial \Delta} - \frac{\partial^2 E\Pi}{\partial e^H \partial \Delta} \\ \frac{\partial^2 EU^L}{\partial e^L \partial e^H} - \frac{\partial^2 E\Pi}{\partial e^L \partial e^H} & \frac{\partial^2 EU^L}{\partial e^L \partial \Delta} - \frac{\partial^2 E\Pi}{\partial e^L \partial \Delta} \end{vmatrix} \qquad \text{(C.4)}$$

The signs of the terms appearing in eqs. (C.3) and (C.4) can be determined as follows.

$$\frac{\partial^2 EU^H}{\partial e^{H2}} - \frac{\partial^2 E\Pi}{\partial e^{H2}} < 0, \frac{\partial^2 EU^L}{\partial e^{L2}} - \frac{\partial^2 E\Pi}{\partial e^{L2}} < 0 \qquad \text{(C.5)}$$

in view of the negative definiteness of Ω.

Differentiating eq. (2a) one obtains

$$\frac{\partial^2 EU^H}{\partial e^{H2}} = \rho^{H2}\Delta\cdot\upsilon^{H\prime\prime}\left[W_0 + I^H - K - L - P^H(e)\right]\left(\frac{\partial^2 I^H}{\partial e^{H2}} - \frac{\partial^2 P^H}{\partial e^{H2}}\right)$$
$$+\left(\rho^H - \rho^{H2}\Delta\right)\upsilon^{H\prime\prime}\left[W_0 + J^H - L - P^H(e)\right]\left(\frac{\partial^2 I^H}{\partial e^{H2}} - \frac{\partial^2 P^H}{\partial e^{H2}}\right)$$
$$+\left(\rho^H - \rho^{H2}\Delta\right)\upsilon^{H\prime\prime}\left[W_0 + J^H - L - P^H(e)\right]\left(\frac{\partial^2 J^H}{\partial e^{H2}} - \frac{\partial^2 P^H}{\partial e^{H2}}\right)$$
$$+\left(1 - \rho^H - \rho^H\Delta + \rho^{H2}\Delta\right)\upsilon^{H\prime\prime}\left[W_0 - P^H(e)\right]\left(-\frac{\partial^2 P^H}{\partial e^{H2}}\right) > 0; \qquad \text{(C.6)}$$

$\partial^2 I^H / \partial e^{H2} < 0$ reflects decreasing marginal effectiveness of effort while $\partial^2 P^H / \partial e^{H2} > 0$ follows from eq. (1a) if $\partial^2 \lambda^H / \partial e^2 > 0$ (which is likely). Thus, the three first terms are positive and together almost certainly dominate the negative fourth one.

Similarly, differentiating eq. (2b) yields

$$\frac{\partial^2 EU^L}{\partial e^{L2}} = \rho^{L2}\Delta\cdot\upsilon^{L\prime\prime}\left[W_0 + I^L - K - L - P^L(e)\right]\left(\frac{\partial^2 I^L}{\partial e^{L2}} - \frac{\partial^2 P^L}{\partial e^{L2}}\right)$$
$$+\left(\rho^L - \rho^{L2}\Delta\right)\upsilon^{L\prime\prime}\left[W_0 + J^L - L - P^L(e)\right]\left(\frac{\partial^2 I^L}{\partial e^{L2}} - \frac{\partial^2 P^L}{\partial e^{L2}}\right)$$
$$+\left(\rho^L - \rho^{L2}\Delta\right)\upsilon^{L\prime\prime}\left[W_0 + J^H - L - P^L(e)\right]\left(\frac{\partial^2 J^L}{\partial e^{L2}} - \frac{\partial^2 P^L}{\partial e^{L2}}\right)$$
$$+\left(1 - \rho^L - \rho^L\Delta + \rho^{L2}\Delta\right)\upsilon^{L\prime\prime}\left[W_0 - P^L(e)\right]\left(-\frac{\partial^2 P^L}{\partial e^{L2}}\right) > 0. \qquad \text{(C.7)}$$

Next, from eq. (2a), one also obtains

$$\frac{\partial^2 EU^H}{\partial e^H \partial \Delta} = \rho^{H2} \upsilon^{H\prime} \left[W_0 + I^H - K - P^H(e) \right] \left(\frac{\partial I^H}{\partial e^H} - \frac{\partial P^H}{\partial e^H} \right)$$

$$+ \left(\rho^H - \rho^{H2} \right) \upsilon^{H\prime} \left[W_0 + I^H - K - P^H(e) \right] \left(\frac{\partial I^H}{\partial e^H} - \frac{\partial P^H}{\partial e^H} \right)$$

$$+ \left(\rho^H - \rho^{H2} \right) \upsilon^{H\prime} \left[W_0 + J^H - L - P^H(e) \right] \left(\frac{\partial J^H}{\partial e^H} - \frac{\partial P^H}{\partial e^H} \right)$$

$$+ \left(-\rho^H + \rho^{H2} \right) \upsilon^{H\prime} \left[W_0 - P^H(e) \right] \left(-\frac{\partial P^H}{\partial e^H} \right) < 0. \qquad \text{(C.8)}$$

With $\rho^H > \rho^{H2}$, the first three terms are negative, and together they almost certainly dominate the positive fourth. From eq. (2b), one similarly obtains

$$\frac{\partial^2 EU^L}{\partial e^L \partial \Delta} = \rho^{L2} \cdot \upsilon^{L\prime} \left[W_0 + I^L - K - L - P^L(e) \right] \left(\frac{\partial I^L}{\partial e^L} - \frac{\partial P^L}{\partial e^L} \right)$$

$$+ \left(\rho^L - \rho^{L2} \right) \upsilon^{L\prime} \left[W_0 + I^L - K - P^L(e) \right] \left(\frac{\partial I^L}{\partial e^L} - \frac{\partial P^L}{\partial e^L} \right)$$

$$+ \left(\rho^L - \rho^{L2} \right) \upsilon^{H\prime} \left[W_0 + J^L - L - P^L(e) \right] \left(\frac{\partial J^L}{\partial e^L} - \frac{\partial P^L}{\partial e^L} \right)$$

$$+ \left(-\rho^L + \rho^{L2} \right) \upsilon^{L\prime} \left[W_0 - P^L(e) \right] \left(-\frac{\partial P^L}{\partial e^L} \right) < 0 \qquad \text{(C.9)}$$

since once again the fourth term almost certainly is dominated by the sum of the three first ones, which are positive this time since the IC intends to attract low-risk types (see above).

Next, from eq. (5) one has, noting that $\partial^2 \pi / \partial e^H \partial e^L = \partial^2 \pi / \partial e^L \partial e^H = \partial^2 P^H / \partial e^H \partial e^L$ $= \partial^2 P^L / \partial e^L \partial e^P = \partial^2 I^H / \partial e^H \partial e^L = \partial^2 I^L / \partial e^L \partial e^P = 0$ constitute reasonable assumptions,

$$\frac{\partial^2 E\Pi}{\partial e^{H2}} = \partial^2 \pi / \partial e^{H2} \cdot \left[\frac{\partial P^H}{\partial e^H} - \frac{\partial I^H}{\partial e^H} - \frac{\partial J^H}{\partial e^H} \right] + \partial \pi / \partial e^H \cdot \left[\frac{\partial^2 P^H}{\partial e^{H2}} - \frac{\partial^2 I^H}{\partial e^{H2}} - \frac{\partial^2 J^H}{\partial e^{H2}} \right] < 0 \qquad \text{(C.10)}$$

and

$$\frac{\partial^2 E\Pi}{\partial e^{L2}} = \partial^2 \pi / \partial e^{L2} \cdot \left[\frac{\partial P^L}{\partial e^L} - \frac{\partial I^L}{\partial e^L} - \frac{\partial J^L}{\partial e^L} \right] + \partial \pi / \partial e^L \cdot \left[\frac{\partial^2 P^L}{\partial e^{L2}} - \frac{\partial^2 I^H}{\partial e^{H2}} - \frac{\partial^2 J^L}{\partial e^{L^2}} \right] < 0, \quad \text{(C.11)}$$

repectively in view of the negative definiteness of the Hessian pertaining to the IC´s optimum. Moreover, eq. (5) also implies

$$\frac{\partial^2 E\Pi}{\partial e^H \partial \Delta} = \frac{\partial^2 E\Pi}{\partial e^L \partial \Delta} = 0. \quad \text{(C.12)}$$

Finally,

$$\frac{\partial^2 EU^H}{\partial e^H \partial e^L} = \frac{\partial^2 EU^L}{\partial e^L \partial e^H} = 0. \quad \text{(C.13)}$$

In all, eq. (C.3) boils down to (recall that $\Omega < 0$)

$$\frac{de^H}{d\Delta} = \frac{-1}{\Omega} \begin{vmatrix} \frac{\partial^2 EU^H}{\partial e^H \partial \Delta} < 0 & 0 \\ \frac{\partial^2 EU^L}{\partial e^L \partial \Delta} < 0 & \frac{\partial^2 EU^H}{\partial e^{H2}} - \frac{\partial^2 E\Pi}{\partial e^{H2}} < 0 \end{vmatrix} = \frac{-1}{\Omega} \frac{\partial^2 EU^H}{\partial e^H \partial \Delta} \left(\frac{\partial^2 EU^H}{\partial e^{H2}} - \frac{\partial^2 E\Pi}{\partial e^{H2}} \right)$$
$$> 0. \quad \text{(C.14)}$$

Therefore, a *de*crease in Δ is found to lower the IC´s selection effort when confronted with a high-risk type, confirming Figure 1.

Finally, eq. (C.4) becomes

$$\frac{de^L}{d\Delta} = \frac{-1}{\Omega} \begin{vmatrix} \frac{\partial^2 EU^H}{\partial e^{H2}} - \frac{\partial^2 E\Pi}{\partial e^{H2}} < 0 & \frac{\partial^2 EU^H}{\partial e^H \partial \Delta} < 0 \\ 0 & \frac{\partial^2 EU^L}{\partial e^L \partial \Delta} < 0 \end{vmatrix} = \frac{-1}{\Omega} \left(\frac{\partial^2 EU^L}{\partial e^{L2}} - \frac{\partial^2 E\Pi}{\partial e^{L2}} \right) \frac{\partial^2 EU^L}{\partial e^L \partial \Delta}$$
$$> 0. \quad \text{(C.15)}$$

Therefore, a *de*crease in Δ is found to lower the IC´s selection effort when confronted with a low-risk type, confirming Figure 1.

The final issue is which of the two levels of risk selection effort is affected more strongly. First, comparing eqs. (C.6) and (C.7), one sees that

$$\left|\frac{\partial^2 EU^H}{\partial e^{H2}}\right| > \left|\frac{\partial^2 EU^L}{\partial e^{L2}}\right| \text{ almost certainly because } \rho^H > \rho^L. \qquad \text{(C.16)}$$

Second, it is difficult to discern any systematic difference in the terms appearing in eqs. (C.10) and (C.11) since the IC´s selection effort does not have a differential effect on the share of high-risk types π *ex ante,* resulting in

$$\frac{\partial^2 E\Pi}{\partial e^{H2}} \cong \frac{\partial^2 E\Pi}{\partial e^{L2}} \qquad \text{(C.17)}$$

as a reasonable guess and hence

$$\left|\frac{\partial^2 EU^H}{\partial e^{H2}} - \frac{\partial^2 E\Pi}{\partial e^{H2}}\right| > \left|\frac{\partial^2 EU^L}{\partial e^{L2}} - \frac{\partial^2 E\Pi}{\partial e^{L2}}\right| . \qquad \text{(C.18)}$$

Third, eqs. (C.8) and (C.9) imply

$$\left|\frac{\partial^2 EU^H}{\partial e^H \partial \Delta}\right| > \left|\frac{\partial^2 EU^L}{\partial e^L \partial \Delta}\right| \text{almost certainly, again because } \rho^H > \rho^L. \qquad \text{(C.19)}$$

Using eqs. (C.16) through (C.19), a comparison of eqs. (C.14) and (C.15) yields

$$\left|\frac{de^H}{d\Delta}\right| > \left|\frac{de^L}{d\Delta}\right|, \qquad \text{(C.19)}$$

as shown in Figure 2. It is noteworthy that this result does not depend on the sign of $de^H / d\Delta$ and $de^L / d\Delta$, respectively.