Competitive Personalized Pricing

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The era of big data

- We live in the era of big data.
- Massive collection of individual-level data
  - Online search and transactions: Google, Amazon, Alibaba, TripAdvisor
  - Social networking services: Facebook, Instagram, Twitter
  - Mobile apps
  - Loyalty programs and purchase history
- Information is also collected and traded by data brokers.
  - Bloomberg, Bluekai (Oracle), Teradata, etc.
  - This industry is estimated to turn over $150 billion a year.
- It is common for a typical firm to have a dedicated team for data analytics and a position titled chief data officer.
Big data and personalized pricing

• The availability of individual-level data enables firms to make more precise targeted advertising and personalized offers, i.e., price discrimination.

• Examples
  • Coupons.com (personalized and targeted online coupons)
  • Amazon’s ‘real-time’ pricing (updated every 10 minutes)
  • Uber’s ‘route-based pricing’ (charges customers based on the predicted willingness to pay)
  • Loyalty programs - personalized discounts on-line or through mobile apps (Safeway's Just For U and smart cart)
  • Target’s Guest ID number and pregnancy-prediction model
Introduction

Consumer reaction to price discrimination

- Suppose a firm has information on some targeted consumers but no information on non-targeted consumers.
- Targeted consumers are offered personalized prices and non-targeted consumers are offered a non-discriminatory uniform price.
- Suppose the uniform price is lower than personalized prices (e.g., new customer discount, sign-up offers, etc.).
  - In some cases, new customers are treated better (growing market, fierce competition, switching costs) - our focus.
  - In other cases, repeat customers are treated better (loyalty discount).
- Then some consumers may choose proactive identity management.
  - Prevent firms from tracking them (ex ante identity management)
  - Act as a new customer in repeat purchase when necessary (ex post identity management) - our focus
- These consumers are called active; otherwise passive.
Introduction

Evidence on active consumers

- A 2013 survey by Consumer Report (US)
  - 33% of consumers negotiated with their existing cell-phone providers, 76% of them successful at least once for average saving of $80
  - 32% of customers for bank cards, 69% of them successful at least once for average saving of $100.

- Google search of discussion threads in forum sites (Reddit, Whirlpool, etc) using text recognition (loyal, existing, customer, discount, successful, etc)
  - (# results, # success, average saving)
  - Cable - 1.21 million, 0.7 million, $231
  - Credit card - 0.92 million, 0.63 million, $85
  - Internet - 1.42 million, 0.48 million, $202
  - Cell-phone - 0.9 million, 0.36 million, $147.50

- Some personal evidence from insurance contracts renewal
Main research questions

- Conventional wisdom: More consumer information, hence finer price discrimination, intensifies competition and hurts firms unless there are significant heterogeneities at the firm- or consumer-level (Thisse and Vives, 1988; Fudenberg and Tirole, 2000; Choe et al., 2017).

- Research questions
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  • What are the implications for the regulation of the collection/use of individual-level information?
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  - What are the implications for the regulation of the collection/use of individual-level information? (Complicated.)
Firms and consumers

- Consumers are uniformly distributed on $[-1/2, 1/2]$.
- Two firms, $A$ at $1/2$ and $B$ at $-1/2$, produce competing brands of a consumer good at 0 marginal cost.
- Consumer $x$’s gross utility from buying a good from firm $A$ is $V_A(x) = 1 + x/2$, that from firm $B$ is $V_B(x) = 1 - x/2$.
- So consumers on $[0, 1/2]$ are loyal to firm $A$ and those on $[-1/2, 0]$ are loyal to firm $B$.
- Given prices $p_A, p_B$, consumer $x$ chooses firm $A$ iff
  \[ V_A(x) - p_A > V_B(x) - p_B \text{ or } p_A < p_B + x. \]
Target segment and pricing

- Each firm has an exogenously given target segment on which each firm knows the exact consumer loyalty.
- Firm A’s target segment is $[a, 1/2]$ and firm B’s is $[-1/2, b]$.
- For $x \in [a, 1/2]$, firm A can charge personalized price $p_A(x)$. For all others, firm A charges a uniform price $q_A$.
- For $y \in [-1/2, b]$, firm B can charge personalized price $p_B(y)$. For all others, firm B charges a uniform price $q_B$.
- Two-stage pricing game
  - Firms first set publicly observable uniform prices $q_A, q_B$ for non-targeted consumers.
  - Then firms choose personalized prices, $p_A(x), p_B(y)$.
  - Consumers decide which firm to choose.
  - Solve for subgame perfect equilibria.
Equilibria with passive consumers

Figure 0: Target Segments and Pricing Strategies

\[ B: \frac{-1}{2} b \quad a \quad A: \frac{1}{2} \]

\[ p_A(x) q_A \]

\[ p_B(y) q_B \]

Figure 0: Target Segments and Pricing Strategies
Benchmark outcomes

- No discrimination: Hotelling
  - \( a = -b = 1/2 \); each firm's target segment is \( \emptyset \), i.e., no information.
  - \( q_A = q_B = 1/2 \); \( \pi_A = \pi_B = 1/4 \)
  - \( a = b = 0 \); firm \( i \) chooses \((p_i, q_i)\) with \( p_i \) for the target segment.
  - \( p_A = p_B = 1/3 \); \( q_A = q_B = 1/6 \); \( \pi_A = \pi_B = 5/36 \)
- Personalized pricing: Thisse & Vives (1988)
  - \( a = -b = -1/2 \); full information, hence personalized prices for all consumers
  - \( p_A(x) = x \ \forall x \geq 0, = 0 \ \forall x \leq 0 \); \( p_B(y) = -y \ \forall y \leq 0, = 0 \ \forall y \geq 0 \);
    \( \pi_A = \pi_B = 1/8 \)
- So more customer info is bad for firms if it is used to intensify (price) competition: conventional wisdom.
Three types of equilibria

- Passive consumers choose from two prices, i.e., a passive consumer $x$ targeted by firm $A$ chooses the lowest price from $\{p_A(x), q_B\}$.
- Equilibrium with one-way poaching
  - Possible when only one firm targets the other’s loyal consumers
  - Total industry profit is $\Pi = (2 + 2a - a^2)/8 \in [1/4, 11/32]$.
- Equilibrium with two-way poaching (Thisse & Vives outcome)
  - When each firm targets the other’s loyal consumers: $a \leq 0 \leq b$
  - Total industry profit is $\Pi = 1/4$.
- Equilibrium with partial Hotelling outcome
  - Possible when there is a large segment not targeted by either firm, hence commonly contestable
  - Total industry profit is $\Pi = 1/4 + (8ab + 9(a - b) - 5(a^2 + b^2))/18 \in [1/4, 1/2]$. 
Equilibria with passive consumers

\[ p_B(y) = -y \]
\[ p_A(x) = \max\{0, x - b/2\} \]
\[ q_A = 0 \]
\[ q_B = -b/2 \]

Figure 1: Equilibrium with one-way poaching by firm B
Equilibria with passive consumers

\[ p_B(y) = \max\{0, -y\} \quad p_A(x) = \max\{0, x\} \]

\[ q_A = 0 \quad q_B = 0 \]

Figure 2: Equilibrium with two-way poaching
Equilibria with passive consumers

\[ p_B(y) = -y + q_A \]
\[ p_A(x) = x + q_B \]

\[ q_B = \frac{(a - 2b)}{3} \]

\[ q_A = \frac{(2a - b)}{3} \]

Figure 3: Equilibrium with partial Hotelling outcome
Discussions

- Market is fully covered in all possible equilibria.
  - Uniform price and personalized prices are delinked, so no reason to leave some non-targeted consumers not served.
  - All equilibria efficient.
- Total industry profit is the lowest in the equilibrium with two-way poaching and is equal to 1/4.
  - Perils of targeting rival’s loyal consumers
  - Worst if both target each other’s loyal consumers
- Total industry profit is the highest in Hotelling equilibrium \((a = -b = -1/2)\) and is equal to 1/2.
  - No info and no discrimination is best.
  - Consistent with conventional wisdom
Equilibria with active consumers

- An active consumer $x$ targeted by firm $A$ chooses the lowest price from $\{p_A(x), q_A, q_B\}$ (instead of $\{p_A(x), q_B\}$).
- If a firm tries to poach rival’s loyal consumers with low uniform price, then all its active targeted consumers will also choose the uniform price (instead of the personalized price).
- This makes it costly to poach rival’s targeted consumers.
- Then it is best to charge the maximum personalized price to all of its targeted consumers, and choose a uniform price that is not accepted by any consumers ($q_A, q_B \geq 5/4$).
- We call this the PPD (perfect price discrimination) equilibrium.
- In the PPD equilibrium, each firm extracts full surplus from all targeted consumers.
- Total industry profit is maximized when $a = b = 0$: $\pi_A^* = \pi_B^* = 9/16$ and $\Pi^* = 9/8 > 1/2$ (Hotelling profit).
Equilibria with active consumers

\[
p_B(y) = 1 - \frac{y}{2} \\
p_A(x) = 1 + \frac{x}{2}
\]

Figure 4: PPD equilibrium
Equilibria with active consumers

Figure 6: PPD equilibrium without full market coverage

\[ p_B(y) = 1 - \frac{y}{2} \]

\[ p_A(x) = 1 + \frac{x}{2} \]
Comparing equilibria with active vs passive consumers

• Suppose $a = b = 0$ (or $-a = b = \varepsilon$ for small $\varepsilon > 0$).
  • Active consumers $\Rightarrow$ PPD equilibrium with the maximum possible industry profit $9/8$
  • Passive consumers $\Rightarrow$ equilibrium with the Thisse-Vives outcome and the lowest possible industry profit $1/4$
  • Active consumers can make firms better off by enabling them to extract full surplus through PPD.
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• Suppose $(-\sqrt{17} + 4)/2 \leq b < 0 < a \leq (\sqrt{17} - 4)/2$, i.e., small segment around 0 not targeted by either firm.
  - Active consumers $\Rightarrow$ PPD equilibrium without full market coverage
  - Passive consumers $\Rightarrow$ equilibrium with partial Hotelling outcome
  - Active consumers can lead to inefficiency by inducing firms not to serve the commonly non-targeted segment.

• For any $(a, b)$, total industry profit in equilibrium with active consumers is larger than that in equilibrium with passive consumers.

• These results also hold when a fraction of consumers are active or when consumers have to incur cost $c > 0$ to become active.
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Our work is related to the recent debate on internet privacy protection and the collection/use of individual data for commercial purposes.

Australia, UK
- Consumers should be informed if their individual data are collected.
- Firms need consumers’ consent to use individual data for commercial purposes.
- Consumers may demand their individual data be deleted.

US
- In the final days of Obama administration, the FTC approved internet privacy protections similar to those in Australia and UK.
- This regulation was repealed by the House of Representatives on March 28, 2017.
- Maureen Ohlhausen (Acting Chair of the FTC): “Information can be used to target some consumers with higher prices but the same information can be used to target consumers with a better deal”
- Why did the Trump government really repeal the internet privacy act?
- To be more business-friendly?
Policy debate on internet privacy

- Two related issues: use of consumer information by firms and consumer empowerment
- Use of information by firms
  - Laxer regulation can benefit consumers by intensifying competition through more readily available consumer info.
  - Competition the most fierce with full information ($a = -b = -1/2$).
Two related issues: use of consumer information by firms and consumer empowerment

Use of information by firms
- Laxer regulation can benefit consumers by intensifying competition through more readily available consumer info.
- Competition the most fierce with full information $\left(a = -b = -\frac{1}{2}\right)$.

Consumer empowerment related to identity management
- Australia-UK type regulation is more likely to make consumers more active (through awareness and empowerment).
- US-type regulation (or lack of it) may leave consumers passive, hence benefit them (whether or not it was the original intention).
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- Consumer empowerment related to identity management
  - Australia-UK type regulation is more likely to make consumers more active (through awareness and empowerment).
  - US-type regulation (or lack of it) may leave consumers passive, hence benefit them (whether or not it was the original intention).
- On both accounts, laxer regulation is likely to intensify competition subject to several caveats.
  - Sole purpose of information is for pricing.
  - Applies in the competitive setting with symmetric firms.
  - We ignored other (perhaps more sensitive) aspect of internet privacy.
Summary of the main results

- Consumer information can toughen competition when it is used only for pricing purposes.
- When all consumers are passive, competition is the most intense when each firm targets its rival’s loyal customers.
- Individual consumer can benefit from being active but collective activism can hurt consumers.
- As more consumers become active, competition gets softer since poaching rival’s targeted customers can impose additional cost.
- With active consumers, firms can extract full consumer surplus through perfect price discrimination.
- With active consumers, there can be also welfare loss when some market segment is not served.
- Tighter regulation on the use of individual information may make consumers more active, benefiting firms as a result.
- Laxer regulation may benefit consumers but at possible costs of privacy and other related concerns.
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