Contract Regulation in Selection Markets

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Roadmap

Motivation 1

- Selection markets are often tightly regulated
  - mandatory purchase / non-purchase fees (health insurance in US, Germany)
  - minimal coverage (most markets)
  - maximal coverage (US exchanges, "platinum" plans)
- How do these affect equilibrium and welfare?

In this paper

- Tractable model of a competitive selection market
  - continuum of types
  - realistic regulation:
    - minimum and maximum coverage
    - non-purchase fee
  - special cases: Akerlof 70 and Rothschild-Stiglitz 76
- Equilibrium typically exhibits partial pooling
  - depends non-trivially on the type distribution (unlike in RS)
- Equilibrium is unique if the type distribution is log-concave.
- Increasing the non-purchase fee increases welfare if the density of cost types is decreasing.
- The optimal level of the minimum coverage is positive, below full insurance and induces some pooling at the minimum coverage.
- The optimal level of the maximum coverage is full insurance (even in an extension that allows for moral hazard).

Literature

- **Theory of regulation in markets for lemons**
  - Weyl Veiga 2016, Veiga 2023, Einav Finkelstein Tebaldi 2016, Handel Hendel Whinston 2015, Gemmo Kubitza Rothschild 2020, etc
- **Theory of regulation in RS settings**
  - Veiga Weyl 2016, Azevedo Gottlieb 2017, Neudeck Podczeck 1996, Encinosa 2001, Noton Olivella 2015, Farinha Luz et al 2022
- **Empirics of regulation in markets for lemons**
  - Finkelstein 2004, Einav Finkelstein Schrimpf 2010, Saltzman 2021, Landais et al 2021, Geruso et al 2021, Marone Sabety 2022

Roadmap

Types

- Type $\mu > 0$ captures expected cost
- Types $\Theta = [\underline{\mu}, \overline{\mu}]$
- PDF $f(\mu) > 0$, CDF $F(\mu)$
- We will assume f log-concave: $\frac{\partial^2}{\partial \mu^2} \ln [f(\mu)] \leq 0$

Contracts

- If an individual buys coverage x, the insurer covers a share x of the loss
- Allowed contracts are

$$x \in X = \{0\} \cup [\underline{x}, \overline{x}] \subseteq [0, 1]$$

- Not buying: $x = 0$
- Minimal coverage: $\underline{x} \geq 0$
- Maximal coverage: $\overline{x} \leq 1$
- Full insurance: $x = 1$

Cost

- (Endogenous) price of coverage x is

$$p(x) \geq 0$$

- A contract is a pair

$$(x, p)$$

- If type μ buys (x, p), the expected cost to the insurer is

$$x\mu$$

Utility

$$u(\mu,x,p) = x\mu + g(\mu,x) - p - T \cdot \mathbb{I}\{x=0\}$$

- Even if buyers were risk neutral, they would transfer to the insurer the expected cost $x\mu$
- Risk aversion surplus $g(\mu,x)$
- Non-purchase fee $T \geq 0$
- We assume

$$\frac{\partial g}{\partial x} > 0, \qquad \frac{\partial^2 g}{\partial x^2} < 0, \qquad \frac{\partial g}{\partial \mu} \geq 0.$$

  and $g(\mu,0) \equiv 0$, $\frac{\partial g}{\partial x}(\mu,1) \equiv 0$
- Quasi-linearity in p consistent with CARA
- If $T > 0$, assume $\underline{x} > 0$ to preserve continuity

Timing

1. Regulator chooses $(\underline{x}, \overline{x}, T)$
2. Insurers compete and individuals make choices, with the outcome given by an AG equilibrium (described later)

Assumptions

- Quasi-linearity in p (no wealth effects)
- No insurance loads
- Exclusive contracts
- No moral hazard
  - but included in an extension

Roadmap

AG Equilibrium, intuition

- Equilibrium concept from Azevedo Gottlieb 2017 (AG)
- Intuitively: in equilibrium
  - individuals optimize
  - each contract breaks even
  - the price of non-traded contracts is robust to small perturbations in the economy

AG Equilibrium, more formally

- An allocation α is a distribution on $\Theta \times X$
  - e.g, $\alpha(\{\mu, x\})$ is mass of types μ purchasing contract x
- A **weak equilibrium** is a price $p(x)$ and an allocation α such that
  - individuals choose x to maximize utility
  - each contract breaks even: $p(x) = x \cdot \mathbb{E}_\alpha[\mu \mid x]$
- Typically, there exist many weak equilibria
- An economy is a triple $[\Theta, X, f]$
- An **equilibrium** is the limit of a sequence of weak equilibria of perturbed economies, where there is a vanishing mass of "behavioral" zero-cost individuals who purchase every contract.

Theorem (AG)

Every economy has an equilibrium. In equilibrium, $p(x)$ is continuous and almost everywhere differentiable. Equilibrium need not be unique

Roadmap

Equilibrium Regimes

- An equilibrium "regime" is defined by whether or not there a positive mass of individuals choosing x in...

$$x > \underline{x}, \qquad x = \underline{x}, \qquad x = 0$$

- EG, all equilibria where individuals buy $x \in \{0, \underline{x}\}$ have the same structure, uniqueness properties, etc

Some regimes are not possible

Lemma

In any equilibrium, if there is a mass of individuals choosing $x = 0$, then there is also a mass of individuals choosing $x = \underline{x}$.

Equilibrium regimes

Some choose $x > \underline{x}$	Some choose $x = \underline{x}$	Some choose $x = 0$	Regime
Y	Y	Y	Dispersive
Y	-	-	RS
-	Y	-	boring
-	-	Y	not possible
Y	Y	-	Perfect Purchase, Partial Pooling (PPPP)
-	Y	Y	Lemons
Y	-	Y	not possible

When does each regime happen?

- Some sufficient conditions:
  - If $\underline{x}$ is sufficiently low $\rightarrow$ RS
  - If $\overline{x} - \underline{x}$ is sufficiently small $\rightarrow$ Lemons
- More conditions in the paper

Roadmap

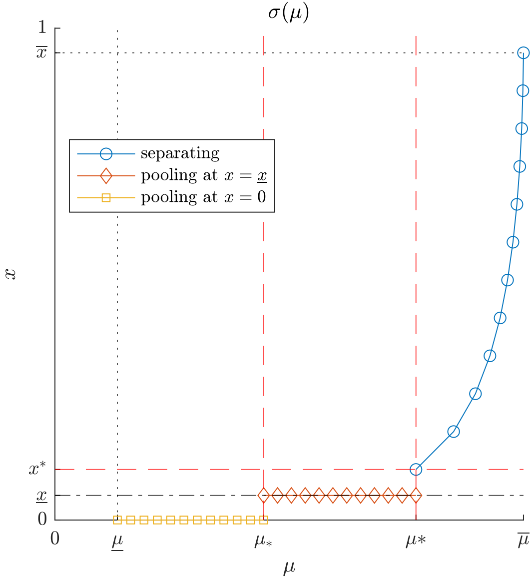
Roadmap

Dispersive Equilibrium

some buy	some buy	some buy
$x > \underline{x}$	$x = \underline{x}$	$x = 0$

- Requires $\overline{x} > \underline{x} > 0$
- Let $\sigma(\mu)$ be the contract that type μ chooses (almost surely) in equilibrium.

Dispersive Equilibrium: graphically



Equilibrium characterization

Proposition (Dispersive Equilibrium)

1. *There is an* $x^* \in [\underline{x}, \overline{x}]$ *and a* $\mu^* < \overline{\mu}$ *such that types* $\mu \in [\mu^*, \overline{\mu}]$ *buy* $x \in [x^*, \overline{x}]$*. For these types, let* $\tau = \sigma^{-1}$*. Then, for these types,* σ *satisfies*

$$\overline{\mu} - \mu = \int_{\sigma(\mu)}^{\overline{x}} \frac{1}{x} \frac{\partial g}{\partial x}(\tau(x), x)\, dx, \qquad \forall \mu \in [\mu^*, \overline{\mu}] \tag{1}$$

These contracts break even:

$$p(\sigma(\mu)) = \sigma(\mu)\mu, \qquad \forall \mu \in [\mu^*, \overline{\mu}]$$

2. *For* $x \in [\underline{x}, x^*)$*, price* $p(x)$ *makes type* μ^* *indifferent between* $(x^*, p(x^*))$ *and any* $(x, p(x))$

3. *There is a* $\mu_* \in \left(\underline{\mu}, \mu^*\right)$ *such* $\mu \in [\mu_*, \mu^*)$ *buys* $x = \underline{x}$*. This contracts breaks even:*

$$p(\underline{x}) = \underline{x} \cdot \mathbb{E}[\mu \mid \mu \in [\mu_*, \mu^*)].$$

4. *Type* μ_* *is indifferent between* $(\underline{x}, p(\underline{x}))$ *and* $(0,0)$

5. *Types* $\mu \in [\underline{\mu}, \mu_*)$ *purchase* $x = 0$ *and it breaks even:* $p(0) = 0$.

Intuition 1: shape of σ in the region of full separation

- Type $\overline{\mu}$ buys $x = \overline{x}$:
  - $p'(x) \leq \overline{\mu}$
  - For $x < \overline{x}$, for type $\overline{\mu}$, $\frac{\partial u}{\partial x} = \overline{\mu} + g'(\overline{\mu}, x) - p'(x) > 0$
- For types in the region of full separation, utility satisfies the FOC

$$\mu + \frac{\partial g}{\partial x}(\mu, x) - p'(x) = 0$$

- Price is differentiable (from AG), so

$$p'(x) = \tau(x) + x \cdot \tau'(x)$$

- Use $\mu = \tau(x)$. Combine these to get

$$\mu + \frac{\partial g}{\partial x}(\mu, x) - \left[\tau(x) + x \cdot \tau'(x)\right] = 0 \Leftrightarrow \tau'(x) = \frac{1}{x}\frac{\partial g}{\partial x}(\tau(x), x)$$

- Boundary condition $\overline{x} = \sigma(\overline{\mu})$. Integrating $\int_{\sigma}^{\overline{x}}$ yields the result

Corollary

Corollary

In the region of full separation, the allocation $\sigma(\mu)$ is independent of $f, \underline{x}, T$.

- $(\underline{x}, T)$ affect μ^*, but not $\sigma(\mu)$
- $\overline{x}$ does directly affect $\sigma(\mu)$
- In this region, things behave as in RS76

Intuition 2: Why is $x \in (\underline{x}, x^*)$ not purchased?

- Suppose the set of non-purchased contracts is small ($x^* \approx \underline{x}$)
- If indeed this was a dispersive equilibrium
  - type μ^* chooses x^* at a price $p = \mu^* x^*$
  - The price of $\underline{x}$ is determined by all the types who choose $\underline{x}$, who are all less costly than μ^*.
- If μ^* switches to purchasing the minimum coverage, she obtains approximately the same level of coverage but a discretely lower price $\rightarrow$ a contradiction.

Roadmap

RS

- All individuals choose $x > \underline{x}$
- Everyone is in the region of full separation
- This is the equilibrium structure in RS76
- Sufficient condition: $\underline{x}$ sufficiently small (indeed, in RS76, there is no minimum coverage)

RS, graphically

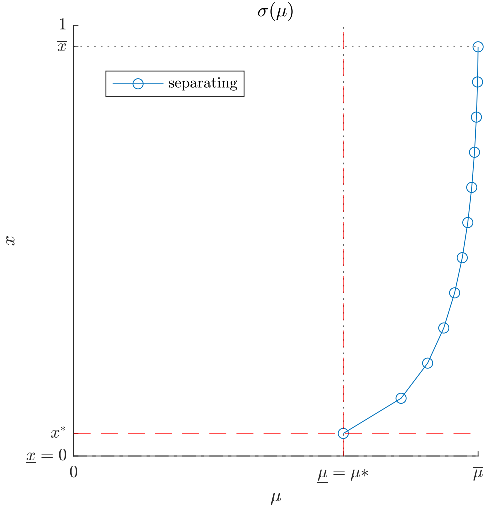


Figure 1: An illustration of an RS equilibrium (with $\underline{x} = 0$).

RS

Proposition

If the equilibrium regime is RS, it is described by Proposition 1, with

$$\mu^* = \mu_* = \underline{\mu}$$

However, nobody buys the minimum coverage, so its price is not determined by the break-even condition (but by the indifference curve of type $\underline{\mu}$). Also, type $\underline{\mu}$ strictly prefers x^* to $x = 0$

PPPP equilibrium

- All individuals choose $x > \underline{x}$ or $x = \underline{x}$
- Some individuals pool at the minimum coverage
- Tends to occur if T is large

PPPP, graphically

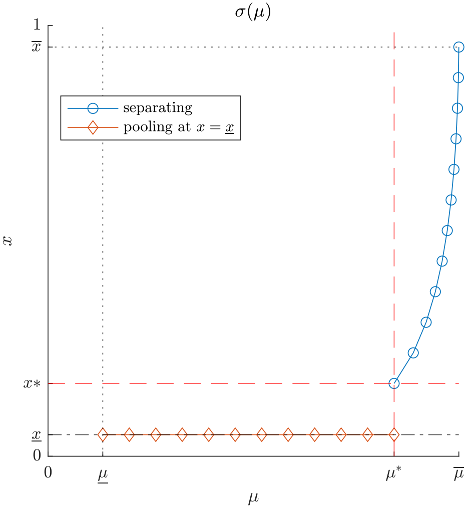


Figure 2: Illustration of a “PPPP” equilibrium.

PPPP equilibrium

Proposition

If the equilibrium regime is PPPP, it is described by Proposition 1, with

$$\mu_* = \underline{\mu}$$

Moreover, type $\underline{\mu}$ strictly prefers $\underline{x}$ to zero.

Lemons equilibrium

- All individuals buy $x \in \{0, \underline{x}\}$
- No mass in the region of full separation
- As in Akerlof 1970 and EFC 2010
- Occurs if $\overline{x}, \underline{x}$ sufficiently similar
- AG equilibria are Nash equilibria

Proposition

If the equilibrium regime is Lemons, it is described by Proposition 1, with

$$\mu^* = \overline{\mu}.$$

Since there is no one in the region of full separation, (1) is vacuous.

Roadmap

Uniqueness

- If the regime is RS, it is unique
- If the regime is PPPP, it is the unique PPPP equilibrium

Proposition

If f is log-concave, equilibrium is unique.

Roadmap

Comparative Statics

- Consider small changes in $(\underline{x}, \overline{x}, T)$
- Assume f log-concave. This will be used in two ways:
  - uniqueness
  - sign some effects
- For tractability, henceforth assume $g(\mu, x) = g(x), \forall \mu$

Welfare

- Welfare is
$$W = [F(\mu^*) - F(\mu_*)]\, g(\underline{x}) + \int_{\mu^*}^{\overline{\mu}} g(\sigma(\mu)) f(\mu) d\mu.$$

First Best

- First best: everyone buys full insurance
- Achievable with $T = \infty$ and $\underline{x} = \overline{x} = 1$
- Two potential problems:
  - politically difficult
  - suppose that instead of a tax on non-buyers there is a subsidy to buyers. Government must subsidize all individuals to buy. If there is a shadow cost of public funds, "full insurance for all" is not socially optimal (because $g'(1) = 0$)

Roadmap

Adjusting T

- RS, PPPP: nobody choosing $x = 0$, so changes in T have no effect
- Lemons: increasing T shifts some non-buyers into buying $\rightarrow$ increases W

Adjusting T

Lemma

If the regime is dispersive, and f log-concave,

$$\frac{\partial \mu_*}{\partial T} < 0, \qquad \frac{\partial \mu^*}{\partial T} > 0.$$

1. T increases $\rightarrow$ type μ_* shifts from $x = 0$ to $x = \underline{x}$
2. This lowers $p(\underline{x})$
3. Type μ^* shifts from $x = x^*$ to $x = \underline{x}$
4. This raises $p(\underline{x})$. f log-concave signs the overall effect

- Welfare:
  - rises proportionately to $f(\mu_*)(g(\underline{x}) - 0)$
  - falls proportionately to $f(\mu^*)(g(x^*) - g(\underline{x}))$

Adjusting T

Proposition

If the regime is dispersive with thresholds μ_*, μ^* then

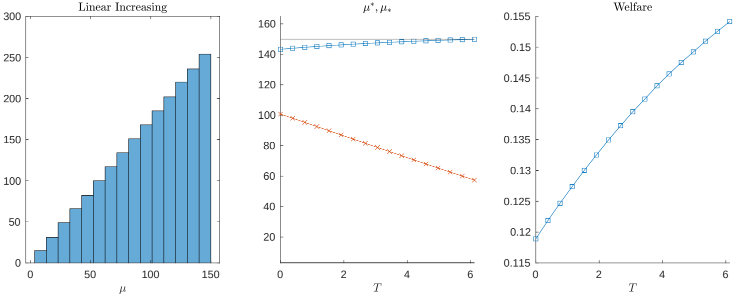
$$f(\mu_*) \geq f(\mu^*) \Rightarrow \frac{\partial W}{\partial T} > 0.$$

If f is weakly decreasing for all μ, then

$$\frac{\partial W}{\partial T} > 0, \forall T.$$

Adjusting T

- Condition is sufficient but not necessary:



Roadmap

Adjusting $\overline{x}$

- Increasing $\overline{x}$ (weakly) increases welfare if f log-concave

- Lemons: no effect
- RS / PPPP: welfare obviously increases (for any f)

Adjusting $\overline{x}$

Proposition

For dispersive equilibria, if f is log-concave,

$$\frac{\partial W}{\partial \overline{x}} > 0.$$

- Type $\overline{\mu}$ purchases greater coverage
- In the region of full separation, types $\mu > \mu^*$ purchase greater coverage
- Some individuals switch from $\underline{x}$ to $x > \underline{x}$, which lowers $p(\underline{x})$
- Some individuals switch from 0 to $\underline{x}$, which also lowers $p(\underline{x})$
- Log-concavity: the fall in $p(\underline{x})$ does not cause too many of those who switched up from $\underline{x}$ to $x > \underline{x}$ to "fall back down"

Roadmap

Ambiguity

- Positive effects
  - When $\underline{x}$ rises, those purchasing it become better off
  - This can induce some to raise their chosen coverage from 0 to $\underline{x}$
- Negative effects
  - Possibly some buyers of $x > \underline{x}$ now lower their choice to $\underline{x}$
  - This would increase $p(\underline{x})$, so it can also result in some individuals lowering their choice from $\underline{x}$ to 0.

Optimal $\underline{x}$ is > 0

- There is always a (small) level of $\underline{x}$ which strictly increases welfare.
- Suppose $\underline{x} = 0$, so regime is RS
- Now consider a gradual increase in $\underline{x}$
- For some level of the minimum coverage (denoted $\underline{x}_0$), the equilibrium regime shifts from RS to PPPP.
  - why to PPPP? individuals cannot pool at $x = 0$ without pooling at $x = \underline{x}$
  - $\underline{x}_0$ solves $\overline{\mu} - \underline{\mu} = \int_{\underline{x}_0}^{\overline{x}} \frac{g(x)}{x} dx$.
- When $\underline{x} \approx \underline{x}_0$, then $x^* \approx \underline{x}_0$ and $\mu^* \approx \underline{\mu}$

Proposition

We have $\lim_{\underline{x} \to \underline{x}_0} \frac{\partial W}{\partial \underline{x}} = 0$ *and* $\lim_{\underline{x} \to \underline{x}_0} \frac{\partial^2 W}{\partial \underline{x}^2} = 0$. *However, in a right-neighborhood of* $\underline{x}_0$,

$$\frac{\partial^3 W}{\partial \underline{x}^3} > 0$$

and hence, in a right neighborhood of $\underline{x}_0$, *W is strictly increasing in* $\underline{x}$.

Roadmap

Adjusting $\underline{x}$

Lemma

If the equilibrium regime is Lemons, and f is log-concave, then

$$\frac{\partial \mu_*}{\partial \underline{x}} > 0, \forall \underline{x} < 1.$$

- Higher coverage $\underline{x}$ (and the corresponding adjustment in price) shrinks the set of buyers due to adverse selection: the cost of infra-marginal types (i.e., $p(\underline{x})$) increases faster than the willingness to pay of marginal types

Adjusting $\underline{x}$

social planner's welfare maximizing choice of quantity	$\approx$	monopolists's profit maximizing choice of quantity

- Let quantity be $q(\underline{x}) = 1 - F(\mu_*(\underline{x}))$
- Then

$$\frac{\partial \underline{x}}{\partial q} = -\left(f(\mu_*) \frac{\partial \mu_*}{\partial \underline{x}} \right)^{-1} \leq 0.$$

Welfare

- Welfare is
$$W = q \cdot g\left(\underline{x}(q)\right)$$
- Surplus $g\left(\underline{x}(q)\right)$ behaves like an inverse demand function.
- FOC:
$$\frac{\partial W}{\partial q} = g\left(\underline{x}(q)\right) + q \cdot g'\left(\underline{x}(q)\right)\frac{d\underline{x}}{dq} = 0 \tag{2}$$
- Selling insurance to another marginal individual entails:
  - marginal gains: surplus of the marginal individual, $g\left(\underline{x}(q)\right)$
  - infra-marginal losses: increasing q requires lowering the $\underline{x}$ enjoyed by all q infra-marginal individuals: surplus falls proportionally to $q \cdot g'\left(\underline{x}(q)\right)$

Optimal $\underline{x}$ is < 1

- We've seen that it is optimal to choose $\overline{x} = 1$
- What is the optimal level of $\underline{x}$? We know it is $> \underline{x}_0$....
  - Is $\underline{x} = 1$ optimal?
  - Yes, if everyone buying full insurance is an equilibrium.
  - Suppose it is not (e.g., T cannot be set high enough)
  - Then, if $\underline{x} = \overline{x} = 1$, the equilibrium regime is Lemons.
  - We show that this is not optimal

Optimal $\underline{x}$ is < 1

Proposition

If $\overline{x} = 1$, then

$$\frac{dW}{dq}\Big|_{\underline{x}=1} > 0 \qquad \textit{and} \qquad \frac{dW}{dx}\Big|_{\underline{x}=1} < 0$$

if and only if all individuals buying $\underline{x} = 1$ is not an equilibrium.

- At full insurance
  - marginal surplus from additional insurance vanishes, since $g'(1) = 0$
  - marginal lowering of q due to adverse selection does not
- Optimal minimum coverage is greater than $\underline{x}_0$ but below full insurance

Roadmap

Moral Hazard (MH)

- MH = insurer cost increases disproportionately with coverage x
  - Eg, individuals use more healthcare when they receive better insurance, especially high-cost individuals
- Key question: in the presence of MH, can there be OVER-insurance in equilibrium?
  - if so, this would be a reason to impose $\overline{x} < 1$

Modeling MH

- Utility and cost are now

$$u(\mu, x, p) = \mu x + g(x) + w(\mu, x) - p, \qquad c(\mu, x) = \mu x + k(\mu, x).$$

Assumption

$w(\cdot), k(\cdot)$ are twice continuously differentiable, increasing in μ and strictly increasing in x, with $k(,0) \equiv w(,0) \equiv 0$.
We assume $\frac{\partial k}{\partial x}(\mu, x) > \frac{\partial w}{\partial x}(\mu, x) > 0$, $\forall x > 0$ and $\forall \mu$.
Moreover,

$$\frac{\partial^2 k}{\partial x^2}(\mu, x) \geq \frac{\partial^2 w}{\partial x^2}(\mu, x), \qquad \frac{\partial^2 k}{\partial \mu \partial x}(\mu, x) \geq \frac{\partial^2 w}{\partial \mu \partial x}(\mu, x).$$

- The wedge $k(\mu, x) - w(\mu, x)$ is increasing concave in x and increases more quickly in x for higher μ

Social Surplus

- Social surplus is

$$s(\mu,x) = g(x) + w(\mu,x) - k(\mu,x).$$

Equilibrium

Proposition

Suppose $X = [0, \overline{x}]$ and MH is present. There is a unique equilibrium. Either no individual purchases, or all purchase positive coverage as follows:

1. *There is a cut-off coverage $x^* \in (0, \overline{x})$ and a maximal purchased coverage $\tilde{x} \in (x^*, \overline{x}]$, s.t. all types purchase contracts $x \in [x^*, \tilde{x}]$ and all such contracts are purchased.*
2. *Type $\overline{\mu}$ buys the maximal purchased coverage $\tilde{x}$*
3. *The allocation rule σ is strictly increasing and $\sigma \leq \tilde{x}$. Let $\tau = \sigma^{-1}$ be defined on $x \in [x^*, \tilde{x}]$. Then,*

$$\tau'(x) = \frac{1}{x + \frac{\partial k}{\partial \mu}(\tau(x), x)} \frac{\partial s}{\partial x}(\tau(x), x), \qquad \forall x \in (x^*, \tilde{x}) \tag{3}$$

4. *Each contract breaks even: $p(x) = c(\tau(x), x), \forall x \in [x^*, \tilde{x}]$.*

What is the maximal purchased coverage $\tilde{x}$?

Proposition

In equilibrium, $\tilde{x} = \overline{x}$ *if*

$$\frac{\partial s}{\partial x}(\overline{\mu}, \overline{x}) \geq 0.$$

If $\tilde{x} < \overline{x}$*, then* $\tilde{x}$ *satisfies*

$$\frac{\partial s}{\partial x}(\overline{\mu}, \tilde{x}) = 0.$$

- If information was symmetric, each type would obtain coverage such that $\frac{\partial s}{\partial x} = 0$
- Asymmetric information: coverage chosen by low risks distorted downwards but "no distortion at the top"

MH reduces equilibrium coverage

Corollary

Suppose $X = [0, \overline{x}]$. All else equal, for each type μ, equilibrium coverage is (weakly) higher if $w(\cdot) \equiv k(\cdot) \equiv 0$ than in a model with MH.

- But, under MH, the optimal amount of coverage is also lower

Excessive insurance?

- Let $x^{\star\star}(\mu)$ be the coverage that maximizes surplus for type μ

Lemma

If $x^{\star\star}(\mu) > 0$, it is the unique value that satisfies

$$\frac{\partial s}{\partial x}(\mu, x^{\star\star}(\mu)) = 0. \tag{4}$$

Moreover, $x^{\star\star}(\mu) < 1$, and $x^{\star\star}(\cdot)$ it is weakly decreasing in μ.

- Full insurance is not optimal for any individual
- The optimal coverage is lower for higher cost types

Excessive insurance?

Proposition

In equilibrium, every type $\mu < \overline{\mu}$ obtains coverage that is strictly lower than what is socially optimal. Full insurance $\overline{x} = 1$ is not purchased even if it is offered.

- At most, type $\overline{\mu}$ buys $\tilde{x}$ which is optimal for that type
- Equilibrium coverage is increasing in type
- Socially optimal coverage is decreasing in type
- MH leads to UNDER-insurance in equilibrium for every type (except perhaps $\overline{\mu}$)

Welfare

Proposition

Suppose that $X = [0, \overline{x}]$*, and MH is present. Suppose that, in equilibrium, positive coverage is purchased by all. If* $\overline{x} > \tilde{x}$*, then* $\frac{\partial W}{\partial \overline{x}} = 0$*. If* $\tilde{x} = \overline{x}$*, then* $\frac{\partial W}{\partial \overline{x}} > 0$.

- The presence of MH does not provide a rational for $\overline{x} < 1$
  - best case scenario ($\overline{x} > \tilde{x}$): does not affect welfare.
  - if $\tilde{x} \geq \overline{x}$, then it reduces welfare.

Roadmap

- Tractable model of a competitive selection market
  - includes common contract restrictions
  - nests, as special cases, Akerlof 1970 and RS76
- Equilibrium typically exhibits partial pooling
  - depends non-trivially on the type distribution (unlike in RS)
- Equilibrium is unique if the type distribution is log-concave.
- Increasing the non-purchase fee increases welfare if the density of types is decreasing.
- The optimal level of the minimum coverage is positive, below full insurance and induces some pooling at the minimum coverage contract.
- The optimal level of the maximum coverage is full insurance (even in an extension that allows for moral hazard).

THANK YOU!

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