Segmentation and Nonlinear Pricing in the Postal Sector

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Introduction

- Network operators typically use quite sophisticated pricing policies
- Both nonlinear pricing (NLP, second degree) and segmentation (third degree)
- Postal sector:
  - volume discounts
  - Ramsey pricing

- Welfare impact is theoretically ambiguous, but "often" positive
- Still regulators are often reluctant
- Study segmented nonlinear pricing (SNLP): combines segmentation with NLP
  - Operator can group customers into a certain number of categories on the basis of an exogenously observable characteristic at no cost
  - Category specific nonlinear tariffs (tagging in the public economics literature)

Basic model

- The utility of a customer of type i who consumes quantity q_i and pays t_i is given by

$$\theta_i u(q_i) - t_i,$$

  where u is increasing and strictly concave ($u' > 0$ and $u'' < 0$) while θ_i is a parameter reflecting the valuation of the good

- Reservation utility normalized to zero (for the time being)

- There are two categories of customers, a and b, and each category consists of two types (levels of θ) of customers

- Overall: 4 types characterized by their valuation of the good: $\theta_{1a}, \theta_{2a}, \theta_{1b}, \theta_{2b}$, with $\theta_{1j} < \theta_{2j}$, $j = a, b$.

- For the time being: groups to not overlap

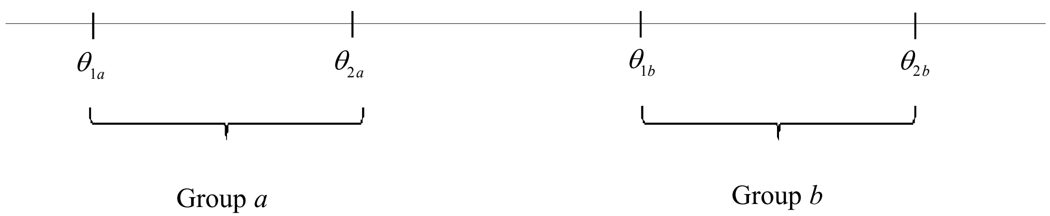

Figure 1: Separate groups

- Single operator with cost function

$$C(q_{1a}, q_{2a}, q_{1b}, q_{2b}) = F + \sum_i n_i c_i q_i,$$

- Objective: profit maximization

Efficient solution (first-best)

$$\max_{q_{1a},q_{2a},q_{1b},q_{2b}} \quad \theta_{1a}u(q_{1a})+\theta_{2a}u(q_{2a})+\theta_{1b}u(q_{1b})+\theta_{2b}u(q_{2b})-F-(c_{1a}q_{1a}+c_{2a}q_{2a}+c_{1b}q_{1b}+c_{2b}q_{2b})$$

yielding

$$\theta_{2b}u'(q^*_{2b}) = c_{2b},$$
$$\theta_{1b}u'(q^*_{1b}) = c_{1b},$$
$$\theta_{2a}u'(q^*_{2a}) = c_{2a},$$
$$\theta_{1a}u'(q^*_{1a}) = c_{1a}.$$

Marginal willingness to pay = marginal cost (= price under decentralization)

Nonlinear pricing without tagging (NLP)

$$\begin{aligned} \max \quad & t_{1a} + t_{2a} + t_{1b} + t_{2b} - F - (c_{1a}q_{1a} + c_{2a}q_{2a} + c_{1b}q_{1b} + c_{2b}q_{2b}) \\ \text{s.t.} \quad & \theta_{2b}u(q_{2b}) - t_{2b} = \theta_{2b}u(q_{1b}) - t_{1b}, \\ & \theta_{1b}u(q_{1b}) - t_{1b} = \theta_{1b}u(q_{2a}) - t_{2a}, \\ & \theta_{2a}u(q_{2a}) - t_{2a} = \theta_{2a}u(q_{1a}) - t_{1a}, \\ & \theta_{1a}u(q_{1a}) - t_{1a} = 0. \end{aligned}$$

Can be rewritten as

$$\begin{aligned} \max_{q_{1a},q_{2a},q_{1b},q_{2b}} \quad & \theta_{1a}u(q_{1a}) + \theta_{2a}u(q_{2a}) + \theta_{1b}u(q_{1b}) + \theta_{2b}u(q_{2b}) - F - (c_{1a}q_{1a} + c_{2a}q_{2a} + c_{1b}q_{1b} + \\ & - (\theta_{2b} - \theta_{1b})u(q_{1b}) - 2(\theta_{1b} - \theta_{2a})u(q_{2a}) - 3(\theta_{2a} - \theta_{1a})u(q_{1a}). \end{aligned}$$

Total surplus minus rents

This yields

$$\theta_{2b} u'(q_{2b}^{nt}) = c_{2b},$$
$$(2\theta_{1b} - \theta_{2b}) u'(q_{1b}^{nt}) = c_{1b},$$
$$(3\theta_{2a} - 2\theta_{1b}) u'(q_{2a}^{nt}) = c_{2a},$$
$$(4\theta_{1a} - 3\theta_{2a}) u'(q_{1a}^{nt}) = c_{1a},$$

and

$$q_{2b}^{nt} = q_{2b}^{*},$$
$$q_{1b}^{nt} < q_{1b}^{*},$$
$$q_{2a}^{nt} < q_{2a}^{*},$$
$$q_{1a}^{nt} < q_{1a}^{*}.$$

Nonlinear pricing with tagging (SNLP)

In tag $j = a, b$, we solve

$$\begin{aligned} \max_{q_{1j}, q_{2j}, t_{1j}, t_{2j}} \quad & t_{1j} + t_{2j} - F - (c_{1j} q_{1j} + c_{2j} q_{2j}) \\ \text{s.t.} \quad & \theta_{2j} u(q_{2j}) - t_{2j} = \theta_{2j} u(q_{1j}) - t_{1j}, \\ & \theta_{1j} u(q_{1j}) - t_{1j} = 0. \end{aligned}$$

which yields

$$\begin{aligned} & \theta_{2j} u'(q_{2j}^t) = c_{2j} \\ & (2\theta_{1j} - \theta_{2j}) u'(q_{1j}^t) = c_{1j}, \end{aligned}$$

and

$$\begin{aligned} q_{2j}^t &= q_{2j}^*, \\ q_{1j}^t &< q_{1j}^*. \end{aligned}$$

Tagged vs. non-tagged solution

We have

$$
\begin{aligned}
q_{2b}^{nt} &= q_{2b}^{t} = q_{2b}^{*},\\
q_{1b}^{nt} &= q_{1b}^{t} < q_{1b}^{*},\\
q_{2a}^{nt} &< q_{2a}^{t} = q_{2a}^{*},\\
q_{1a}^{nt} &< q_{1a}^{t} < q_{1a}^{*}.
\end{aligned}
$$

so that *in our setting the profit-maximizing solution under tagging (SNLP) always yields a higher level of welfare than the profit-maximizing solution without tagging (NLP).*

Intuition

- Consumption level of any type, i, affects the informational rents of all the "higher" types individuals are "connected" to type i directly or indirectly via binding incentive constraints
- Optimal policy: tradeoff between surplus and informational rents; consumption levels are distorted downwards to mitigate rents
- Explains that for group b nothing changes when tagging is introduced
- In the untagged case q_{2a} and q_{1a} affect the rents of all types in group b and q_{1a} additionally affects the rents of type $2a$
- When tagging is introduced, the link between groups is cut; inter-group mimicking is no longer possible $\Longrightarrow$ q_{2a} no longer affects any rents (and is left undistorted) while q_{1a} solely influences the rents of type $2a$

Variations and extensions

Overlapping groups

- Assume now that $\theta_{1a} < \theta_{1b} < \theta_{2a} < \theta_{2b}$
- This yields

$$
\begin{aligned}
q_{2b}^{nto} &= q_{2b}^{t} = q_{2b}^{*}, \\
q_{2a}^{nto} &< q_{2a}^{t} = q_{2a}^{*}, \\
q_{1b}^{nto} &\gtreqless q_{1b}^{t} < q_{1b}^{*}, \\
q_{1a}^{nto} &\gtreqless q_{1a}^{t} < q_{1a}^{*}.
\end{aligned}
$$

- Welfare impact is ambiguous

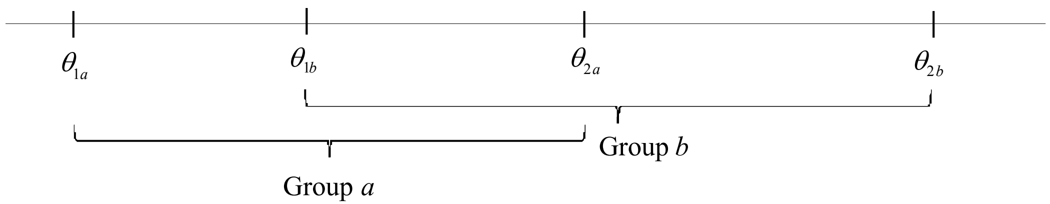

Figure 2: Overlapping groups

Linear pricing as outside option

- In the postal sector we can think about the reservation utility as being determined by the stamp price.
- The reservation utility of an agent with parameter θ is then given by

$$v(p, \theta) = \max_{q} \quad \theta u(q) - pq, \tag{1}$$

  where p is the stamp price
- Solution (and our results) are not affected when p is sufficiently large
- Note that sharing of surplus is affected

Conclusion

- Studied pricing policies which combine market segmentation (tagging) with nonlinear pricing
- Assume that the operator can group customers into categories on the basis of an exogenously observable characteristic at no cost
- When the groups do not overlap the profit maximizing SNLP solution yields a higher welfare (total surplus) than the standard NLP solution
- Result quite robust, could easily be generalized to more general distributions of the taste parameter

- With overlapping groups:
  - Total surplus generated by the high type in each group increases when tagging is introduced
  - Impact on the consumption level of low types is ambiguous
  - Total welfare impact ambiguous
- Other extension: simple linear tariff (the stamp price) is available to all customers and determines their reservation utility: no impact on results when the stamp price is sufficiently large

- To sum up, this paper shows that conceding more pricing flexibility to a profit-maximizing operator who is able to categorize its customers according to their valuation of services, can be welfare enhancing
- General result, but particularly significant in postal sector where volumes are declining