A Robust Framework to Balance Anti-Discrimination and Risk-Adequacy in Insurance Pricing

Wiebke Hansen

House of Insurance, Leibniz Universität Hannover

(joint work with Stefan Weber & Mario V. Wüthrich)

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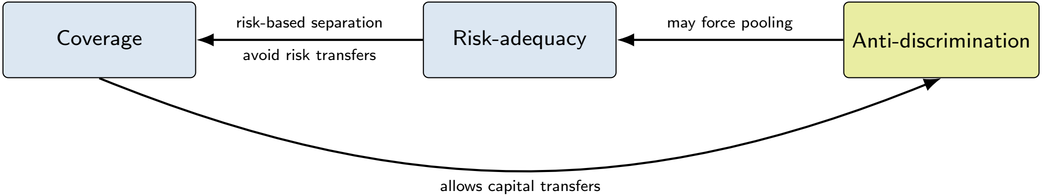
The basic conflict

Insurance premiums are set by pricing tariffs.

A tariff **C** separates risks into tariff classes. All risks within the same class pay the same price.

How to choose C?



Idea: Quantify objectives and solve vector optimization problem for **Pareto-optimal** solutions.

$$\min_{\mathbf{C}} f(\mathbf{C}) = (f_1(\mathbf{C}), f_2(\mathbf{C}), \dots)$$

Contribution: Framework specifying the decision object, the relevant constraints, and the trade-off structure.

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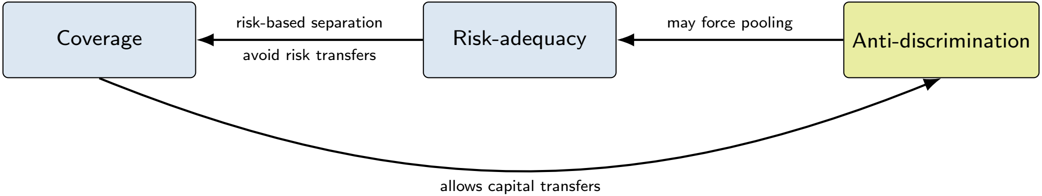

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What is a pricing tariff?

Policyholder level

- Each risk produces a future claim Y and is characterized by a type $\Theta = \vartheta$, that determines its claim law.
- A pricing rule Π quantifies the risk upon its claim law.

Benchmark risk premium $\pi(\vartheta) := \Pi(\mathbb{P}^{Y|\Theta}(\vartheta, \cdot))$

Tariff level

$\mathbf{C} = (C, \xi_{\Theta|C}, \Lambda)$

- C: Assigns ϑ to tariff classes c
- $\xi_{\Theta|C}$: Aggregates benchmark prices inside c
- Λ: Records capital transfers between classes

Charged premium $\pi^{\mathbf{C}}(c) := \Lambda(c) + \int \pi(\vartheta)\, \xi_{\Theta|C}(c, d\vartheta).$

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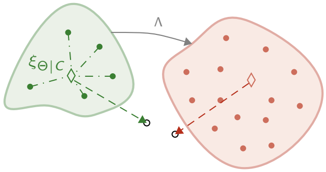

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Risk-adequate pricing - similar pay similarly, different pay differently

Avoid cross-subsidization.

- Policyholders should pay for their marginal risk contribution to the portfolio.
- Achieve suitable balance between risk-separation and pooling.

Risk-similarity: $\mathrm{dist}(\vartheta, \vartheta') := \mathrm{dist}_{\mathcal{M}_1}(\mathbb{P}^{Y|\Theta}(\vartheta, \cdot), \mathbb{P}^{Y|\Theta}(\vartheta', \cdot))$, for a probability pseudometric $\mathrm{dist}_{\mathcal{M}_1}$.

Type-level prices r are risk-adequate if, for $\mathbb{P}$-a.e. (ϑ, ϑ'),

$$\underline{\varphi}(\mathrm{dist}(\vartheta, \vartheta')) \leq \mathrm{dist}_{\mathbb{R}}(r(\vartheta), r(\vartheta')) \leq \overline{\varphi}(\mathrm{dist}(\vartheta, \vartheta')).$$

$\underline{\varphi}, \overline{\varphi} : \mathbb{R}_{\geq 0} \to \mathbb{R}_{\geq 0}$ calibrate how much premium separation is appropriate for a given risk separation.

How risk-adequate is a tariff?

Expected distance of $\pi^{\mathbf{C}}$ to the closest risk-adequate price $r \in \mathcal{R}$.

$$f_1(\mathbf{C}) := \inf_{r \in \mathcal{R}} \mathbb{E}\left[\mathrm{dist}_{\mathbb{R}}(\pi^{\mathbf{C}}(C(\Theta)), r(\Theta))\right].$$

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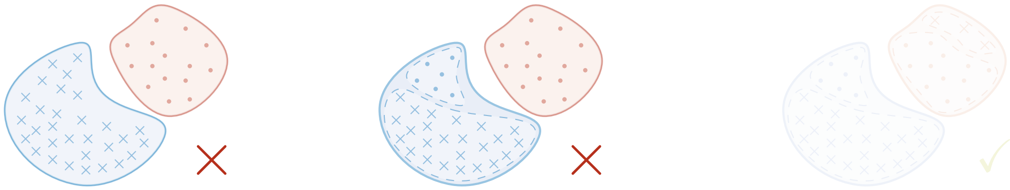
Anti-discrimination and its effect on risk-adequacy

Anti-discrimination restricts risk-based separation.

- Some policyholder variables D are considered protected (e.g., gender, ethnicity, religion).
- Policyholders must not be priced differently because of D.
- No protected group (e.g., men, women) must be excluded from a tariff class.



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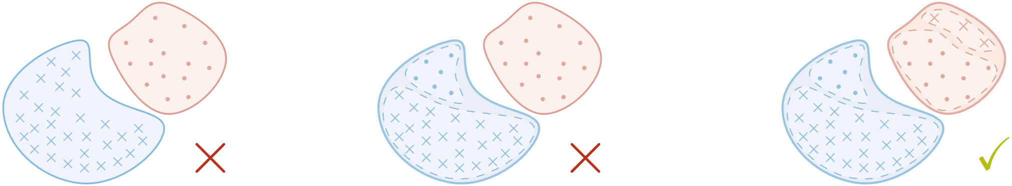

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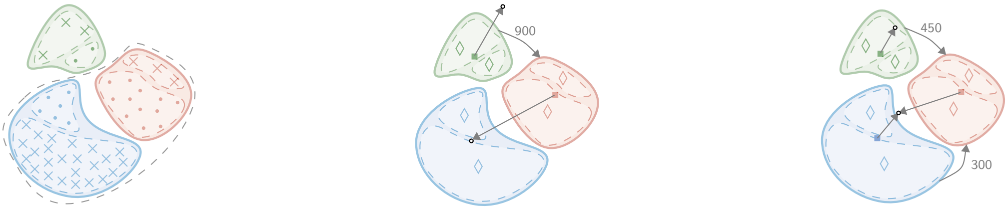

Subsidization across tariff classes could be interpreted as discrimination.

- Cross-subsidization is a capital transfer between tariff classes.
- Tariff classes C generally have different demographics $\mathbb{P}^{D|C}$.
- Transfers Λ might affect protected groups differently.

Variability of cross-subsidization among protected groups:

$$f_2(\mathbf{C}) := \mathrm{Var}\Big(\mathbb{E}[\Lambda(C) \mid D]\Big)$$

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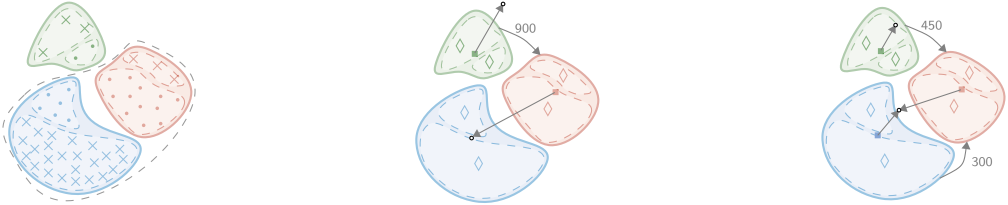

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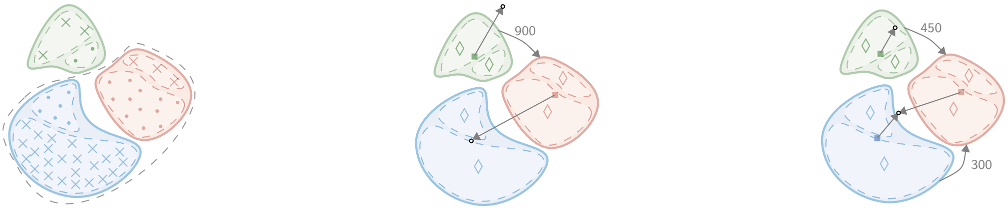

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What is new?

New perspective on anti-discriminatory pricing.

- Insurance pricing aims for portfolio coverage and two-sided risk-adequacy.
- This goal is normatively constrained by anti-discrimination law.
- Anti-discrimination is not merely a constraint on prediction, but a constraint on tariff construction.
- Anti-discrimination is decomposed into sub-objectives and quantified. Existing notions can be included.

$$\boxed{\min_{\mathbf{C}} f(\mathbf{C}) = (f_1(\mathbf{C}), f_2(\mathbf{C}), \ldots)}$$

Robust to uncertainty. The framework can identify optimal tariffs - even if we lack portfolio information.

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