Competitive Price Targeting
Strategic Interactions in Mobile Marketing

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Mobile marketing and price targeting

- Targeting competitive locations to drive coupon redemption
  - Dunkin’: 3.6%
  - Department store: 2%
Mobile marketing and price targeting

- Targeting competitive locations to drive coupon redemption
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- A source of incremental sales
Mobile marketing and price targeting

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  - Department store: 2%

- A source of incremental sales
- Not accounting for competitive response
Competitive price targeting

- Monopoly: targeting weakly dominates uniform pricing
  - Firms may optimize based on unilateral evaluations

- Oligopoly: targeting can result in lower prices and profits in every segment
  - Asymmetric best response a necessary condition for ambiguity (Corss, 1998)
  - Cannot necessarily commit to no targeting (Thisse and Vives, 1988; Shaer and Zhang, 1995)
Competitive price targeting

- **Monopoly**: targeting weakly dominates uniform pricing
  - Firms may optimize based on unilateral evaluations

- **Oligopoly**: targeting can result in lower prices and profits in every segment
  - Asymmetric best response a necessary condition for ambiguity (Corts, 1998)
  - Cannot necessarily commit to no targeting (Thisse and Vives, 1988; Shaffer and Zhang, 1995)
Research objectives

- Estimate the effect of price targeting on profits in a competitive market
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- Evaluate the adequacy of unilateral optimization
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- Estimate the effect of price targeting on profits in a competitive market
- Evaluate the adequacy of unilateral optimization
- Challenge: firms (and researchers) lack information on own price response under varying competitive prices
Agenda

1. Introduction
2. Field Experiment
3. Model
4. Results
Offensive Promo
Offensive Promo

Defensive Promo
Experimental design

- Randomly assigned prices
  - 3 levels for offense (holdout, medium, high)
  - 3 levels for defense (holdout, low, medium)
Experimental design

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- Observed segments
  - 2 locations (symmetric design)
  - 2 behavioral types (high and low based on recency)
Experimental design

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  - 3 levels for defense (holdout, low, medium)

- Observed segments
  - 2 locations (symmetric design)
  - 2 behavioral types (high and low based on recency)

- \( N = 500 \) per cell, 18,000 total, mid-day on a Saturday
Aggregate response

Asymmetric cross-promotional effects

Defense is effective, but all firms still discount
Aggregate response

Defense is effective, but all firms still discount.
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Asymmetric cross-promotional effects
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Observations

- Similar pattern across 4 segments
- In “equilibrium” everyone chooses maximum discount
Observations

- Similar pattern across 4 segments
- In “equilibrium” everyone chooses maximum discount
- Discrete pricing treatments limit observed strategy sets
  - Limited range and resolution
Agenda

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Estimating the impact on profits

- Estimate a demand model
  - Probit, MCMC
Estimating the impact on profits

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- Derive best response functions
  - Posterior represents firms’ beliefs
Estimating the impact on profits

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- Derive best response functions
  - Posterior represents firms’ beliefs

- Identify fixed points
  - Compare profits across targeting scenarios
Demand model

- Consumers choose $y \in \{A, B, C\}$, where $j = A, B$ denote the theaters and $j = C$ is the outside option.

- $k = 1, \ldots, K$ observable segments, with population weights $\lambda^k$.

- $p_j$ is the ticket price at theater $j$. 

12/23
Utility

- **Consumer** $h$’s utility if a member of segment $k$:

\[
\begin{align*}
    u_{hA} &= \theta^k_A - \alpha^k p_A + \tilde{\epsilon}_{hA} \\
    u_{hB} &= \theta^k_B - \alpha^k p_B + \tilde{\epsilon}_{hB} \\
    u_{hC} &= \tilde{\epsilon}_{hC}
\end{align*}
\]
Utility

- Consumer $h$’s utility if a member of segment $k$:

  \[
  u_{hA} = \theta^k_A - \alpha^k p_A + \tilde{\epsilon}_{hA} \\
  u_{hB} = \theta^k_B - \alpha^k p_B + \tilde{\epsilon}_{hB} \\
  u_{hC} = \tilde{\epsilon}_{hC}
  \]

- Correlated errors allow for flexible substitution patterns:

  \[
  \eta_h \equiv \begin{bmatrix} \tilde{\epsilon}_{hA} - \tilde{\epsilon}_{hC} \\ \tilde{\epsilon}_{hB} - \tilde{\epsilon}_{hC} \end{bmatrix} \sim N(0, \Psi)
  \]
Estimation

- We can express utilities as:
  \[
  U_h \equiv \begin{bmatrix} u_{hA} \\ u_{hB} \end{bmatrix} = B^k X + \eta_h
  \]

- And choice probabilities as:
  \[
  Pr (y_h = j | B^k, X, \psi^k) = Pr (u_{hj} - u_{hi} > 0, \forall i \neq j)
  \]
Estimation

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U_h \equiv \begin{bmatrix} u_{hA} \\ u_{hB} \end{bmatrix} = B^kX + \eta_h
\]

- And choice probabilities as:

\[
Pr (y_h = j | B^k, X, \Psi^k) = Pr (u_{hj} - u_{hi} > 0, \forall i \neq j)
\]

- Transformation of the utilities leads to a trinomial probit
- Estimate using MCMC separately for each segment
- Retain \( R \) posterior draws for subsequent computations, \( \{ B^{r,k}, \Psi^{r,k} \} \)
Scenarios for comparison

- Competitive equilibrium with uniform pricing
Scenarios for comparison

- Competitive equilibrium with uniform pricing
- Competitive equilibrium with targeted pricing
Scenarios for comparison

- Competitive equilibrium with uniform pricing
- Competitive equilibrium with targeted pricing
- Unilateral targeting
  - A deviation from uniform pricing, without competitive response
Uniform pricing

Firm $j$'s pricing problem

$$p_j^{\text{uniform}} = \arg\max_p \left\{ p \sum_{k=1}^K \lambda^k \mathbb{E} \left[ Pr\left( j \mid B^k, p, \psi^k \right) \mid D^k \right] \right\}$$

$$\approx \arg\max_p \left\{ p \left[ \sum_{k=1}^K \lambda^k \frac{1}{R} \sum_{r=1}^R Pr\left( j \mid B^{r,k}, p, \psi^{r,k} \right) \right] \right\}$$
Uniform pricing

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$$\approx \arg\max_p \left\{ p \left[ \sum_{k=1}^K \lambda^k \frac{1}{R} \sum_{r=1}^R Pr \left( j | B^{r,k}, p, \Psi^{r,k} \right) \right] \right\}$$

- FONC

$$\sum_{k=1}^K \lambda^k \sum_{r=1}^R Pr \left( j | B^{r,k}, p, \Psi^{r,k} \right) + p_j^{\text{uniform}} \sum_{k=1}^K \sum_{r=1}^R \lambda^k \frac{\partial Pr \left( j | B^{r,k}, p, \Psi^{r,k} \right)}{\partial p_j} = 0$$
Targeted pricing

- Firm $j$’s pricing problem for a partition $\Omega$ of the $K = 4$ segments

$$p_j^\Omega = \arg\max_p \{ \sum_{\omega \in \Omega} p_\omega \sum_{k \in \omega} \lambda^k \mathbb{E} \left[ Pr \left( j \mid B^k, p, \psi^{r,k} \right) \mid D^k \right] \}$$

$$\approx \arg\max_p \left\{ \sum_{\omega \in \Omega} p_\omega \sum_{k \in \omega} \lambda^k \frac{1}{R} \sum_{r=1}^R Pr \left( j \mid B^{r,k}, p, \psi^{r,k} \right) \right\}$$
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$$\approx \argmax_p \left\{ \sum_{\omega \in \Omega} p_\omega \sum_{k \in \omega} \lambda^k \frac{1}{R} \sum_{r=1}^{R} Pr \left( j \mid B^{r,k}, p, \Psi^{r,k} \right) \right\}$$

- FONC ($\forall \omega \in \Omega$)

$$\sum_{k \in \omega} \left( \lambda^k \sum_{r=1}^{R} Pr \left( j \mid B^{r,k}, p, \Psi^{r,k} \right) + p_j^\Omega \sum_{r=1}^{R} \lambda^k \frac{\partial Pr \left( j \mid B^{r,k}, p, \Psi^{r,k} \right)}{\partial p_j} \right) = 0$$
Agenda

1. Introduction
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4. Results
### Parameter estimates

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>High, A</th>
<th>Low, A</th>
<th>High, B</th>
<th>Low, B</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\theta_A$</td>
<td>-0.344</td>
<td>0.25</td>
<td>-1.066</td>
<td>-1.413</td>
</tr>
<tr>
<td></td>
<td>(-0.651,-0.028)</td>
<td>(-0.178,0.695)</td>
<td>(-1.344,-0.79)</td>
<td>(-1.737,-0.964)</td>
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<tr>
<td>$\theta_B$</td>
<td>-1.043</td>
<td>-0.628</td>
<td>-0.376</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>(-2.002,-0.425)</td>
<td>(-1.499,-0.023)</td>
<td>(-0.741,-0.035)</td>
<td>(-0.311,0.349)</td>
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<tr>
<td>$\alpha$</td>
<td>-0.027</td>
<td>-0.044</td>
<td>-0.027</td>
<td>-0.028</td>
</tr>
<tr>
<td></td>
<td>(-0.033,-0.021)</td>
<td>(-0.053,-0.035)</td>
<td>(-0.036,-0.019)</td>
<td>(-0.043,-0.017)</td>
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<tr>
<td>$\rho_{A,B}$</td>
<td>0.796</td>
<td>-0.951</td>
<td>0.962</td>
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<td></td>
<td>(0.443,0.931)</td>
<td>(-0.99,-0.826)</td>
<td>(0.926,0.985)</td>
<td>(-0.953,0.955)</td>
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## Elasticity estimates

<table>
<thead>
<tr>
<th></th>
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<th>Low, A</th>
<th>High, B</th>
<th>Low, B</th>
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<tbody>
<tr>
<td><strong>Both set regular prices of 75 RMB</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>$p_A$</td>
<td>-5.33</td>
<td>0.15</td>
<td>-16.99</td>
<td>13.17</td>
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<tr>
<td>$p_B$</td>
<td>0.15</td>
<td>-10.17</td>
<td>3.72</td>
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</tr>
<tr>
<td>Firm A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$p_A$</td>
<td>3.44</td>
<td>-8.35</td>
<td>-4.84</td>
<td>0.42</td>
</tr>
<tr>
<td>$p_B$</td>
<td>-8.35</td>
<td>0.00</td>
<td>-8.96</td>
<td></td>
</tr>
<tr>
<td>Firm B</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Both set prices of 30 RMB (60% off)</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>$p_A$</td>
<td>-1.40</td>
<td>0.10</td>
<td>-7.97</td>
<td>5.95</td>
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<tr>
<td>$p_B$</td>
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<td>-2.07</td>
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<tr>
<td>Firm A</td>
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</tr>
<tr>
<td>$p_A$</td>
<td>1.52</td>
<td>-3.44</td>
<td>0.03</td>
<td>-1.91</td>
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<tr>
<td>$p_B$</td>
<td>-3.44</td>
<td>0.00</td>
<td>-1.25</td>
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Best-response functions (targeting on one dimension)

Best Response
Geographic Targeting

Best Response
Type Targeting

Theater A price
Theater B price

BR_A defense
BR_A offense
BR_B offense
BR_B defense
location A equil
location B equil
uniform equil

BR_A High
BR_A Low
BR_B High
BR_B Low
High equil
Low equil
uniform equil
Equilibrium profits vs. unilateral targeting profits

<table>
<thead>
<tr>
<th></th>
<th>Firm A</th>
<th>Firm B</th>
</tr>
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<tbody>
<tr>
<td>Uniform</td>
<td>196</td>
<td>291</td>
</tr>
<tr>
<td>Location</td>
<td>196</td>
<td>298</td>
</tr>
<tr>
<td>Type</td>
<td>198</td>
<td>295</td>
</tr>
<tr>
<td>Type and Location</td>
<td>197</td>
<td>297</td>
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</table>
Equilibrium profits vs. unilateral targeting profits

<table>
<thead>
<tr>
<th></th>
<th>Equilibrium</th>
<th></th>
<th>Unilateral</th>
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</thead>
<tbody>
<tr>
<td></td>
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<td>Firm B</td>
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<td></td>
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<tr>
<td>Location</td>
<td>196</td>
<td>298</td>
<td>198</td>
<td>302</td>
</tr>
<tr>
<td>Type</td>
<td>198</td>
<td>295</td>
<td>197</td>
<td>294</td>
</tr>
<tr>
<td>Type and Location</td>
<td>197</td>
<td>297</td>
<td>200</td>
<td>304</td>
</tr>
</tbody>
</table>
Conclusions

- Competition moderates the effectiveness of price targeting

- Firms could easily mis-estimate the profitability of targeting
  - Overestimate geographical targeting (asymmetric best response)
  - Underestimate behavioral targeting (symmetric best response)

- Future research: consumer response
  - Consumer dynamics (Shin and Sudhir, 2010)
  - Strategic consumers (Chen, Li, and Sun, 2015)
# Uniform pricing equilibrium

<table>
<thead>
<tr>
<th>Share:</th>
<th>Firm A</th>
<th>Firm B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>19.2942</td>
<td>18.8641</td>
</tr>
<tr>
<td>High type, location A</td>
<td>0.1896</td>
<td>0.0168</td>
</tr>
<tr>
<td>Low type, location A</td>
<td>0.2795</td>
<td>0.0465</td>
</tr>
<tr>
<td>High type, location B</td>
<td>0.0005</td>
<td>0.2039</td>
</tr>
<tr>
<td>Low type, location B</td>
<td>0.0106</td>
<td>0.2380</td>
</tr>
<tr>
<td>Expected profit per 100 customers messaged</td>
<td>196.04</td>
<td>291.33</td>
</tr>
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</table>
Equilibrium prices

<table>
<thead>
<tr>
<th></th>
<th>Market</th>
<th>Firm A Price</th>
<th>Firm B Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uniform</td>
<td>Pooled</td>
<td>19.294</td>
<td>18.864</td>
</tr>
<tr>
<td>by geography</td>
<td>Loc A</td>
<td>19.575</td>
<td>10.564</td>
</tr>
<tr>
<td></td>
<td>Loc B</td>
<td>10.485</td>
<td>20.064</td>
</tr>
<tr>
<td>by type</td>
<td>High</td>
<td>22.948</td>
<td>23.786</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>18.597</td>
<td>17.775</td>
</tr>
<tr>
<td>by geography and type</td>
<td>A High</td>
<td>21.335</td>
<td>10.870</td>
</tr>
<tr>
<td></td>
<td>A Low</td>
<td>19.146</td>
<td>10.546</td>
</tr>
<tr>
<td></td>
<td>B High</td>
<td>5.230</td>
<td>20.595</td>
</tr>
<tr>
<td></td>
<td>B Low</td>
<td>11.874</td>
<td>19.322</td>
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</table>
Importance of considering competitive response

<table>
<thead>
<tr>
<th></th>
<th>Firm A Profit</th>
<th>Firm B Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uniform pricing</td>
<td>196</td>
<td>291</td>
</tr>
<tr>
<td>Equilibrium targeting</td>
<td>197</td>
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Targeting choice as a strategic game

<table>
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<tr>
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</table>
Experimental purchase response by segment

Location A

Location B

Defensive Purchases

Offensive Purchases
Experimental revenues by segment

Location A

Location B

Defensive Revenues

Offensive Revenues
Posterior profit differences: unilateral/equilibrium vs. uniform pricing

Unilateral Location Targeting
Theater A

Unilateral Location Targeting
Theater B

Unilateral Type Targeting
Theater A

Unilateral Type Targeting
Theater B

Unilateral Type & Location Targeting
Theater A

Unilateral Type & Location Targeting
Theater B

Location Targeting
Theater A

Location Targeting
Theater B

Type Targeting
Theater A

Type Targeting
Theater B

Type & Location Targeting
Theater A

Type & Location Targeting
Theater B
Posterior profit differences: unilateral/equilibrium vs. uniform pricing