When two-part tariffs are not enough: Mixing with nonlinear pricing

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Setup and Research Questions

- Often consumers combine (“mix”) goods from different sellers
  - Examples: coffee, tea, TV, drinks
- Consumers are heterogenous in their relative preference for these goods
- Can two-part tariffs arise in the fully nonlinear pricing equilibrium?
- How does exclusivity arise endogenously?
  - Equilibrium in exclusive contracts?
  - How many consumers consume one good only?

Modeling Framework

- Setup of Anderson and Neven (1989)
- Two firms at ends of Hotelling line of length 1, $c \geq 0$
- Consumer:
  - Located at $0 \leq x \leq 1$, fixed utility of consumption v
  - Consumes quantities $q_1 + q_2 = 1$
  - Actual quantities consumed are not observable, free disposal
  - Transport cost $t(1 - q_1 - x)^2$
- Firms compete in fully nonlinear tariffs T_i: $[0,1] \to \mathbb{R}$
- Two settings: Consumer types are observable or not
- Efficient allocation is $q_1 = 1 - x$: exclusivity is inefficient unless $x = 0,1$

Observable Consumer Types

- Firms compete for each consumer separately
- Infinitely many Nash equilibria resulting in efficient allocation
  - Reason: only marginal price at equilibrium allocation and “global curvature” count
- Among those is a unique two-part tariff, with
  - Marginal price equal to marginal cost
  - Fixed fees equal to marginal contribution to surplus
- Thus two-part tariffs arise in a fully nonlinear pricing equilibrium if types are observable
- Outcomes: $CS = v - c - \frac{2}{3}t, \Pi = \frac{1}{3}t, W = v - c$

Observable Consumer Types (2)

- Are all equilibrium allocations efficient?
- No, not if $c > 0$: Nash equilibria in flat fees
- If $0 < c < t$: partial exclusivity on $\left[0, \frac{c}{2t}\right] \cup \left[1 - \frac{c}{2t}, 1\right]$
  - Consumers on $\left[\frac{c}{2t}, 1 - \frac{c}{2t}\right]$ continue to mix
- If $c \geq t$: full exclusivity can arise
- Logic behind results:
  - With positive marginal cost, a consumer who already bought a flat fee from one firm has zero opportunity cost for additional units

Observable Consumer Types (3)

- Exogenous exclusivity:
  - Assume that either firms or consumers can and want to commit to exclusive contracts without mixing
- Nash equilibrium in exclusive contracts the same as on previous slides
- Outcomes: $CS = v - c - \frac{7}{12}t, \Pi = \frac{1}{4}t, W = v - c - \frac{1}{12}t$
  - *Higher* consumer surplus than in efficient allocation
  - Competition now is for the *contract* rather than marginal units
  - Total welfare lower due to inefficiency, of course

Unobservable Types: Nash Equilibrium

- We consider general nonlinear tariffs that are differentiable on (0,1)
- Unique Nash eq. : $T(q) = (c+t)q + \frac{t}{3}q(1-q)$
- Mixing only for $x \in \left[\frac{1}{3}, \frac{2}{3}\right]$, otherwise exclusivity
  - Exclusive customers pay Hotelling price $p^H = c + t$
  - Mixing customers pay per unit: $p = p^H + \frac{t}{3}(1-q)$
  - Again firms are pivotal in realizing gains from mixing, so can extract extra surplus
  - Still, amount of mixing is only efficient at $x = 0, \frac{1}{2}, 1$
- Outcome: $CS = v - c - \frac{29}{27}t, \Pi = \frac{14}{27}t, W = v - c - \frac{1}{27}t$

Unobservable Types: Two-Part Tariffs

- Is there a Nash equilibrium in fully nonlinear tariffs that involves two-part tariffs, at least for some parameter values?
  - Results in the literture: yes if market sufficiently competitive
- In our framework the answer is "no"
- Two-part tariffs are never even a best response to any other (differentiable) tariff
- Reason: Firms choose their tariffs in order to sort customers
  - Set higher marginal prices for smaller quantities

Unobservable types: Exclusivity

- Can full exclusivity arise endogenously?
- Exclusive contracts are equivalent to contracts $T(0) = 0, T(q) = P \ \forall q \in (0,1]$
  - Due to assumption of free disposal
  - These are differentiable on $q \in (0,1)$
- Thus cannot arise in equilibrium
- In all Nash equilibria at least some consumers mix

Unobservable types: Exclusivity (2)

- Consider again the outcome under commitment to exclusivity
  - This time identical to "traditional" Hotelling model
- Firms earn lower profit $\Pi = \frac{1}{2}t$
- Non-mixing consumer are unaffected
- Mixing consumers' surplus is lower
- Thus nobody is better off under commitment to exclusivity

Competition in Different Tariffs

- Depending on type of competition we obtain the following market outcomes:

Pricing	Mixing	Consumers	Profits	Welfare
Linear (AN)	$[0,1]$	$v-c-1.000t$	$0.5000t$	$v-c$
Two-part (HV)	$[0.382, 0.618]$	$v-c-1.072t$	$0.5172t$	$v-c-0.03715t$
Nonlinear	$[1/3, 2/3]$	$v-c-1.074t$	$0.5186t$	$v-c-0.03704t$

- Linear pricing leads to highest consumer surplus and welfare
- Nonlinear pricing extracts more surplus and creates inefficient exclusivity
- Additional effects from fully nonlinear tariffs over two-part tariffs are small

Thank you!

- Questions?

Sketch of Proof for NE with unobs. Types

1) Assume firm 2 offers differentiable tariff T_2, and firm 1 offers menu $\{p(x), q(x)\}$ to $x \in [0, \overline{x}]$
2) Firm 1 solves

$$\max_{p,q} \Pi_1 = \int_0^{\overline{x}} (p(x) - cq(x))dx$$

$$s.t.\, U(x) \geq \widetilde{U}(x, \hat{x}) \ \forall x, \hat{x} \in [0, \overline{x}],$$

$$U(x) \geq U_2(x) = v - T_2(1) - t(1-x)^2 \ \forall x \in [0, \overline{x}].$$

3) ICCs summed up as $U(x) = U(\overline{x}) - \int_x^{\overline{x}} u_x(s, q(s))ds$
4) Resulting objective function

$$\Pi_1 = \int_0^{\overline{x}} [u(x, q(x)) - cq(x) + xu_x(x, q(x))]dx - \overline{x}U(\overline{x}).$$

5) FOC: $T_2'(1 - q(x)) + 2t(1 - q(x) - x) = u_\lambda(x, q(x))$

$$= c - xu_{x\lambda}(x, q(x)) = c + 2tx$$

Sketch of Proof for NE with unobs. Types (2)

6) With differentiable T_1, the consumer's choice of quantity is given by $u_\lambda(x,\lambda) = T_1'(\lambda)$.
7) Thus $T_1' = u_\lambda = c + 2tx, T_2' = c + 2t(1-x)$
8) Result: $q(x) = 1$ if $x \leq \frac{1}{3}$, $q(x) = 2 - 3x$ if $\frac{1}{3} \leq x \leq \frac{2}{3}$, and $\overline{x} \leq \frac{2}{3}$
9) Since $q^{-1}(z) = \frac{2-z}{3}$ we find $T'(q) = c + 2t\frac{2-q}{3}$
10) Last step: show that fixed parts are zero

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