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# How Can Adverse Selection Increase Social Welfare?

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Actuarial Teachers' and Researchers' Conference, June 2019

# Background

## Adverse selection:

Information asymmetry leading to **raised pooled price** of insurance and **lowering of demand** for insurance, usually portrayed as a bad outcome, both for insurers and for society.

↳ Economic vs actuarial adverse selection.

## Adverse selection vs Moral hazard

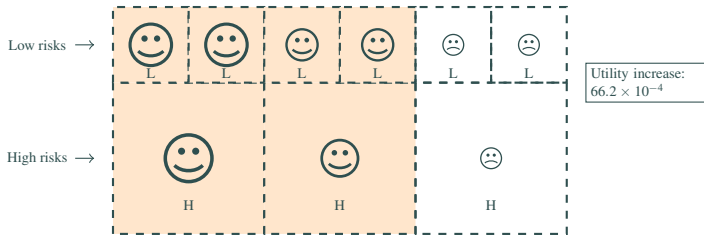
- **Moral hazard** occurs when asymmetric information leads to a change in the behaviour of the policyholder **after** purchasing insurance.
- **Adverse selection** occurs when there is an information asymmetry **prior** to insurance purchase.

↳ Our focus here is on adverse selection.

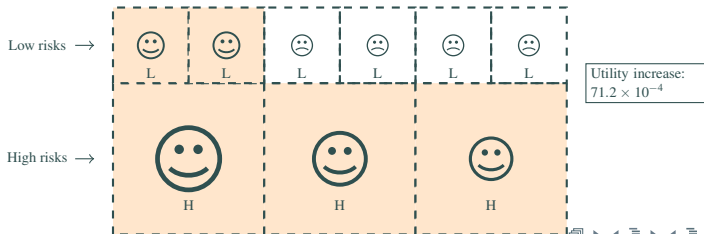
**Question:** Policymakers often see merit in restricting insurance risk classification. How can we reconcile theory with practice?

# 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:  $\pi_L = \pi_H = 0.028$**



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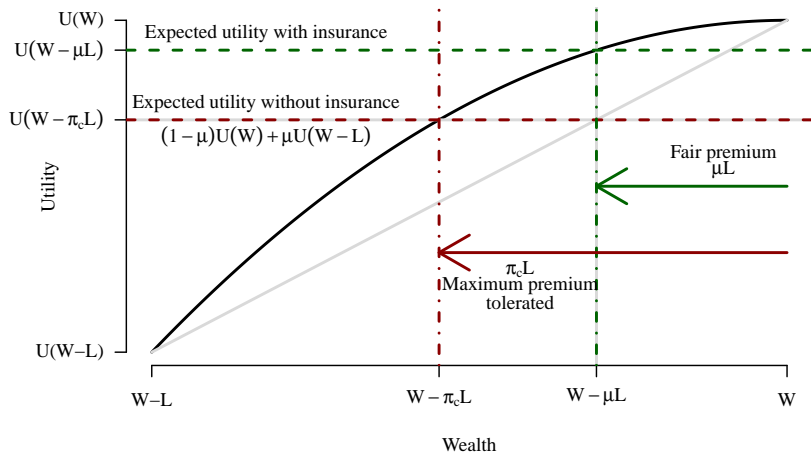
# Why do people buy insurance?

## Assumptions

Consider an individual with

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

# Expected utility: With and without insurance



# Modelling demand for insurance

## Simplest model:

If everybody has exactly the same  $W$ ,  $L$ ,  $\mu$  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  $\gamma$  is drawn from random variable  $\Gamma$  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  $\gamma$ .

## Condition for buying insurance:

Given a premium  $\pi$ , an individual will buy insurance if:

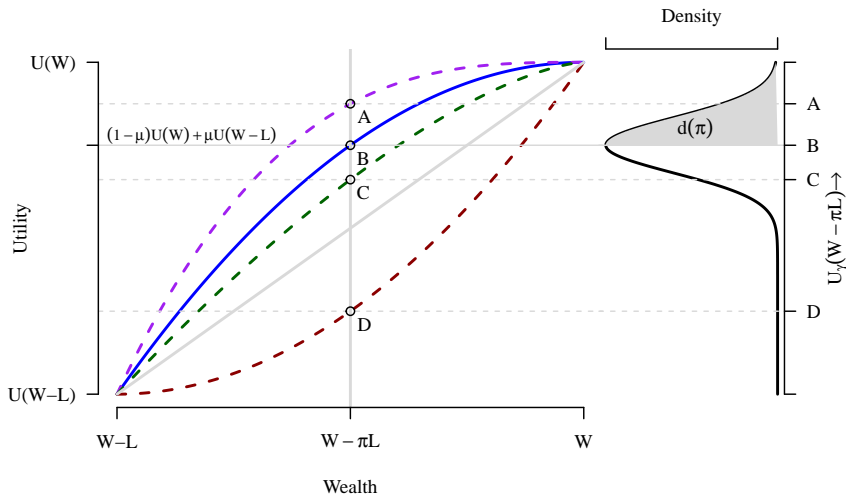
$$\underbrace{U_\gamma(W - \pi L)}_{\text{With insurance}} > \underbrace{(1 - \mu) U_\gamma(W) + \mu U_\gamma(W - L)}_{\text{Without insurance}} = (1 - \mu).$$

## Demand as a function of premium:

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

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

# Insurance demand and heterogeneity in risk aversion



# Iso-elastic demand

## Constant demand elasticity

If demand for insurance can be modelled as<sup>1</sup>:

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

then elasticity of demand is a constant:

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

<sup>1</sup>Assumptions:  $W = L = 1$ ,  $U_\gamma(w) = w^\gamma$  and  $\Gamma$  has the following distribution function:

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

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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:  $\pi_1, \pi_2$ ;
- iso-elastic demand:

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

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

Assume for simplicity  $W = L = 1$ .

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

# Market equilibrium

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

# Full risk classification vs Pooling

## Full risk classification

If risk classification is allowed:

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

## Pooling

If risk classification is banned:

- Pooled (equilibrium) premium is  $\pi_0$ , where  $\mu_1 \leq \pi_0 \leq \mu_2$ .
- No losses for insurers!  $\Rightarrow$  No (actuarial) adverse selection.
- Economic adverse selection!

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# Social welfare

## Definition (Social welfare)

Social welfare,  $S$ , under premium regime  $\underline{\pi} = (\pi_1, \pi_2)$ , is the expected utility for the whole population:

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

↳ It is possible to split  $S(\underline{\pi})$  into two components:

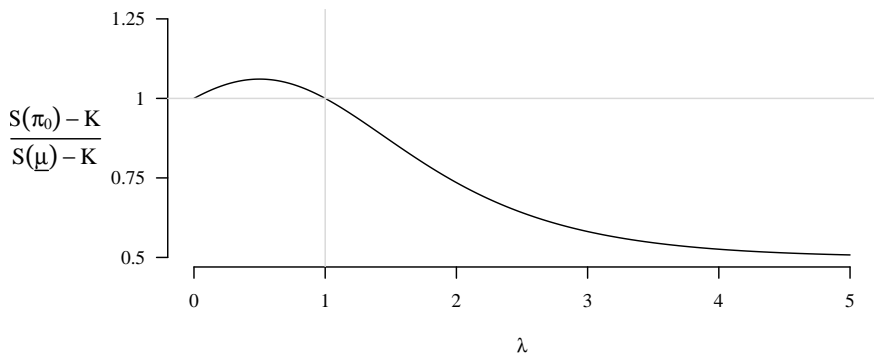
$$S(\underline{\pi}) = f(\underline{\pi}) + K,$$

where  $f(\underline{\pi})$  depends on the premium regime under consideration, while  $K$  does not.

## Full risk classification vs Pooling

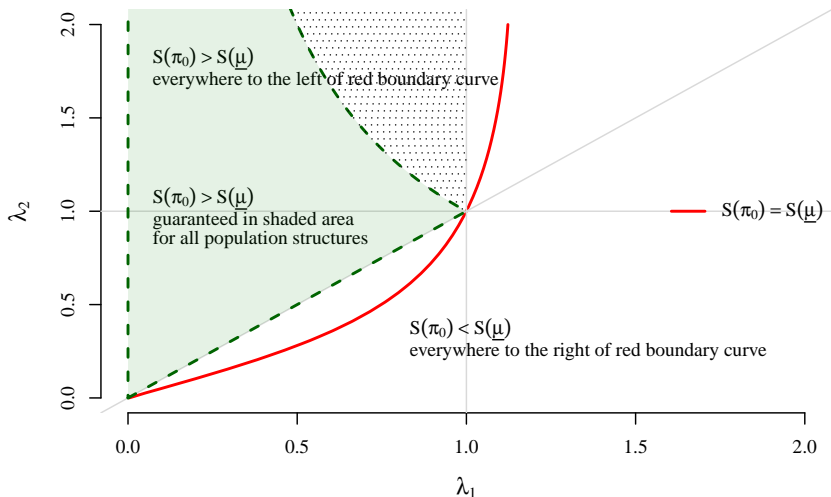
- $S(\underline{\mu})$ : Social welfare under full risk classification.
- $S(\pi_0)$ : Social welfare under pooling.

# Same iso-elastic demand elasticity $\lambda$



- $\lambda < 1 \Leftrightarrow S(\pi_0) > S(\underline{\mu}) \Rightarrow$  Pooling is *better* than full risk classification.
- $\lambda > 1 \Leftrightarrow S(\pi_0) < S(\underline{\mu}) \Rightarrow$  Pooling is *worse* than full risk classification.
- **Empirical evidence suggests  $\lambda < 1$  in many insurance markets.**

# Different iso-elastic demand elasticities ( $\lambda_1, \lambda_2$ )



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# Loss coverage

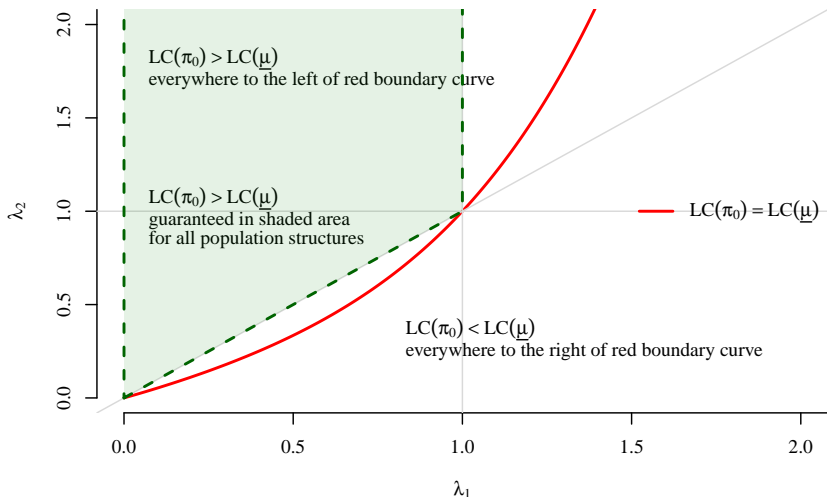
Individual utilities are inherently unobservable, so quantification of social welfare can be problematic. An alternative approach is to quantify the (observable) loss coverage.

## Definition (Loss coverage)

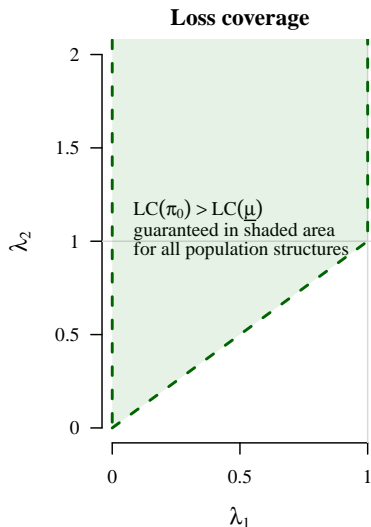
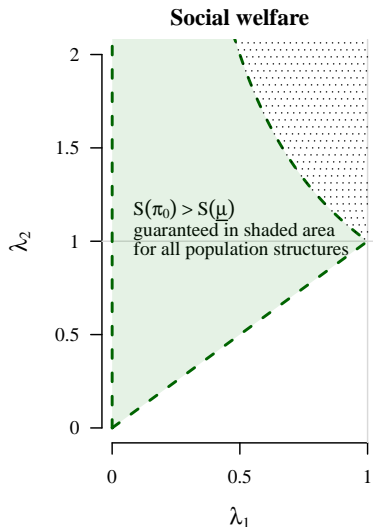
For a premium regime  $\underline{\pi}$ , loss coverage is defined as expected population losses compensated by insurance, i.e.:

$$LC(\underline{\pi}) = E[QX].$$

# Different iso-elastic demand elasticities ( $\lambda_1, \lambda_2$ )



# Social welfare and loss coverage



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# Conclusions

Adverse selection need not always be adverse.

Under realistic assumptions of insurance demand elasticities, restricting risk classification can increase social welfare.

## Reference: Loss coverage blog

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