Screening and Adverse Selection in Frictional Markets

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Introduction

Many markets feature adverse selection and imperfect competition

- Examples: insurance, loans, financial securities

In these markets, contracts used to screen different types

- Examples: differential coverage, loan amounts, trade sizes

A unified theoretical framework is lacking

- Large empirical literature (and some theory)
- But typically restricts contracts and/or assumes perfect competition

But many important questions

- Recent push to make these markets more competitive, transparent
- Is this a good idea?

This Paper

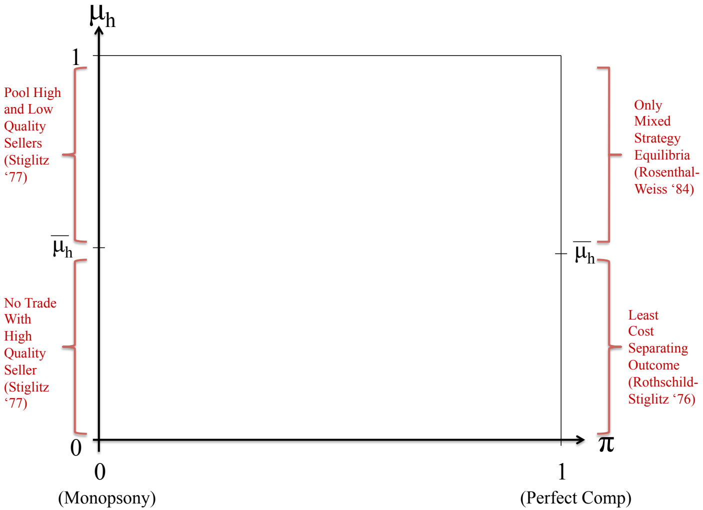
A tractable model of adverse selection, screening and imperfect comp.

1. Complete characterization of the unique equilibrium
2. Explore positive predictions for distribution of contracts
3. Policy experiments: changes in competition, transparency

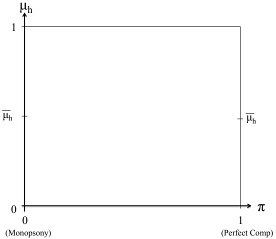
Sketch of Model: Key Ingredients

- Adverse Selection: sellers have private info about quality
  - A fraction μ_h have quality h, the rest quality ℓ
- Screening: Buyers offer general menus of non-linear contracts
  - Price-quantity pairs: induce sellers to self-select
- Imperfect Comp: sellers receive either 1 or 2 offers (à la Burdett-Judd)
  - Buyer competing with another with prob π, otherwise monopsonist.
  - Contract offered before buyers know

What We Know (Equilibrium)



Objective



Obj: Characterize eqm for any degree of adverse selection and imperfect comp.

Financial and Insurance markets typically characterized by imperfect comp.

What are the implications of imperfect comp. for....

- Terms of trade
- Welfare
- Policy

Summary of Findings

Methodology

- New techniques to characterize unique eqm for all $(\mu_h, \pi) \in [0,1]^2$
- Establish important (and general!) property of all equilibria:
  - *Strictly rank preserving:* offers for ℓ and h ranked exactly the same
    - No specialization

Positive Implications

- Equilibrium can be pooling, separating, or mix
- Separation when adverse selection severe, trading frictions mild
- Pooling when adverse selection mild, trading frictions severe

Normative Implications

- Adverse selection severe: *interior* π maximizes surplus from trade
- Adverse selection mild: welfare unambiguously decreasing in π
- Increasing transparency/relaxing info frictions can $\uparrow$ or $\downarrow$ welfare

Related Literature

Empirical

- Chiappori and Salanie (2000); Ivashina (2009); Einav et al. (2010); Einav et al. (2012)

Adverse Selection and Screening

- Rothschild and Stiglitz (1976); Dasgupta and Maskin (1986); Rosenthal and Weiss (1984); Mirrlees (1971); Stiglitz (1977); Maskin and Riley (1984); Guerrieri, Shimer and Wright (2010); Many, many others

Imperfect Competition and Selection

- Search Frictions: Burdett and Judd (1983); Garrett, Gomes, and Maestri (2014)
- Specialization: Benabou and Tirole (2014), Mahoney and Weyl (2014), Veiga and Weyl (2015)

Environment

Model Environment

Large number of buyers and sellers

- Each Seller endowed with 1 divisible asset
  - Seller values asset at rate c_i
  - Two types of sellers $i \in \{l, h\}$ with prob. μ_i
- Buyer values type i asset at rate v_i
- If x units sold for transfer t, payoffs are
  - Seller: $t + (1 - x)c_i$
  - Buyer: $xv_i - t$
- Assumptions:
  - Gains to trade: $v_i > c_i$
  - Lemons Assumption: $v_l < c_h$
  - Adverse Selection: Only sellers know asset quality

Model Environment

Screening

- Buyers post arbitrary menus of exclusive contracts
- Screening menus intended to induce self-selection

Search frictions

- Each seller receives 1 offer w.p. $1 - \pi$ and both w.p. π
  - Refer to seller with 1 offer as Captive
  - Refer to seller with 2 offers as non-Captive

Stylized Model of Trade

- best examples: corporate loans market; securitization (maybe)
- other examples: information-based trading; insurance

Strategies

- Each buyer offers arbitrary menu of contracts $\{(x_n, t_n)_{n\in\mathcal{N}}\}$
- Captive seller's choice: best (x_n, t_n) from one buyer
- Non-captive seller's choice: best (x_n, t_n) among both buyers

Revelation Principle

sufficient to consider

- menus with two contracts $\mathbf{z} \equiv \{(x_l, t_l), (x_h, t_h)\}$

$$(IC_j): \qquad t_j + c_j(1 - x_j) \;\geq\; t_{-j} + c_j(1 - x_{-j}) \qquad j \in \{h, l\}$$

- seller j: chooses contract j from available the set of menus available

Equilibrium Price Dispersion

- Suppose $\pi \in (0, 1)$: no symmetric pure strategy equilibrium exists
  - buyers can guarantee positive profits: trade only with captive types
  - in a pure strategy equilibrium: have to share non-captive types
    There is always an incentive to undercut

- Only mixed strategy equilibria possible
  $\Rightarrow$ equilibrium features price dispersion
  $\Rightarrow$ equilibrium described by buyers' distribution over menus

Equilibrium definition

A symmetric equilibrium is a distribution $\Phi(\mathbf{z})$ such that almost all $\mathbf{z}$ satisfy,

1. *Incentive compatibility*:

$$t_j + c_j(1 - x_j) \geq t_{-j} + c_j(1 - x_{-j}) \qquad j \in \{h, l\}$$

2. *Seller optimality*:

$$\chi_i(\mathbf{z}, \mathbf{z}') \text{ maximizes her utility}$$

3. *Buyer optimality*: for each $z \in Supp(\Phi)$

$$\mathbf{z} \in \arg\max_{\mathbf{z}} \sum_{i \in \{l,h\}} \mu_i(v_i x_i - t_i) \left[1 - \pi + \pi \int_{\mathbf{z}'} \chi_i(\mathbf{z}, \mathbf{z}')\Phi(d\mathbf{z}')\right] \qquad (1)$$

Characterization

Equilibrium described by non-degenerate distribution in 4 dimensions

Proceed in 4 steps

1. Show that menus can be summarized by a pair of utilities (u_h, u_l)
   - Reduces dimensionality of problem to distribution in 2 dimensions
2. Show there is a 1-1 mapping between u_l and u_h
   - Reduces problem to distribution in 1 dimension + a monotonic function
3. Construct Equilibrium
4. Show that constructed equilibrium is unique

A utility representation

Result (Dasgupta and Maskin (1986))

In all menus offered in equilibrium,

- *the low types trades everything:* $x_l = 1$
- IC_l *binds:* $t_l = t_h + c_l(1 - x_h)$

Result

Equilibrium menus can be represented by (u_h, u_l) *with corresponding allocations*

$$t_l = u_l \qquad x_h = 1 - \frac{u_h - u_l}{c_h - c_l} \qquad t_h = \frac{u_l c_h - u_h c_l}{c_h - c_l}$$

Since we must have $0 \leq x_h \leq 1$,

$$c_h - c_l \geq u_h - u_l \geq 0$$

A utility representation

Marginal distributions

$$F_j\left(u_j\right) \quad = \quad \int_{\mathbf{z}'} \mathbf{1}\left[t_j' + c_j\left(1 - x_j'\right) \leq u_j\right] d\Phi\left(\mathbf{z}'\right) \qquad\qquad j \in \{h, l\}$$

Then, each buyer solves

$$\begin{aligned}
\Pi(u_h, u_l) \quad &= \quad \max_{u_l \geq c_l,\ u_h \geq c_h} \sum_{j \in \{l,h\}} \mu_j \left[1 - \pi + \pi F_j\left(u_j\right)\right] \Pi_j\left(u_h, u_l\right) \\
\text{s. t.} \quad & \qquad c_h - c_l \geq u_h - u_l \geq 0 \\
\text{with } \ \Pi_l\left(u_h, u_l\right) \quad &\equiv \quad v_l x_l - t_l = v_l - u_l \\
\Pi_h\left(u_h, u_l\right) \quad &\equiv \quad v_h x_h - t_h = v_h - u_h \frac{v_h - c_l}{c_h - c_l} + u_l \frac{v_h - c_h}{c_h - c_l}
\end{aligned}$$

Need to characterize the two linked distributions F_l and F_h !

Further Simplifying the Characterization

Result

F_l and F_h have connected support and are continuous.

- Except for a knife-edge case (see paper)
- Proof more involved than standard case because of interdependencies

Result

The profit function $\Pi(u_h, u_l)$ is strictly supermodular.

- Intuition: $u_l \uparrow \Rightarrow \Pi_h \uparrow \Rightarrow$ stronger incentives to attract high types
- $\Rightarrow \quad U_h(u_l) \equiv argmax_{u_h} \Pi(u_h, u_l)$ is weakly increasing

Strict Rank Preserving

Theorem

$U_h(u_l)$ is a strictly increasing function.

Idea of Proof

- $U_h(u_l)$ increasing due to super-modularity of profit function
- F_l and F_h have no holes or mass points imply U_h is strictly increasing and not a correspondence

Strict Rank Preserving

Theorem

$U_h(u_l)$ is a strictly increasing function.

Implications for Characterization

- Rank ordering of equilibrium menus identical across types
- Menus attract same fraction of both types $F_l(u_l) = F_h(U_h(u_l))$
- Greatly simplifies the analysis: only have to find $F_l(u_l)$ and $U_h(u_l)$

Broader Implications

- Buyers do not specialize or attract only a subset of types
- Terms of trade offered to both types are positive correlated

Robust to any number of types

- Relies only on utility representation and ability to show distributions are well behaved

Constructing Equilibria

Equilibria: The two limit cases

Monopsony: $\pi = 0$

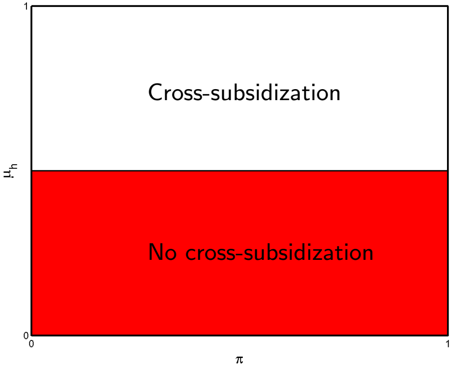
- $\mu_h < \bar{\mu}_h \Rightarrow$ Sep. with $x_h = 0$ and $\Pi_l > \Pi_h = 0$
  - No Cross-subsidization
- $\mu_h \geq \bar{\mu}_h \Rightarrow$ Pooling with $x_h = x_l = 1$ and $\Pi_h > 0 > \Pi_l$
  - Cross-subsidization

Bertrand: $\pi = 1$

- $\mu_h < \bar{\mu}_h \Rightarrow$ Sep. with $x_h < 1$, $\Pi_h = \Pi_l = 0$
  - No Cross-subsidization
- $\mu_h < \bar{\mu}_h \Rightarrow$ Sep. with $x_h < 1$, $\Pi = 0$, but $\Pi_h > 0 > \Pi_l$
  - Cross-subsidization

Intuition: Higher $\mu_h \Rightarrow$ Relaxing IC^l more attractive

Types of equilibria in the middle



High μ_h

- $\Pi_h > 0 > \Pi_l$
- All separating, all pooling or a mix

Low μ_h

- $\Pi_l, \ \Pi_h \ \geq \ 0$
- All separating, $U_h(u_l) \neq u_l$

No cross-subsidization: Characterization

Focus on separating equilibrium in no-cross subsidization region

Recall problem of a buyer:

$$\begin{aligned} \Pi(u_h, u_l) \quad &= \quad \max_{u_l \geq c_l,\ u_h \geq c_h} \sum_{j \in \{l,h\}} \mu_j \left[1 - \pi + \pi F_j\left(u_j\right)\right] \Pi_j\left(u_h, u_l\right) \\ \text{s. t.} \quad & \quad c_h - c_l \geq u_h - u_l \geq 0 \end{aligned}$$

- In separating equilibrium we construct, $c_h - c_l > u_h > u_l$
- Sufficient to ensure local deviations unprofitable

No cross-subsidization: Characterization

Marginal benefits vs costs of increasing u_l

$$\underbrace{\frac{\pi f_l\left(u_l\right)\Pi_l}{1-\pi+\pi F_l\left(u_l\right)}}_{\text{MB of more low types}} + \underbrace{\frac{\mu_h}{1-\mu_h}\frac{v_h-c_h}{c_h-c_l}}_{\text{MB of relaxing } IC_l} = \underbrace{1}_{MC}$$

Boundary conditions

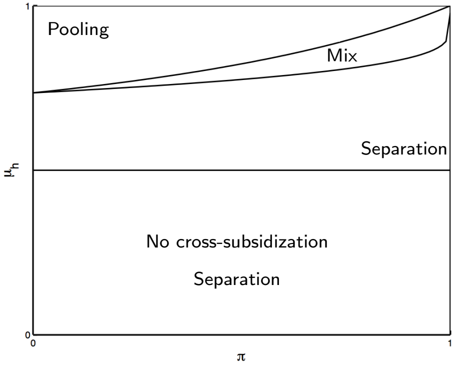
$$F_l(c_l)=0 \qquad F_l(\bar{u}_l)=1 \qquad \rightarrow \quad F_l(u_l)$$

Equal profit condition

$$\left[1-\pi+\pi F_l\left(u_l\right)\right]\ \Pi(U_h,u_l)=\overline{\Pi} \quad \rightarrow \quad U_h(u_l)$$

Pursue similar construction in other regions of parameter space

Equilibrium Regions in the Middle



More Competition implies *less* pooling

- Gains to cream-skimming increase in π

Milder Adverse Selection (higher μ_h) implies *more* pooling

- increased incentives to trade high volume
- increased cost of cream-skimming

▸ Price Dispersion

Theorem

For every (π, μ_h) there is a unique equilibrium.

Equilibrium Implications

Positive and Normative Implications

Is improving competition desirable for volume or welfare?

- For high μ_h, monopsony dominates perfect competition
- For low μ_h, perfect competition dominates monopsony
- Will show: for low μ_h, welfare maximized at interior π

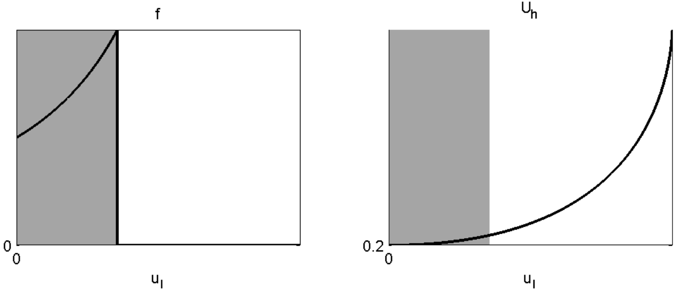
Is increasing transparency desirable?

- Allowing insurers, loan officers, dealers to discriminate on observables?
- Interpret increased transparency as increased spread in μ_h
- Desirability depends on curvature of welfare function with respect to μ_h
- Will show: Concavity/Convexity of welfare function depends on π, μ_h

Equilibrium Implications: Competition

Competition with No Cross-Subsidization

Assume μ_h in no cross-subsidization region

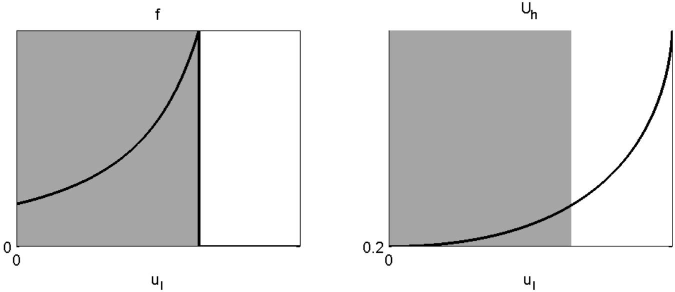


Equilibrium Distribution and $U_h(u_l)$ for $\pi = 0.2$

Shaded Region indicates support of F_l

Competition with No Cross-Subsidization

Assume μ_h in no cross-subsidization region



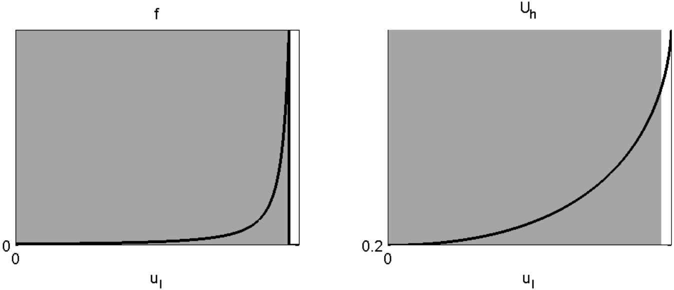
Equilibrium Distribution and $U_h(u_l)$ for $\pi = 0.5$

Shaded Region indicates support of F_l

- Increase in π increases F_l in sense of FOSD

Competition with No Cross-Subsidization

Assume μ_h in no cross-subsidization region



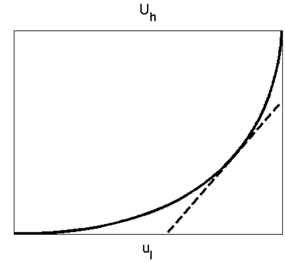
Equilibrium Distribution and $U_h(u_l)$ for $\pi = 0.9$

Shaded Region indicates support of F_l

- Increase in π increases F_l in sense of FOSD
- Driven by increased competition for (abundant) low-quality sellers

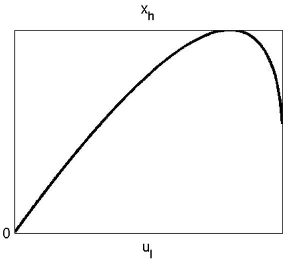
Competition with No Cross-Subsidization

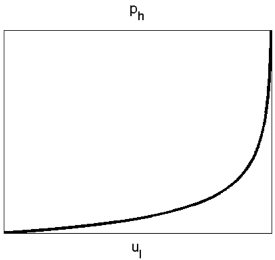
How is trade volume related to U_h?



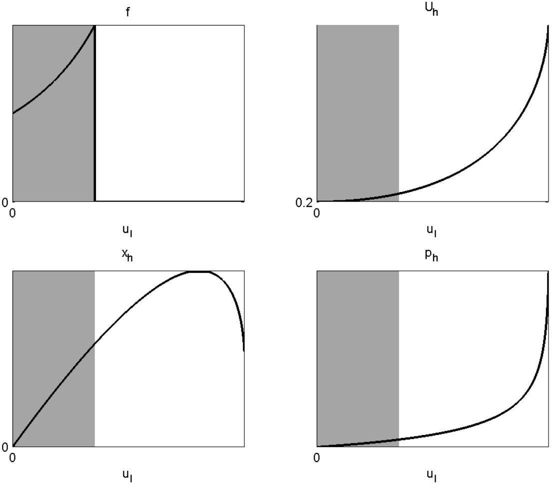
$$x_h(u_l) \quad = \quad 1 - \frac{U_h(u_l) - u_l}{c_h - c_l}$$

$$x_h'(u_l) \quad > \quad 0 \quad \Leftrightarrow \quad U_h'(u_l) \quad > \quad 1$$



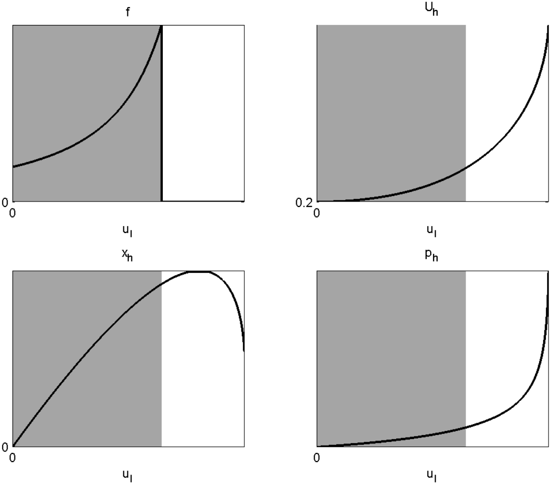


Competition with No Cross-Subsidization



Equilibrium Objects for $\pi = 0.2$

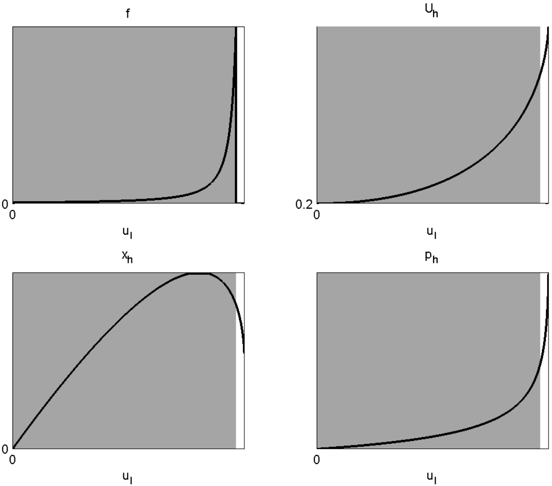
Competition with No Cross-Subsidization



Equilibrium Objects for $\pi = 0.5$

- From low π, increase in π increases volume

Competition with No Cross-Subsidization



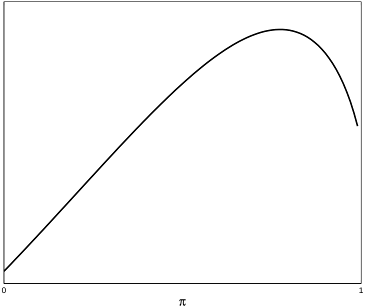
Equilibrium Objects for $\pi = 0.9$

- From moderate π, increase in π <u>decreases</u> volume

Competition and Welfare

When no cross-subsidization

$$W(\mu_h, \pi) = (1-\mu_h)(v_l - c_l) + \mu_h(v_h - c_h)\int x_h(u_l)dF(u_l)$$



Why is welfare decreasing?

- μ_h low implies few high types
- Competition less fierce for high types
- Demand from high types relatively inelastic
- Equal profits $\Rightarrow$ greater dispersion in prices
- Implies $U_h'(u_l) > 1$

Welfare maximized for interior π

With Cross-Subsidization, welfare (weakly) maximized in monopsony outcome

- Full trade $\Rightarrow$ all gains to trade exhausted

Equilibrium Implications: Transparency

Desirability of Transparency

Do the following policies improve welfare ?

- Allowing insurance providers to discriminate based on observables
- Introducing credit scores in loan markets
- Requiring OTC market participants to disclose trades

In model, interpret increased transparency as mean-preserving spread of μ_h

- Each seller has individual μ'_h; Buyers know distribution over μ'_h
- Buyers restricted to offering contracts associated with $E[\mu'_h]$
- Under transparency, buyers allowed to offer μ_h-specific menus
- Need to compare $E[W(\mu'_h, \pi)]$ to $W(E[\mu'_h], \pi)$

Is Transparency Desirable? Answer: Depends on π !

- W is linear when $\pi = 0$ and $\pi = 1$ $\Rightarrow$ no effect on welfare
- W is concave when π is high $\Rightarrow$ bad for welfare

Desirability of Transparency: The two limit cases

Monopsony: $\pi = 0$

- $\mu_h < \bar{\mu}_h \Rightarrow x_h = 0$ so that

$$W(\mu_h) = (1 - \mu_h)v_l + \mu_h c_h$$

- $\mu_h > \bar{\mu}_h \Rightarrow x_h = 1$ so that

$$W(\mu_h) = (1 - \mu_h)v_l + \mu_h v_h$$

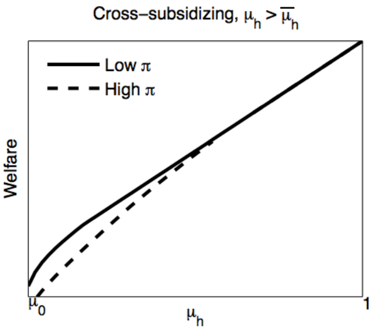
- Welfare is linear in μ_h

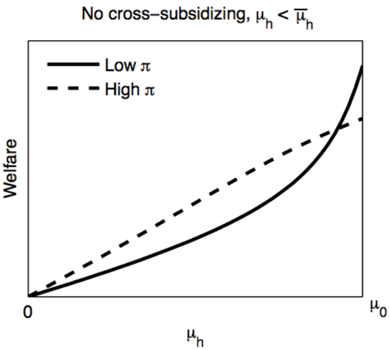
Bertrand: $\pi = 1$

- $\mu_h < \bar{\mu}_h \Rightarrow x_h$ independent of μ_h
- Implies welfare is linear in μ_h

In these cases, welfare is linear in μ_h so that mean-preserving spread (locally) has no impact on welfare

Desirability of Transparency: The general cases





- With cross-subsidization, welfare is concave

  $\Rightarrow$ increases in transparency <u>harm</u> welfare

- Without cross-subsidization, welfare is concave only for high π

  $\Rightarrow$ increases in transparency <u>harm</u> welfare when markets competitive

Conclusion

Methodological contribution

- Imperfect competition and adverse selection with optimal contracts
- Rich predictions for the distribution of observed trades

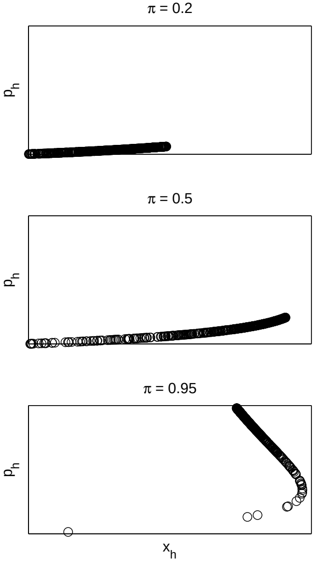
Substantive insights

- Depending on parameters, pooling and/or separating menus in equilibrium
- Competition, transparency can be bad for welfare

Work in progress

- Generalize to N types, curved utility
- Non-exclusive trading

No cross-subsidization: Price vs quantity (conditional)



Correlation $<$ 0 for suff. high π

A strategy to infer competitiveness ?

Back