

# Kent Academic Repository

## Full text document (pdf)

### Citation for published version

Tapadar, Pradip (2015) Why Adverse Selection Need Not Be Adverse. In: Actuarial Teachers' and Researchers' Conference, 13-14 July 2015, Dublin.

### DOI

### Link to record in KAR

<http://kar.kent.ac.uk/49619/>

### Document Version

UNSPECIFIED

#### Copyright & reuse

Content in the Kent Academic Repository is made available for research purposes. Unless otherwise stated all content is protected by copyright and in the absence of an open licence (eg Creative Commons), permissions for further reuse of content should be sought from the publisher, author or other copyright holder.

#### Versions of research

The version in the Kent Academic Repository may differ from the final published version.

Users are advised to check <http://kar.kent.ac.uk> for the status of the paper. **Users should always cite the published version of record.**

#### Enquiries

For any further enquiries regarding the licence status of this document, please contact:

[researchsupport@kent.ac.uk](mailto:researchsupport@kent.ac.uk)

If you believe this document infringes copyright then please contact the KAR admin team with the take-down information provided at <http://kar.kent.ac.uk/contact.html>

# Why Adverse Selection Need Not Be Adverse

Pradip Tapadar

University of Kent, Canterbury, CT2 7NF, UK  
P.Tapadar@kent.ac.uk

Actuarial Teachers' and Researchers' Conference, July 2015

Acknowledgement: Institute and Faculty of Actuaries, UK, has provided a grant to partially support my attendance at this colloquium.

# Contents

- 1 Introduction
- 2 Why do people buy insurance?
- 3 What drives demand for insurance?
- 4 How much of population losses is compensated by insurance?
- 5 Which regime is most beneficial to society?
- 6 Conclusions

# Background

## What is adverse selection?

No commonly accepted standard definition of *adverse selection*.

## Definition (Actuarial perspective)

Insurer faces **loss** due to risk not factored in at the time of sale due to **asymmetric information** between the insurer and the insured.

## Definition (Economic perspective)

An individual's **demand for insurance** (the propensity to buy insurance and the quantity purchased) is **positively correlated** with the individual's **risk of loss** (higher risks buy more insurance).

## Question:

Why is this a **bad outcome** and **for whom**?

# Background

## Arguments against 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?

# Agenda

## We ask:

- **Why** do people buy insurance?
- **What** drives demand for insurance?
- **How much** of population losses is compensated by insurance (with and without risk classification)?
- **Which** regime is most beneficial to society?

## We find:

**Social welfare** is maximised by maximising **loss coverage**.

## Definition (Loss coverage)

**Expected population losses compensated by insurance.**

# Contents

- 1 Introduction
- 2 Why do people buy insurance?**
- 3 What drives demand for insurance?
- 4 How much of population losses is compensated by insurance?
- 5 Which regime is most beneficial to society?
- 6 Conclusions

# Why do people buy insurance?

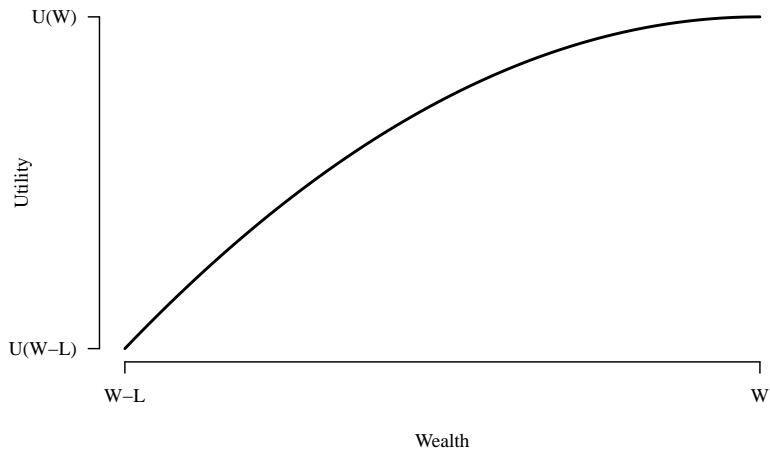
## Assumptions

Consider an individual with

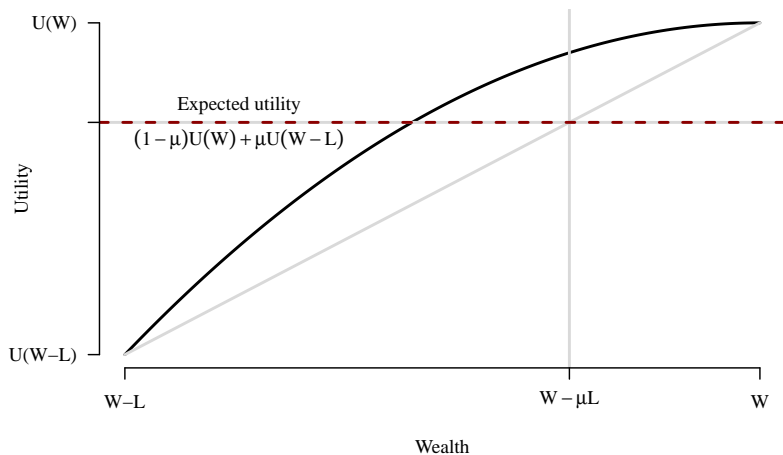
- an initial wealth  $W$ ,
- exposed to the risk of loss  $L$
- with probability  $\mu$ ,
- utility of wealth  $U(w)$ , with  $U'(w) > 0$  and  $U''(w) < 0$ ,
- an opportunity to insure at premium rate  $\pi$ .



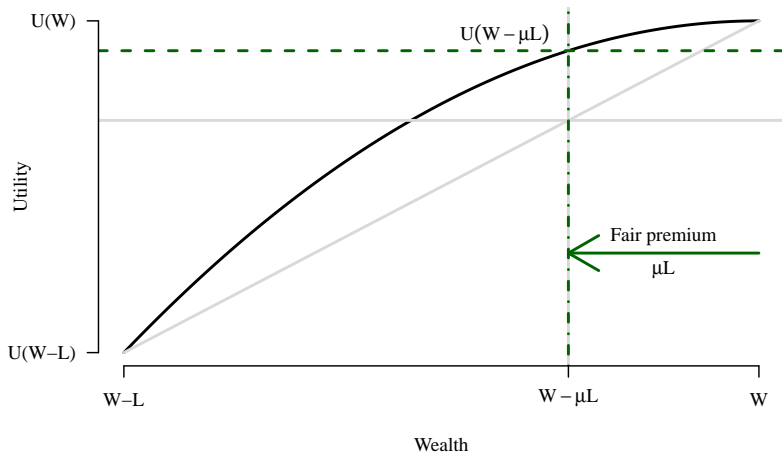
# Utility of wealth



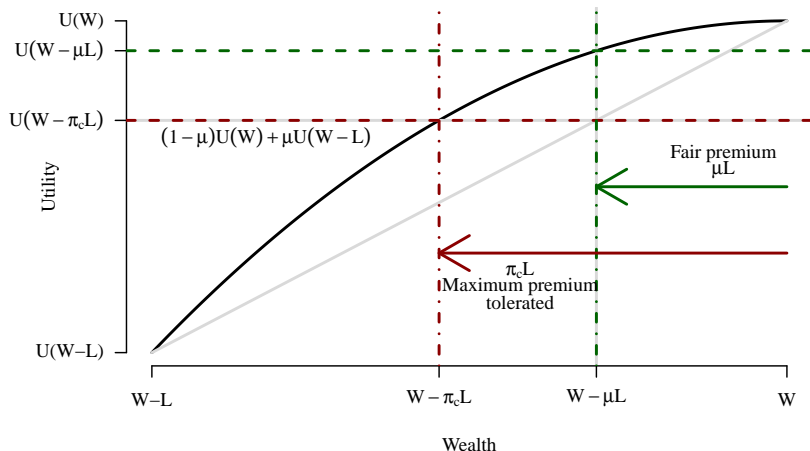
# Expected utility: Without insurance



# Expected utility: Insured at fair actuarial premium



# Maximum premium tolerated: $\pi_c$



# Contents

- 1 Introduction
- 2 Why do people buy insurance?
- 3 What drives demand for insurance?**
- 4 How much of population losses is compensated by insurance?
- 5 Which regime is most beneficial to society?
- 6 Conclusions

# 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:

Heterogeneity can arise for many reasons.  
Here we focus on perception of risk.

## Perception of risk:

Suppose for a group of individuals (all else being equal):

- the underlying risk of loss is a constant  $\mu^*$ , but
- perception of risk is a random variable  $\mu \sim F$ .

## Demand is a survival function

### Condition for buying insurance:

Given a premium  $\pi$ , an individual chosen randomly will buy insurance if perceived risk  $\mu > \mu_c(\pi)$ , where:

$$\underbrace{U(W - \pi L)}_{\text{With insurance}} = \underbrace{(1 - \mu_c(\pi)) U(W) + \mu_c(\pi) U(W - L)}_{\text{Without insurance}}.$$

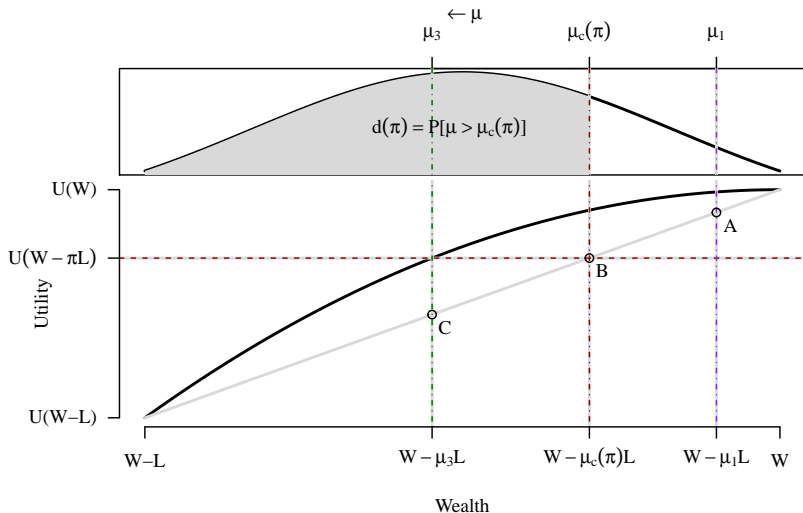
### Demand as a survival function:

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

$$d(\pi) = \text{Prob}[\mu > \mu_c(\pi)],$$

i.e. those individuals who perceive their risks to be greater than the threshold risk  $\mu_c(\pi)$  will purchase insurance.

# Demand is a survival function





## Illustrative example: $W = L = 1$

Power utility function:

$$U(w) = -\frac{(1-w)^{\gamma+1}}{\gamma+1}, \quad 0 \leq w \leq 1, \quad \gamma \geq 0.$$

Threshold risk as a function of premium:

$$\mu_c(\pi) = \pi^{\gamma+1}.$$

Perception of risk:

$$\mu \sim \text{Pareto}(\mu_{min}, \alpha) \Rightarrow \text{Prob}[\mu > x] = \left(\frac{\mu_{min}}{x}\right)^\alpha, \quad x > \mu_{min} > 0, \quad \alpha > 0.$$

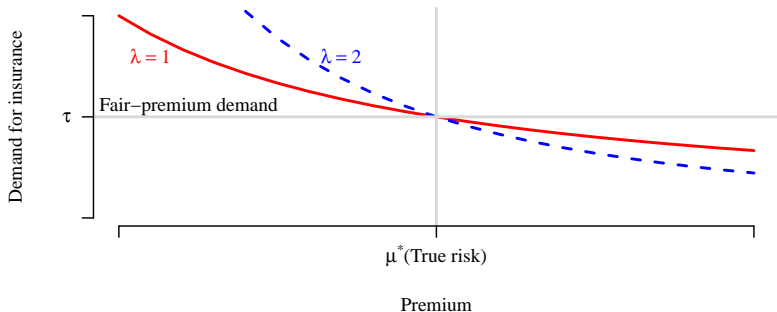
Demand for insurance:

$$d(\pi) = \text{Prob}[\mu > \mu_c(\pi)] \propto \pi^{-\lambda}, \quad \text{for } \lambda = \alpha(\gamma+1) > 0.$$

# Illustrative example: $W = L = 1$

Demand elasticity (Iso-elastic demand):

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



# Contents

- 1 Introduction
- 2 Why do people buy insurance?
- 3 What drives demand for insurance?
- 4 How much of population losses is compensated by insurance?**
- 5 Which regime is most beneficial to society?
- 6 Conclusions

## Risk classification

Consider a population of individuals with the same:

- initial wealth  $W = 1$ ;
- potential loss  $L = 1$ ;
- form of iso-elastic demand function  $d(\pi) \propto \pi^{-\lambda}$ ; and
- demand elasticity  $\lambda$ .

Suppose the population can be divided into 2 risk-groups, with:

- risk of losses:  $\mu_1 < \mu_2$ ;
- population proportions:  $p_1$  and  $p_2$ ;
- fair premium demand:  $d_1(\mu_1) = \tau_1$  and  $d_2(\mu_2) = \tau_2$ , i.e.

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

# Risk-differentiated premium

## Equilibrium:

If risk-differentiated premiums  $\pi_1$  and  $\pi_2$  are allowed,

- Total premium:  $\sum_i p_i d_i(\pi_i) \pi_i$ .
- Total claims:  $\sum_i p_i d_i(\pi_i) \mu_i$ .

Equilibrium is achieved when insurers break even, i.e.  $\pi_i = \mu_i$ .

## Adverse Selection:

No losses for insurers. No (actuarial/economic) adverse selection.

## Loss coverage (Population losses compensated by insurance):

$$\text{Loss coverage} = \sum_i p_i d_i(\mu_i) \mu_i = \sum_i p_i \tau_i \mu_i.$$

# Pooled premium

## Equilibrium:

If only a pooled premium  $\pi_0$  is allowed,

- Total premium:  $\sum_i p_i d_i(\pi_0) \pi_0$ .
- Total claims:  $\sum_i p_i d_i(\pi_0) \mu_i$ .

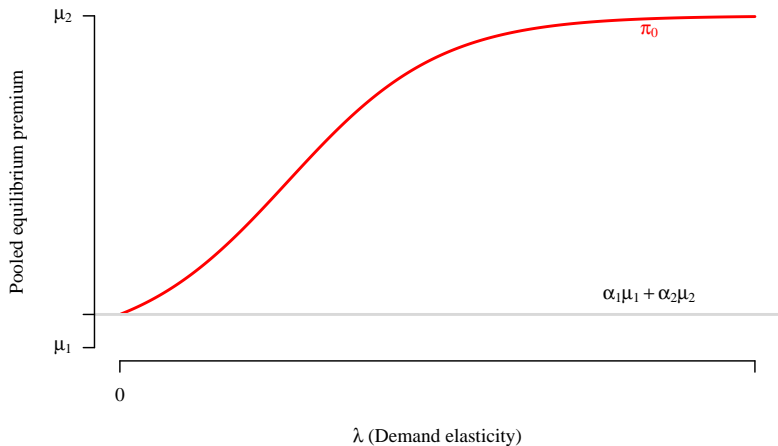
Equilibrium is achieved when insurers break even, i.e.

Total premium = Total claims,

$$\Rightarrow \sum_i p_i d_i(\pi_0) \pi_0 = \sum_i p_i d_i(\pi_0) \mu_i,$$

$$\Rightarrow \pi_0 = \frac{\alpha_1 \mu_1^{\lambda+1} + \alpha_2 \mu_2^{\lambda+1}}{\alpha_1 \mu_1^\lambda + \alpha_2 \mu_2^\lambda}, \text{ where } \alpha_j = \frac{\tau_j p_j}{\tau_1 p_1 + \tau_2 p_2}.$$

# Pooled premium: Adverse selection



# Pooled premium: Adverse selection

## Adverse selection: Summary

- The pooled equilibrium is greater than the average premium charged under full risk classification:

$$\pi_0 > \alpha_1 \mu_1 + \alpha_2 \mu_2 \Rightarrow \text{(Economic) adverse selection.}$$

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

Adverse selection is not useful to measure social efficacy of insurance.



# Loss coverage ratio

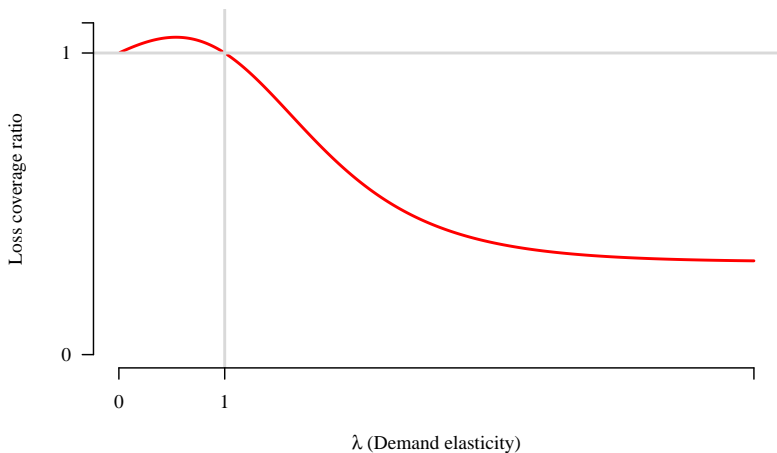
Loss coverage (Population losses compensated by insurance):

$$\text{Loss coverage} = \sum_i p_i d_i(\pi_0) \mu_i.$$

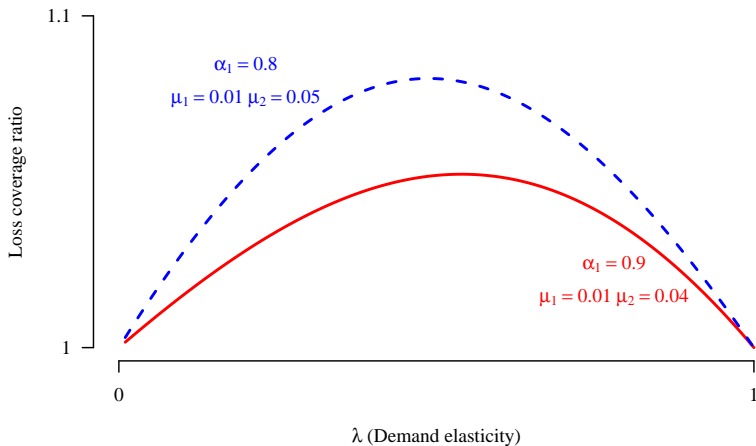
Loss coverage ratio:

$$\begin{aligned} C &= \frac{\text{Loss coverage for pooled premium}}{\text{Loss coverage for risk-differentiated premium}}, \\ &= \frac{\sum_i p_i d_i(\pi_0) \mu_i}{\sum_i p_i d_i(\mu_i) \mu_i}, \\ &= \frac{1}{\pi_0^\lambda} \frac{\alpha_1 \mu_1^{\lambda+1} + \alpha_2 \mu_2^{\lambda+1}}{\alpha_1 \mu_1 + \alpha_2 \mu_2}. \end{aligned}$$

# Loss coverage ratio



# Loss coverage ratio



# Loss coverage ratio: Summary

## Summary

- $\lambda < 1 \Rightarrow$  Loss coverage is more when risk classification is banned.
- $\lambda = 1 \Rightarrow$  Loss coverage is the same in both risk classification regimes.
- $\lambda > 1 \Rightarrow$  Loss coverage is more when full risk classification is used.
- Empirical evidence suggests  $\lambda < 1$ , providing justification for restricting risk classification.
- The maximum value of loss coverage ratio depends on the relative risk and relative size of the risk groups.
- A pooled premium might be highly beneficial in the presence of a small group with very high risk exposure.

# Contents

- 1 Introduction
- 2 Why do people buy insurance?
- 3 What drives demand for insurance?
- 4 How much of population losses is compensated by insurance?
- 5 Which regime is most beneficial to society?**
- 6 Conclusions

# Social welfare

## Definition (Social welfare)

Social welfare,  $G$ , is the sum of all individuals' expected utilities:

$$G = \sum_i p_i \left[ \underbrace{d(\mu_i, \pi_i) U(W - L\pi_i)}_{\text{Insured population}} + \underbrace{(1 - d(\mu_i, \pi_i)) \{ \mu_i U(W - L) + (1 - \mu_i) U(W) \}}_{\text{Uninsured population}} \right].$$

## Linking social welfare to loss coverage

Setting  $U(W - L) = 0$  and assuming  $L\pi_i \approx 0$  gives:

$$\begin{aligned} G &= U(W) \sum_i p_i d(\mu_i, \pi_i) \mu_i + \text{Constant}, \\ &= \text{Positive multiplier} \times \mathbf{\text{Loss coverage}} + \text{Constant}. \end{aligned}$$

Loss coverage provides a good proxy (which depends only on observable data) for social welfare (which depends on unobservable utilities).

**Result: Maximising loss coverage maximises social welfare.**

# Contents

- 1 Introduction
- 2 Why do people buy insurance?
- 3 What drives demand for insurance?
- 4 How much of population losses is compensated by insurance?
- 5 Which regime is most beneficial to society?
- 6 Conclusions**

# Conclusions

## Adverse selection need not be adverse

Restricting risk classification

- will always increase adverse selection;
- increases loss coverage if  $\lambda < 1$ .

## Summary

**Loss coverage provides a better metric than adverse selection in measuring social welfare.**



# References

- HAO, M., MACDONALD, A.S., TAPADAR, P. & THOMAS, R.G. (2015). Insurance loss coverage under restricted risk classification: The case of iso-elastic demand. *Submitted*.
- MACDONALD, A.S. & TAPADAR, P. (2010). Multifactorial disorders and adverse selection: epidemiology meets economics. *Journal of Risk and Insurance*, **77**, 155–182.
- THOMAS, R.G. (2009). Demand elasticity, risk classification and loss coverage: when can community rating work?. *ASTIN Bulletin*, **39**, 403–428.
- THOMAS, R.G. (2008). Loss coverage as a public policy objective for risk classification schemes. *Journal of Risk and Insurance*, **75**, 997–1018.