Insurance Risk Pooling, Loss Coverage and Social Welfare

When is adverse selection not adverse?

Pradip Tapadar

University of Kent

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Background

Adverse selection:

If insurers cannot charge **risk-differentiated** premiums, then:

- higher risks buy more insurance, lower risks buy less insurance,
- raising the **pooled** price of insurance,
- lowering the demand for insurance,

usually portrayed as a bad outcome, both for insurers and for society.

In practice:

Policymakers often see merit in restricting insurance risk classification

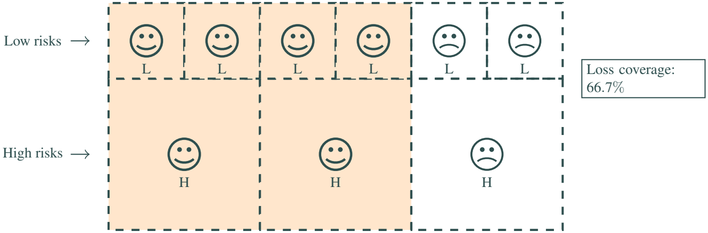
- EU ban on using gender in insurance underwriting.
- Moratoria on the use of genetic test results in underwriting.

Question:

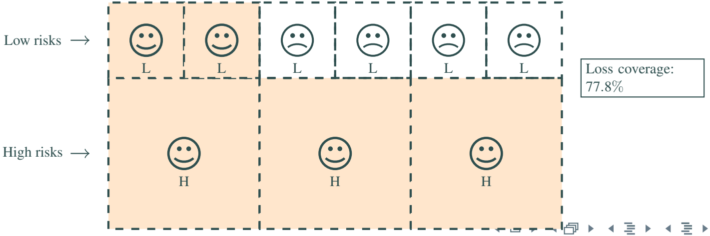
How can we reconcile theory with practice?

Motivation: Two risk-groups $\mu_L = 0.01$ and $\mu_H = 0.04$

Scenario 1: No adverse selection: Risk-differentiated premiums: $\pi_L = 0.01$ **and** $\pi_H = 0.04$



Scenario 2: Some adverse selection: Pooled premiums: $\pi_L = \pi_H = 0.028$



Agenda

We ask:

- **Why** do people buy insurance?
- **What** drives demand for insurance?
- **How much** of population losses is compensated by insurance?
- **Which** regime is most beneficial to society?

Definition (Loss coverage)

Expected population losses compensated by insurance.

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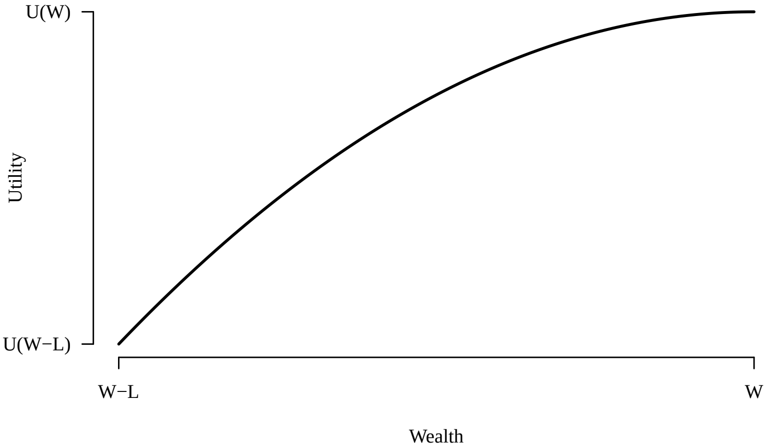
Why do people buy insurance?

Assumptions

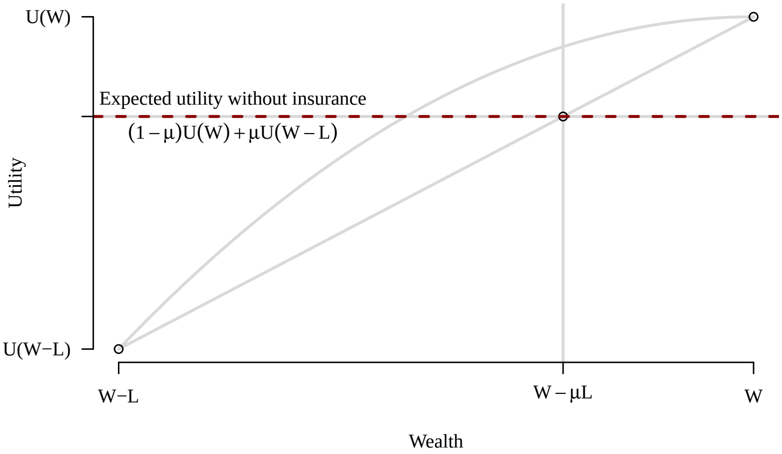
Consider an individual with

- an initial wealth W,
- exposed to the risk of loss L,
- with probability μ,
- utility of wealth $U(w)$, with $U'(w) > 0$ and $U''(w) < 0$,
- an opportunity to insure at premium rate π.

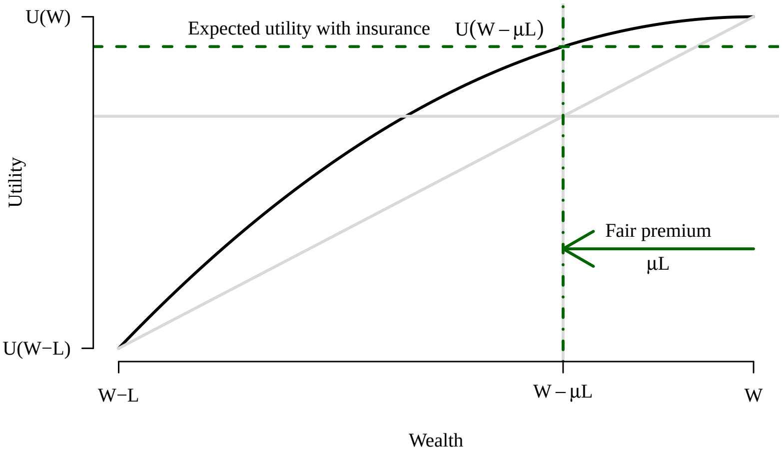
Utility of wealth



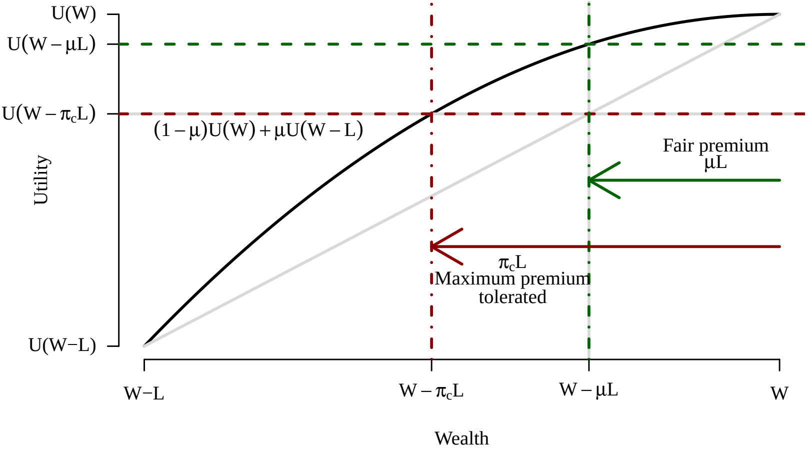
Expected utility: Without insurance



Expected utility: Insured at fair actuarial premium



Maximum premium tolerated: π_c



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Modelling demand for insurance

Simplest model:

If everybody has exactly the same W, L, μ and $U(\cdot)$, then:

- All will buy insurance if $\pi < \pi_c$.
- None will buy insurance if $\pi > \pi_c$.

Reality: Not all will buy insurance even at fair premium. **Why?**

Heterogeneity:

- Even if individuals are **homogeneous** in terms of underlying risk,
- they can still be **heterogeneous** in terms of **risk-aversion**.

Source of Randomness:

An individual's utility function: $U_\gamma(w)$, where parameter γ is drawn from random variable Γ with distribution function $F_\Gamma(\gamma)$.

Insurance demand

Standardisation

As certainty equivalent is invariant to positive affine transformations, we assume $U_\gamma(W) = 1$ and $U_\gamma(W - L) = 0$ for all γ.

Condition for buying insurance:

Given a premium π, an individual will buy insurance if:

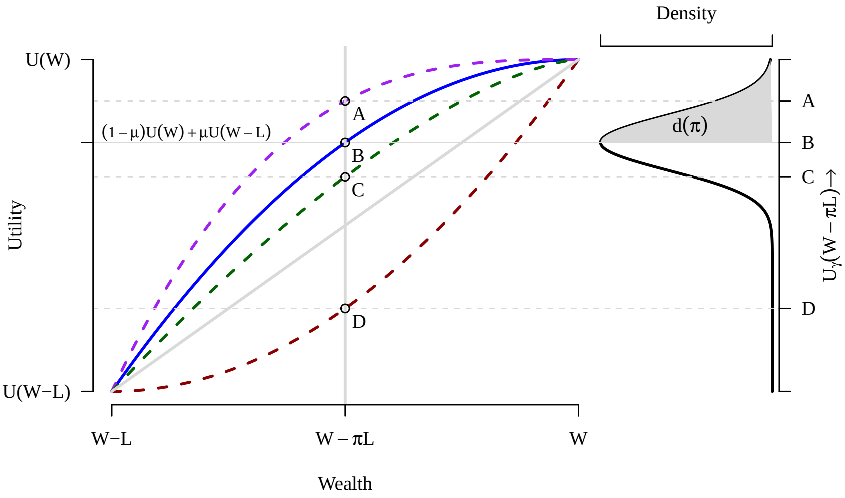
$$\underbrace{U_\gamma\left(W - \pi L\right)}_{\text{With insurance}} > \underbrace{\left(1 - \mu\right) U_\gamma(W) + \mu U_\gamma(W - L) = \left(1 - \mu\right)}_{\text{Without insurance}}.$$

Demand as a function of premium:

Given a premium π, insurance demand, $d(\pi)$, is:

$$d(\pi) = \mathrm{P}\left[U_\Gamma\left(W - \pi L\right) > 1 - \mu\right].$$

Insurance demand and heterogeneity in risk-aversion



Iso-elastic demand

Constant demand elasticity

If demand for insurance can be modelled as[1]:

$$d(\pi) = \tau \left(\frac{\mu}{\pi}\right)^{\lambda},$$

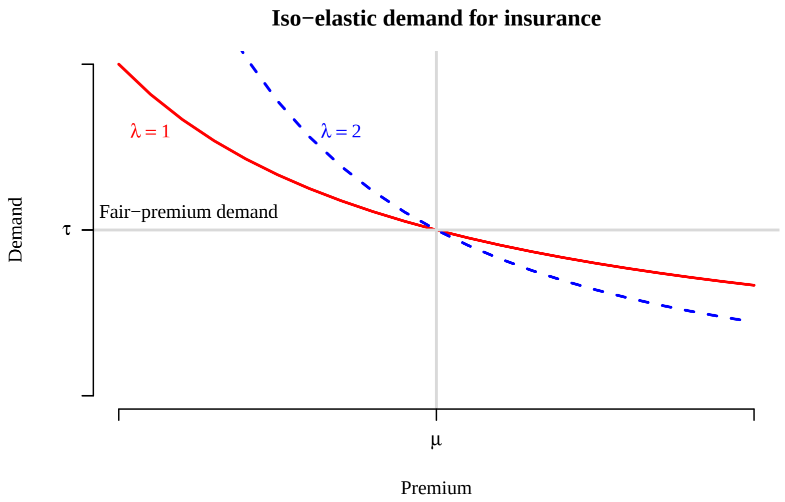
then elasticity of demand is a constant:

$$\epsilon(\pi) = \left| \frac{\frac{\partial d(\pi)}{d(\pi)}}{\frac{\partial \pi}{\pi}} \right| = \lambda.$$

[1] Assumptions: $W = L = 1$, $U_\gamma(w) = w^\gamma$ and Γ has the following distribution function:

$$F_\Gamma(\gamma) = \mathrm{P}\left[\Gamma \leq \gamma\right] = \begin{cases} 0 & \text{if } \gamma < 0 \\ \tau\,\gamma^\lambda & \text{if } 0 \leq \gamma \leq (1/\tau)^{1/\lambda} \\ 1 & \text{if } \gamma > (1/\tau)^{1/\lambda}. \end{cases}$$

Iso-elastic demand



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Risk classification

Risk-groups

Suppose a population can be divided into 2 risk-groups where:

- risk of losses: $\mu_1 < \mu_2$;
- population proportions: p_1, p_2;
- premiums offered: π_1, π_2;
- iso-elastic demand:

$$d_i(\pi) = \tau_i \left(\frac{\mu_i}{\pi}\right)^{\lambda}, \quad i = 1, 2;$$

- fair-premium demand: $\tau_i = d_i(\mu_i)$ for $i = 1, 2$.

Assume $W = L = 1$ and constant demand elasticity λ for all risk-groups.

Note: The framework can be generalised for $n > 2$ risk-groups.

Market equilibrium and loss coverage

For a randomly chosen individual, define:

$$Q = I\,[\,\text{Individual is insured}\,]\,;$$
$$X = I\,[\,\text{Individual incurs a loss}\,]\,;$$
$$\Pi = \text{Premium offered to the individual.}$$

Expected premium, claim and market equilibrium

Expected premium: $E[Q\Pi] = p_1\, d_1(\pi_1)\, \pi_1 + p_2\, d_1(\pi_2)\, \pi_2.$

Expected claim: $E[QX] = p_1\, d_1(\pi_1)\, \mu_1 + p_2\, d_1(\pi_2)\, \mu_2.$

Market equilibrium: $E[Q\Pi] = E[QX].$

Loss coverage (Population losses compensated by insurance)

Loss coverage: $E[QX]$.

Scenario 1: Risk-differentiated premium

Market equilibrium

If risk-differentiated premiums are allowed,

- Equilibrium is achieved when $\pi_1 = \mu_1$ and $\pi_2 = \mu_2$.
- No losses for insurers.
- No (actuarial/economic) adverse selection.

Loss coverage (Population losses compensated by insurance)

$$E[QX] = p_1\, d_1(\mu_1)\, \mu_1 + p_2\, d_1(\mu_2)\, \mu_2,$$
$$= p_1\, \tau_1\, \mu_1 + p_2\, \tau_2\, \mu_2.$$

Scenario 2: Pooled premium

Market equilibrium

If risk-classification is banned, under iso-elastic demand pooled premium is:

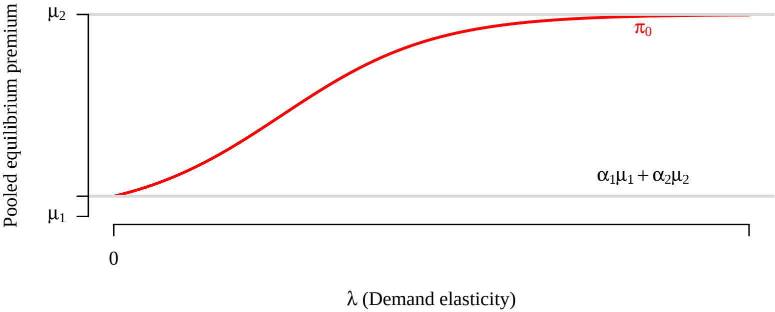
$$\pi_0 = \frac{p_1\ \tau_1\ \mu_1^{\lambda+1} + p_2\ \tau_2\ \mu_2^{\lambda+1}}{p_1\ \tau_1\ \mu_1^{\lambda} + p_2\ \tau_2\ \mu_2^{\lambda}}.$$

No losses for insurers! $\Rightarrow$ No (actuarial) adverse selection.

Loss coverage (Population losses compensated by insurance)

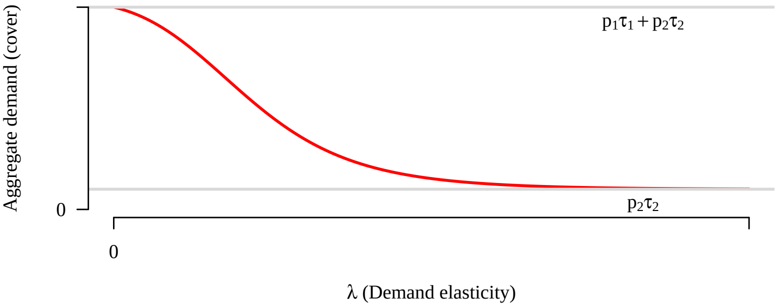
$$E[QX] = p_1\ d_1(\pi_0)\ \mu_1 + p_2\ d_1(\pi_0)\ \mu_2.$$

Adverse selection under pooled premium



Pooled equilibrium is greater than average premium charged under full risk classification: $\pi_0 > \alpha_1\mu_1 + \alpha_2\mu_2 \Rightarrow$ (Economic) adverse selection.

Adverse selection under pooled premium



Aggregate demand (cover) is lower than under full risk classification ⇒ (Economic) adverse selection.

Loss coverage ratio

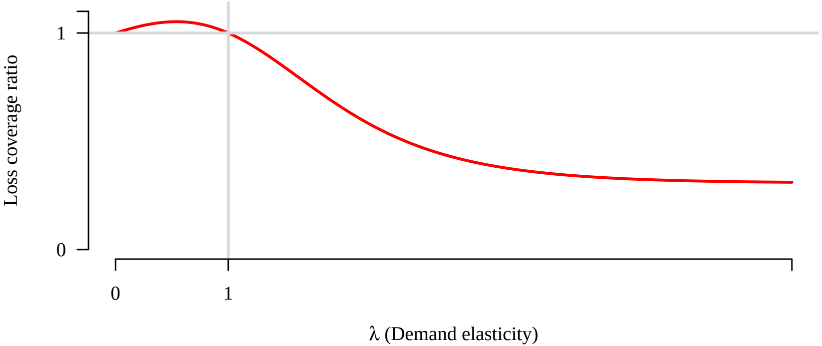
Loss coverage ratio

$$C = \frac{\text{Loss coverage under pooled premium}}{\text{Loss coverage under risk-differentiated premium}},$$
$$= \frac{p_1\, d_1(\pi_0)\, \mu_1 + p_2\, d_1(\pi_0)\, \mu_2}{p_1\, \tau_1\, \mu_1 + p_2\, \tau_2\, \mu_2}.$$

Comparison of risk-classification regimes

- $C > 1 \Rightarrow$ Risk pooling is *better* than full risk classification.
- $C < 1 \Rightarrow$ Risk pooling is *worse* than full risk classification.

Loss coverage ratio



- $\lambda < 1 \Leftrightarrow C > 1 \Rightarrow$ Risk pooling is *better* than full risk classification.
- $\lambda > 1 \Leftrightarrow C < 1 \Rightarrow$ Risk pooling is *worse* than full risk classification.
- **Empirical evidence suggests $\lambda < 1$ in many insurance markets.**

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Social welfare

Definition (Social welfare)

Social welfare, S, is the expected utility for the whole population:

$$S = \mathrm{E}\Big[\underbrace{Q\, U_\Gamma(W - \Pi L)}_{\text{Insured population}} + \underbrace{(1-Q)\left[(1-X)\, U_\Gamma(W) + X\, U_\Gamma(W-L)\right]}_{\text{Uninsured population}} \Big].$$

Linking social welfare to loss coverage under iso-elastic demand

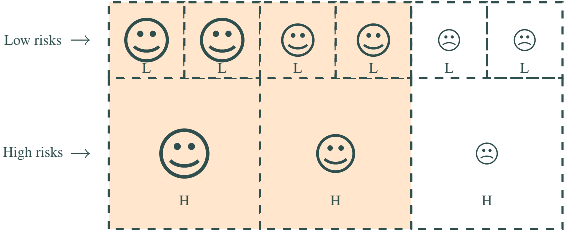
$$S = \frac{1}{\lambda + 1}\,\text{Loss coverage} + \text{Constant}.$$

Result

- **Maximising loss coverage maximises social welfare.**
- $\lambda < 1 \Rightarrow$ **Risk pooling is *better* than full risk classification.**

Motivation: Two risk-groups $\mu_L = 0.01$ and $\mu_H = 0.04$

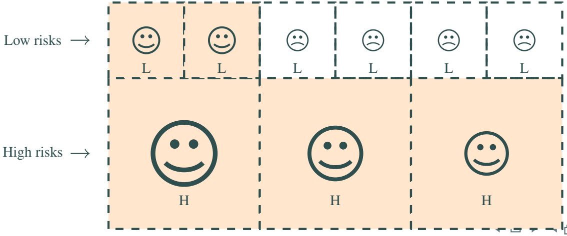
Scenario 1: No adverse selection: Risk-differentiated premiums: $\pi_L = 0.01$ **and** $\pi_H = 0.04$



Loss coverage: 66.7%

Utility increase: 66.2×10^{-4}

Scenario 2: Some adverse selection: Pooled premiums: $\pi_L = \pi_H = 0.028$



Loss coverage: 77.8%

Utility increase: 71.2×10^{-4}

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Conclusions

Adverse selection need not always be adverse.

Restricting risk classification increases loss coverage if $\lambda < 1$.

Maximising loss coverage maximises social welfare.

Restricting risk classification increases social welfare if $\lambda < 1$.

Reference: Loss coverage blog

https://blogs.kent.ac.uk/loss-coverage/