

Monopoly Platforms

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Motivation

Many industries of policy interest exhibit common features:

- 1 Consumption externalities
- 2 Market power
- 3 Multiple groups of participants

Examples: newspapers, operating systems, credit cards etc.

⇒ Development of literature on “multi-sided platforms”

- General goals:
 - 1 Positive: how can we interpret/explain behavior?
 - What drives media slant? (Gentzkow and Shapiro 2010)
 - 2 Prescriptive: how should policy be made?
 - Network neutrality, mergers, regulation
- But allowing such rich realistic settings raises issues
 - Consumer coordination, sorting for best consumers
 - Over last five years I have been working to address these

Plan for talk

Today: increasingly rich (heterogeneous) monopoly models

- Work with Alex White extends to competition
- But much conceptual insight can be gained from monopoly

A quick outline:

- 1 Brief, broader literature review
- 2 Armstrong (2006): only heterogeneity in outside option
 - Model, solution approach and pricing formula
- 3 Weyl (2010): heterogeneous preferences
 - Model and solution approach: *insulating tariffs*
 - Pricing and the Spence distortion, policy applications
- 4 Veiga and Weyl (2011): heterogeneous externalities
 - Simplest one-sided model to show basic idea
 - Extensions: multi-sided, many quality dimensions, others
- 5 Conclusion: directions for future research

A quick review of the literature

Flowers with Katz and Shapiro (1985): exogenous beliefs

- Literature on market power created by coordination
- Liebowitz and Margolis (1994) argue monopoly internalizes
- Most subsequent literature follows one of these trends:
 - 1 Coordination and structure (begins with Rohlfs 74)
 - Caillaud and Jullien (2001,3): “two-sided” market
 - Ellison and Fudenberg (2003): when do markets tip?
 - Ambrus and Argenziano (2009): refine mis-coordination
 - Weyl (2010): as below, firm policies prevent mis-coordination
 - 2 Details of pricing (social studied first by Squire 73)
 - Rochet and Tirole (2003): dominant strategy pricing
 - Armstrong (2006): homogenous consumers, internalize
 - RT2006: equilibrium pricing to heterogeneous consumers
 - Anderson and Coate (2006): reduced-form media pricing
 - Weyl (2010): use insulation as foundation for general pricing

Armstrong's model

Two groups of users: \mathcal{A}, \mathcal{B} , constant MC $c^{\mathcal{A}}N^{\mathcal{A}} + c^{\mathcal{B}}N^{\mathcal{B}}$

- Homogeneous value for number $u^S (N^{-S})$
- Heterogeneous, full support reservation v_i^S , CDF F^S
 - Armstrong-Vickers (01): choose utility \bar{v}^S , internalize

$$\max_{\bar{v}^{\mathcal{A}}, \bar{v}^{\mathcal{B}}} \sum_{S=\mathcal{A}, \mathcal{B}} \left[u^S \left(F^{-S} \left(\bar{v}^{-S} \right) \right) - c^S - \bar{v}^S \right] F^S \left(\bar{v}^S \right)$$

- No coordination: consumers know utility (Dybvig-Spatt 83)
- Net social (private) pricing trivial where $N^S \equiv F^S \left(\bar{v}^S \right)$:

$$P^S = \underbrace{c^S}_{\text{marginal cost}} - \underbrace{u^{-S'} N^{\mathcal{J}}}_{\text{externality}} + \underbrace{\left(\frac{F^S}{f^S} \right)}_{\text{inverse hazard/Cournot distortion} \equiv \mu^S}$$

- Identical to economies of scope: only Cournot distortion

A model with preference heterogeneity

Let's allow heterogeneity in valuation of externality

- Again two sides, but now general cost $C(N^A, N^B)$
- Utility from consuming $u^S(N^{-S}; \theta^S)$
 - Only assume smoothness, full support, quasi-linearity
 - Maintain dependence on *number* on other side
 - RT2006 (RT2003 when $\theta_2 \equiv 0$) special case where
$$u^S(N^{-S}; \theta^S) = \theta_1^S N^{-S} + \theta_2^S$$
- Timing:
 - 1 Platform chooses prices
 - 2 Users decide whether to participate
- How to solve? Coordination problem following prices

The allocation approach

Problem: multiple quantities for any price pair

- But...only one price pair for each quantity
 $P^A(N^A, N^B), P^B(N^B, N^A)$
- Other side ties down distribution of values
- Full support implies smoothly decreasing inverse demand
- If platform *could* choose quantities, easy
 - Unique profit, welfare etc.
- Much like Myerson (1981): easier to solve for allocation
 - Thus the *allocation approach*
- But how to implement, avoid “failure to launch”?

Insulating tariffs

Condition prices on number of people on other side $P^S (N^{-S})!$

- This is just what Armstrong did: internalize externalities
- But Armstrong's strategy doesn't work here: heterogeneity
- RT2003: prices proportional to number on other side
⇒ Strategic *insulation*: optimal choice, not utility, independent
- Here heterogeneity too rich, but natural extension:
 - 1 Choose target quantities $(\widetilde{N}^A, \widetilde{N}^B)$
 - 2 Charge *insulating tariff* $P^S (N^{-S}) \equiv P^S (\widetilde{N}^S, N^{-S})$
 - Armstrong, RT2003 both special cases
 - Compensate *average marginal user* for change in other side
 - Marginal users heterogeneous and change with allocation
 - 3 Target achieved uniquely: any other is inconsistent
 - Whatever equilibrium quantity is conjectured, price is right

Socially optimal pricing

Social value $V^A(N^A, N^B) + V^B(N^B, N^A) - C(N^A, N^B)$

$$P^S = \underbrace{C_S}_{\text{private cost}} - \underbrace{\overline{u^{-S'}} N^{-S}}_{\text{external benefit}}$$

$\overline{u^{-S'}}$ \equiv average externality to participating $-S$ user of marginal S user

- Standard Pigou
 - Armstrong obviously special case
 - RT2003: $C = cN^A N^B$, $u^S = \theta^S N^{-S}$
 - All interaction so $\overline{u^{S'}} = p^S + \overline{s^S} \equiv \frac{P^S + V^S}{N^{-S}}$
 $p^A + p^B - c = -\overline{s^A} = -\overline{s^B}$

Privately optimal pricing

- MR=MC: $\sum_{\mathcal{J}} R_S^{\mathcal{J}} = C_S$

$$\underbrace{P^S - \mu^S}_{\text{classical marginal revenue}} + \underbrace{\widetilde{u}^{-S'} N^{-S}}_{\text{cross-marginal revenue}} = \underbrace{C_S}_{\text{marginal cost}}$$

- Two distortions from inability to price discriminate
 - Classical Cournot: (1838): market power upwards μ^S
 - Spence (1975): internalize wrong quality preference
 - $\widetilde{u}^{-S'} \equiv$ average marginal value to *marginal* users
 - Then you were a tourist
 - More important in MSPs
 - May go in either direction (credit cards v. newspapers)
 - Driven by *source of user heterogeneity*
 - Armstrong: no Spence, RT2003 upward: $\overline{s^{-S}}$

Policy applications

Very quick sampling, just give flavor

1 Measuring market power

- Usually use mark-up, but here adjust for other side
- Subtract from cost average value to marginal users
- Or aggregate across the two sides

2 Regulation (e.g. network neutrality)

- Which side to regulate? Spence and Cournot together
- Quantity better than price as in Sheshinski (1976)
- Price discrimination has additional benefits

3 Mergers

- Need competition model, joint with Alex White
- But basic intuition from here:
 - 1 Add indirect value of diverted sales
 - 2 Add Spence distortion to consumer harms

Allowing heterogeneity of externalities

Key restriction so far: only number of people on other side

- We want to allow composition to matter; start 1-sided
 - How does insulation work? Quantity not sufficient statistic
 - How does sorting work? No price discrimination
- $u(Q; \theta_i) - P, Q = \int_{\theta: u(Q; \theta) \geq P} q(\theta) f(\theta) d\theta$
 \implies Hetero. in *generation of* and *valuation for* externalities
- Keep previous assumptions, but also signed quality: $q > 0$
- Allocation approach now uses quality, not quantity
 - Once quality is tied down, now so are values
 - Therefore also determines order in which users enter
 - By signed quality, monotone in quantity so ties down price
 - Also \implies quality monotone in price so we can insulate
 - Maps everything back to standard framework
 - Charge $P(Q) \equiv P(\tilde{Q}; Q)$ where second entry is beliefs

Deriving optimal pricing

Crucial quantities:

- 1 Average marginal quality \tilde{q}
- 2 Marginal externality to average: $\overline{u'}$
- 3 Marginal externality to marginal: \tilde{u}'
- 4 Extent of sorting by quality for quality
 $\sigma \equiv \frac{N}{\mu} \text{Cov}[u', q | u = P]$

We can use these to derive private and social optimum:

- 1 Marginal social benefit = marginal social cost:
$$P + \tilde{q}\overline{u'}N + \tilde{q}\sigma\frac{C'-P}{\tilde{q}} = C'$$
 - Direct externality + sorting for those who value quality...
 - Value of the latter is same, so infinite series/implicit
- 2 Marginal revenue = marginal cost:
$$P - \mu + \tilde{q}\tilde{u}'N + \tilde{q}\sigma\frac{C'+\mu-P}{\tilde{q}} = C'$$

Private and social pricing

Rearrangement yields simple rules:

1 Social:

$$S \equiv C' - P = \tilde{q} \frac{\overbrace{u'N}^{\text{direct externality}}}{\underbrace{1-\sigma}_{\text{infinite series formula}}}$$

2 Private:

$$D \equiv C' + \mu - P = \tilde{q} \frac{\tilde{u}'N}{1-\sigma}$$

- Telemarkets v. shmoozers on the margin
- (A)Symmetry between social and private conditions
- Spence distortion magnified or mitigated
- With no correlation, collapses to above with average

A multi-sided model

Now we allow multiple sides $\mathcal{S} = \mathcal{A}, \mathcal{B}, \dots$

- $u^S(\mathbf{Q}, \theta_i^S) - P, Q^S = \int_{\theta^S: u^S(\mathbf{q}; \theta^S) \geq P^S} q^S(\theta^S) f^S(\theta^S) d\theta^S$
- Maintain assumptions and insulate w price on all qualities
- Multi-sided analogs of previous quantities:
 - ① Average marginal quality diagonal matrix $\tilde{\mathbf{q}}, \tilde{\mathbf{q}}_S = \tilde{q}^S$
 - ② Marginal externality to average matrix $\overline{\nabla \mathbf{u}} \equiv \left[\overline{u_S^T} \right]_{S, T}$
 - ③ Marginal externality to marginal matrix $\widetilde{\nabla \mathbf{u}} \equiv \left[\widetilde{u_S^T} \right]_{S, T}$
 - ④ Sorting/covar matrix $\Sigma \equiv \left[\frac{N^T}{\mu^T} \text{Cov} [u_S^T, q^T | u^T = P^T] \right]_{S, T}$
 - ⑤ Marginal cost vector $\mathbf{c}, c_S = C_S$
 - ⑥ Participation vector \mathbf{N}

Pricing

Natural multi-dimensional generalization of earlier

1 Social:

$$\mathbf{S} \equiv \mathbf{c} - \mathbf{P} = \tilde{\mathbf{q}} \cdot \underbrace{[\mathbf{I} - \boldsymbol{\Sigma}]^{-1}}_{\text{PageRank/infinite series}} \cdot \underbrace{\nabla \bar{\mathbf{u}} \cdot \mathbf{N}}_{\text{externality}}$$

- Google uses PageRank: value depends on value of links...
- Here it is the infinite series of sorting follow-on

2 Private:

$$\mathbf{D} \equiv \mathbf{c} + \mu - \mathbf{P} = \tilde{\mathbf{q}} \cdot [\mathbf{I} - \boldsymbol{\Sigma}]^{-1} \cdot \tilde{\nabla} \bar{\mathbf{u}} \cdot \mathbf{N}$$

⇒ Spence on other sides matter as well

- Natural multi-dimensional extension
- Rich and poor readers: who likes ads more?

Multi-dimensional quality

Often, one dimensional quality aggregator not enough

- Some subscribers want urbanites, others rural
- This causes basic problems for our approach
 - 1 What is feasible depends on current network
 - 2 Cannot insulate all dimensions simultaneously
- We are currently working on strategies for these
 - Insulating average marginal quality? Necessary conditions?
- In the meantime we've generated formulas anyway
- One-sided, $i = 1, \dots, m$: $u(\mathbf{Q}, \theta_i)$, $Q_i = \int q_i(\theta) f(\theta) d\theta$
- Avg. marg. quality vector $\tilde{\mathbf{q}}$, externality vectors $\overline{\nabla u}$, $\widetilde{\nabla u}$
- Sorting $\sigma = \frac{N}{\mu} [\text{Cov}[u_i, q_j | u = P]]_{i,j}$
- $S = \tilde{\mathbf{q}}^\top [I - \sigma]^{-1} \overline{\nabla u} N$, $D = \tilde{\mathbf{q}}^\top [I - \sigma]^{-1} \widetilde{\nabla u} N$
- Close to multi-product; to combine nicely need tensors
 - In progress...

Extensions

We are working to make this framework very general

- 1 Non-linear aggregators and set functions
 - Not just sum, but richer characteristics (e.g. variance)
 - Richer mathematics (set functions) and economics (cost)
- 2 Non-network quality
 - Political slant, member services, call quality, etc.
 - For applications and theory (more insulation instruments)
- 3 Convergence of PageRank and monotonicity
- 4 Competition
 - Many of the best applications here: multi-homing and ads
 - Easy to fit in unidimensional context with White and Weyl
 - But what about more useful/realistic settings?
- 5 Violations of signed quality
 - Feasible set again depends on quality; how to address?

Potential applications

- 1 Newspaper slant and profits (Gentzkow and Shapiro 2010)
 - Beautiful paper, but coarse profit function: max circulation
 - Could (should?) incorporate sorting and feedback
- 2 Multi-homing and ad revenue (Athey-Calvano-Gans)
 - ACG: hitting same consumer many times with ad bad
 - Logic could be generalized using these techniques
 - Example: substitutability of "niche-ness" on two sides
- 3 Smooth Rothschild-Stiglitz model à la Einav-Finkelstein
 - RS bang-bang, but covariance logic more general
 - Broader distortion caused by cream-skimming motive
- 4 Net neutrality regulation and distortions from market power
 - Heterogeneous both sides, strong interaction with quality
- 5 Competition between exchanges (Cantillon and Yin)
 - Measure heterogeneity of both types, this gives pricing

Conclusion and directions for future research

These papers aspire to three contributions

- 1 Modeling: rich, tractable frameworks for application
- 2 Technical: insulation, smooth sorting, rich objectives
- 3 Substantive: Spence distortion as fundamental policy focus

Suggests a number of directions for future research:

- 1 Empirics: what are these covariances, Spence distortions?
- 2 Extensions: regulation, externalities to non-participants
- 3 Connections: contracting w externalities, common agency
- 4 Big open theory questions
 - Revenue-max matching, dynamic foundations of insulation
 - 0 lower bound on prices (Jain and White 2010)
- 5 Applied theory
 - Abstract results, many specific contexts, smooth screening
 - Other interventions: interconnections, compatibility