Price Discrimination in Two-Sided Markets

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Introduction

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- Two-sided markets have recently received significant attention in the industrial organization literature.
- Two-sided markets are markets organized around platforms where:
  - Two sides (groups) meet at the platform for successful trades to take place.
  - One group’s benefit from joining a platform depends on the size of the other group that joins the same platform.
- There is indirect network externality between these two groups. A parameter $\alpha_l$ measures how much members in group $l$ value members of the other group joining the same platform.
An illustrative example

- Two groups of agents:
  - Readers: who have heterogeneous preferences about the two newspapers.
  - Advertisers: who also have heterogeneous preferences about the two newspapers.
- Indirect network externality
  - Advertisers care about the number of readers a given newspaper has.
  - Readers care about the number of ads (e.g., coupons, job postings, etc.) in a given newspaper.
More examples

- TV Channels (Viewers & Advertisers)
- Credit cards (Merchants & Users)
- Videogame platforms (Gamers & Game developers)
- B2B markets (Input suppliers & buyers)
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- Uniform pricing: Each newspaper charges two prices, one for the readers and one for the advertisers.

  For example, The Washington Post may offer a discounted price to the readers of The Washington Times.
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Third-degree price discrimination is when firms target different groups of consumers with different prices.

- Uniform pricing: Each newspaper charges two prices, one for the readers and one for the advertisers.
- Discriminatory pricing: Each newspaper targets each reader (or group of readers) and each advertiser (or group of advertisers) with different prices.
- For example, *The Washington Post* may offer a discounted price to the readers of *The Washington Times*.
Results on third-degree price discrimination

- The main results from one-sided (i.e., models with no externalities), horizontal differentiation models are:
  - The game is a *prisoners’ dilemma* game.
  - All consumers pay lower prices when firms have the ability to customize their prices.
  - This is due to the *best response asymmetry*: a firm’s strong market is the rival firm’s weak market and vice versa.

- The policy implication is that the antitrust authority may not need to worry much about firms acquiring and using consumer information to customize prices.
Results on two-sided markets

- It is well-known that the presence of network externalities in two-sided markets may intensify the competition, e.g., Armstrong (2006).
- This is because platforms have extra incentives to lower prices so that it can sign up more agents in the other group.
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Nevertheless, we show that, in a two-sided market, price discrimination may actually soften the competition.

This result suggests that two-sided markets can be very different from one-sided markets.
Main results

- Firms (platforms) possess information about the consumers’ brand preferences, which can be used to segment consumers.
- When the indirect externality is strong, price discrimination is more profitable than uniform pricing.
- The results do not change qualitatively when we allow agents to multi-home.
- Profits are higher when prices are private than when they are public.
Outline of the talk

- Literature review and paper’s contribution
- Analysis
  - Uniform prices (no price discrimination)
  - Perfect price discrimination
  - Profit comparison
- Imperfect price discrimination
  - Public prices
  - Private prices
- Multihoming
- Conclusion
Oligopolistic price discrimination (one-sided markets)


Two-sided markets

Literature review

Oligopolistic price discrimination (one-sided markets)

Two-sided markets
- Caillaud and Jullien and Armstrong allow prices to be different across groups (but not within each group, which is what we do).
Paper’s contribution

Our paper combines the above two strands of literature.
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Other applications of two-sided markets

- Tying: Choi (2006)
- Net neutrality: Economides and Tåg (2007)
The model

- There are two horizontally differentiated platforms A and B (indexed by $k$) and two groups of agents 1 and 2 (indexed by $\ell$).
- Agents are distributed according to the distribution function $F_{\ell}(\cdot)$ on the $[0, 1]$ interval, with density $f_{\ell} > 0$. 

![Diagram of platform distribution](image-url)
Consider an agent from group 1 who is located at point $x \in [0, 1]$. His expected indirect utility is:

$$
\begin{align*}
V + \alpha_1 n_{2A}^e - tx - p_{1A}, & \quad \text{if he joins platform } A \\
V + \alpha_1 n_{2B}^e - t(1-x) - p_{1B}, & \quad \text{if he joins platform } B.
\end{align*}
$$

- $\alpha_\ell$ measures the strength of the cross-group externality, $\ell = 1, 2$.
- $n_{2A} = F_2(x_2)$ and $n_{2B} = 1 - F_2(x_2)$ is the number of agents from group 2 that join platforms $A$ and $B$ respectively.
- $p_{\ell k}$ is a lump-sum price platform $k$ charges to group $\ell$ agents.
Two-stage game

- Stage 1: Platforms, simultaneously and independently, choose their prices.
- Stage 2: The agents decide about which platform to join.
Two-stage game

- Stage 1: Platforms, simultaneously and independently, choose their prices.
- Stage 2: The agents decide about which platform to join.

We assume that each agent joins only one platform (single-homing). We relax this assumption later.

We examine two different cases:

▶ Prices are public.
▶ Prices are private.
Uniform prices

- The marginal consumers \((x_1 \text{ and } x_2)\) are defined by

\[
V + \alpha_1 n_{2A} - tx_1 - p_{1A} = V + \alpha_1 n_{2B} - t(1 - x_1) - p_{1B}
\]

\[
V + \alpha_2 n_{1A} - tx_2 - p_{2A} = V + \alpha_2 n_{1B} - t(1 - x_2) - p_{2B}
\]

where

\[
n_{1A} = F_1(x_1), n_{1B} = 1 - F_1(x_1), n_{2A} = F_2(x_2), n_{2B} = 1 - F_2(x_2).
\]

- These are two implicit functions of \(x_1\) and \(x_2\). We can not directly solve \(x_1\) or \(x_2\).
However, by invoking the implicit function theorem, we can obtain the effect of prices on market shares:

\[
\frac{\partial x_1}{\partial p_{1A}} = \frac{\partial x_2}{\partial p_{2A}} = -\frac{t}{2 \left[ t^2 - \alpha_1 \alpha_2 f_1(x_1) f_2(x_2) \right]}
\]

\[
\frac{\partial x_1}{\partial p_{2A}} = -\frac{\alpha_1 f_2}{2 \left[ t^2 - \alpha_1 \alpha_2 f_1(x_1) f_2(x_2) \right]}
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\]
The platforms’ profit functions are

\[ \pi_A = p_1A F_1(x_1) + p_2A F_2(x_2) \]
\[ \pi_B = p_{1B} [1 - F_1(x_1)] + p_{2B} [1 - F_2(x_2)] \]

The first order conditions of platform A are

\[ \frac{\partial \pi_A}{\partial p_{1A}} = F_1(x_1) + p_1Af_1(x_1) \frac{\partial x_1}{\partial p_{1A}} + p_2Af_2(x_2) \frac{\partial x_2}{\partial p_{1A}} \]

- inframarginal rents
- g.1 marginal consumer
- g.2 marginal consumer
Assume symmetry ($p_{lA} = p_{lB}, l = 1, 2$)

$$p_1 = \frac{t}{f_1} - \frac{\alpha_2 f_2}{t} \times \frac{(\alpha_1 + p_2)}{t}$$

- Market power
- Extra group 2 agents
- Profit from an extra group 2 agent
- Feedback effect
Assume symmetry \((p_{lA} = p_{lB}, l = 1, 2)\)

\[
p_1 = \frac{t}{f_1} \quad \alpha_2 f_2 \quad \times \quad \frac{t}{t} \quad (\alpha_1 + p_2)
\]

- market power
- extra group 2 agents
- profit from an extra group 2 agent

The second term measures the external benefit to a platform from attracting an extra group 1 agent.

- The platform can attract more group 2 agents, and makes a \(p_2\) profit from each of them.
- The platform can also extract an additional \(\alpha_1\) revenue from its group 1 agents, now there are more group 2 agents.
- Overall, the platform attracts \(\frac{\alpha_2 f_2}{t}\) extra group 2 agents when it attracts an extra group 1 agent.
Proposition

The equilibrium prices and profits are:

\[ p^*_1A = p^*_1B = \frac{t - \alpha_2 f_1 \left( \frac{1}{2} \right)}{f_1 \left( \frac{1}{2} \right)} \quad \text{and} \quad p^*_2A = p^*_2B = \frac{t - \alpha_1 f_2 \left( \frac{1}{2} \right)}{f_2 \left( \frac{1}{2} \right)} \]

\[ \pi_A = \pi_B = \frac{t - \alpha_2 f_1 \left( \frac{1}{2} \right)}{2 f_1 \left( \frac{1}{2} \right)} + \frac{t - \alpha_1 f_2 \left( \frac{1}{2} \right)}{2 f_2 \left( \frac{1}{2} \right)} \]

- The indirect externality (feedback effect) intensifies the competition and leads to lower profits, relative to the profits when \( \alpha_\ell \) is zero.
Perfect price discrimination

Proposition

- Each agent pays a different price. The agent from group 1 who is located at $x \leq 1/2$ receives two price offers:

  $$p_{1A}^*(x) = t(1 - 2x) \quad \text{and} \quad p_{1B}^*(x) = 0$$

- The maximum price is $t$ and the minimum price is 0.
- This is the equilibrium regardless of whether the prices are private or public.
- We assume that agents cannot coordinate. If they could, they would all join the same platform since they are indifferent between the two platforms.
Intuition about why private and public prices are the same

- When prices are private (and beliefs are passive, eg., McAfee and Schwartz (1994)), an agent (or a group of agents) who observes an out-of-equilibrium price offer believes that market shares will not change.
- When prices are public, price cuts, in general, are more lucrative.
- However, under perfect price discrimination, platforms cannot gain by lowering their prices from the levels when prices are private.
- Platforms cannot gain any new agents by lowering their prices in their own territory.
- In the rival platform’s territory prices are already zero.
Price and profit comparison

No price discrimination

\[ p_l = \frac{t - \alpha_m f \ell \left( \frac{1}{2} \right)}{f \ell \left( \frac{1}{2} \right)} \]
### Price and profit comparison

<table>
<thead>
<tr>
<th>No price discrimination</th>
<th>Perfect price discrimination</th>
</tr>
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<tbody>
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<td>$p_l = \frac{t - \alpha_m f_{\ell}(\frac{1}{2})}{f_{\ell}(\frac{1}{2})}$</td>
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Price and profit comparison

No price discrimination

\[ p_l = \frac{t - \alpha_m f_{\ell}(\frac{1}{2})}{f_{\ell}(\frac{1}{2})} \]

Perfect price discrimination

- Highest price is \( t \) and lowest price is 0.
- Prices, in the symmetric equilibrium, are independent of \( \alpha_1, \alpha_2 \).

Profit comparison when the distribution is uniform

Perfect price discrimination yields higher profits if and only if

\[ t < (\alpha_1 + \alpha_2) \]
Price discrimination may actually soften the competition.
Intuition

- Uniform prices balance optimally three effects: i) inframarginal rents, ii) rents from group 1 marginal consumers and, iii) rents from group 2 marginal consumers.
- Strong externalities, ie., high $\alpha$, lead to a stronger feedback effect and hence lower uniform prices.
Intuition

- Uniform prices balance optimally three effects: i) inframarginal rents, ii) rents from group 1 marginal consumers and, iii) rents from group 2 marginal consumers.

- Strong externalities, ie., high $\alpha$, lead to a stronger feedback effect and hence lower uniform prices.

- On the other hand, discriminatory prices are limit prices and as such they are independent of the feedback effect.

- The goal of the discriminatory prices is to drive the rival platform out of the market and not to balance the above three effects.
Comparison with Armstrong (2006a)

- Armstrong looks at price discrimination (PD) across groups but not within each group. He shows that PD is profitable iff
  \[(t_1 - t_2)^2 > (\alpha_1 - \alpha_2)^2.\]

- This is our uniform pricing case. Our condition for perfect PD to be profitable
  \[t < (\alpha_1 + \alpha_2),\]
is qualitatively different.

- Under symmetry across the two platforms price discrimination in Armstrong’s model is not profitable, while in our framework it may be.
Price below marginal cost

- When prices are allowed to be below marginal cost, and are public, then the discriminatory prices do depend on the indirect externality.
- Platform $A$, for example, can lower its prices to the agents in $[1/2,1]$ from 0 to $-\epsilon$ to induce all of them to switch.
- Then it can raise the prices to its own agents by an amount that is a function of the externality and become better off.
- In the new equilibrium, $\alpha$ affects prices,

\[
\begin{align*}
p_{IA} &= t(1 - 2x) - \alpha_m, \\
p_{IB} &= -\alpha_m, \quad \text{for } x \in [0, 1/2], \quad \text{and} \\
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\end{align*}
\]
Problems with this new equilibrium

- This equilibrium is not very plausible.
- \( c = 0 \). Negative price are unrealistic in many cases (Armstrong 2006).
- \( c > 0 \). If agents make mistakes and choose to buy from the platform at price below marginal cost, then the platform will loose money on these agents without being able to recoup its loses by raising its prices to its own agents.
Robustness

- How sensitive is our result to the assumptions: i) perfect price discrimination and ii) single-homing?
- What if platforms could identify each agent’s brand preference only imperfectly?
- What if agents could join both platforms?
Imperfect price discrimination

- Platforms can segment agents into groups. Price is the same within each group but can vary across groups.
- $N$ represents the number of segments. The higher the $N$ the more precise the information is. As $N \rightarrow \infty$ we recover the perfect discrimination case.
- To simplify the analysis, we assume that the distribution is uniform and set $\alpha_1 = \alpha_2 = \alpha$. 
Market segmentation

First segment

A

0

1

\( \frac{1}{N} \)

B

\( \frac{(s-1)}{N} \)

\( \frac{s}{N} \)

s-th segment

A

0

1

\( \frac{1}{N} \)

B

\( \frac{(s-1)}{N} \)

\( \frac{s}{N} \)

Group 1

Group 2
Prices are public

- Each agent observes all prices before he decides about which platform to join.

Proposition

- *When* $N \geq 4$ *and* $t \leq \frac{\alpha N}{2}$ *the equilibrium profits are,*

  $$\pi_k = \frac{t}{2} - \frac{t}{N}$$
Graphical comparison of profits

\[ \pi_k \]

\[ \frac{t}{2} \]

\[ t - \alpha \]

\[ \tilde{N} = \frac{2t}{2\alpha - t} \]

Discriminatory profits (public prices)

Uniform price profits

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Prices are private

- Platforms target each agent with prices that are privately observed.
- We assume that beliefs are passive: if a deviation in a specific segment is observed, agents do not update their beliefs about the other prices.

**Proposition**

The equilibrium profits are:

\[ \pi_k = \frac{t}{2} - \frac{t}{N} + \frac{20t}{9N^2} \]
Graphical comparison of profits

\[ \pi_k \]

\[ \tilde{N} = \frac{2t}{2\alpha - t} \]

Discriminatory profit (private prices)

Discriminatory profits (public prices)

Uniform price profits
Price transparency

- Price transparency hurts the platforms.
Multihoming

- Agents from both groups are now allowed to join both platforms.
- The indirect utility of the agent from group 1 who is located at $x$ is:

$$U_1 = \begin{cases} 
V + \alpha_1 n^e_{2A} - tx - p_{1A}, & \text{if he joins platform A} \\
V + \alpha_1 n^e_{2B} - t(1-x) - p_{1B}, & \text{if he joins platform B} \\
V + \theta + \alpha - t - p_{1A} - p_{1B}, & \text{if he joins both platforms.}
\end{cases}$$

- $\theta$ measures an incremental benefit agents receive when joining a second platform.
\[ V + \theta + \alpha - t - p_A - p_B \]

\[ V + \alpha n_{mB} - t(1-x) - p_B \]

\[ V + \alpha n_{mA} - tx - p_A \]

Single-homing Multi-homing Single-homing

Platform A \[0\] \[x_{\ell L}\] \[x_{\ell R}\] \[1\] Platform B

Group \( \ell \)
For consumers who multi-home, firms are competing with consumers’ outside option instead of competing with each other.

\[
\begin{align*}
P_{\ell L}^* & \quad \text{Prices when multi-homing is not allowed} \\
P_{\ell R}^* & \quad \text{Prices when multi-homing is allowed}
\end{align*}
\]
Main result and Intuition

- **Main result**: When the indirect externality $\alpha$ is strong, price discrimination is more profitable.

  - Uniform pricing: There are two opposing effects as $\alpha$ increases:
    - Incentives for unilateral price cuts increase.
    - Agents are willing to pay more to join a second platform, leading to higher prices.
    - When $\alpha$ is high enough, the first effect outweighs the second and higher $\alpha$ leads to lower prices, as in the single-homing case.

  - Discriminatory pricing:
    - For consumers who still single-home, discriminatory prices are still the same as in the benchmark single-homing case.
    - For multi-homing consumers, discriminatory prices now keep them indifferent between joining one or two platforms.
    - Discriminatory prices increases with the indirect externality.

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  - Discriminatory prices increases with the indirect externality.
Conclusion

- Price discrimination in horizontally differentiated markets with no externalities ("usually") leads to a prisoners’ dilemma.
- Moreover, the presence of indirect externalities (e.g., two-sided markets) intensifies the competition (under no price discrimination).
- However, we show that price discrimination in two-sided markets may actually soften the competition. This happens when the indirect externality is strong.
- The results do not change qualitatively when we allow agents to multi-home or price discrimination to be imperfect.
- Profits are higher when prices are private. Therefore, firms may have incentives to make prices less transparent.