# 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%

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- Targeting competitive locations to drive coupon redemption
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- A source of incremental sales
- Not accounting for competitive response

# Competitive price targeting

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# 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
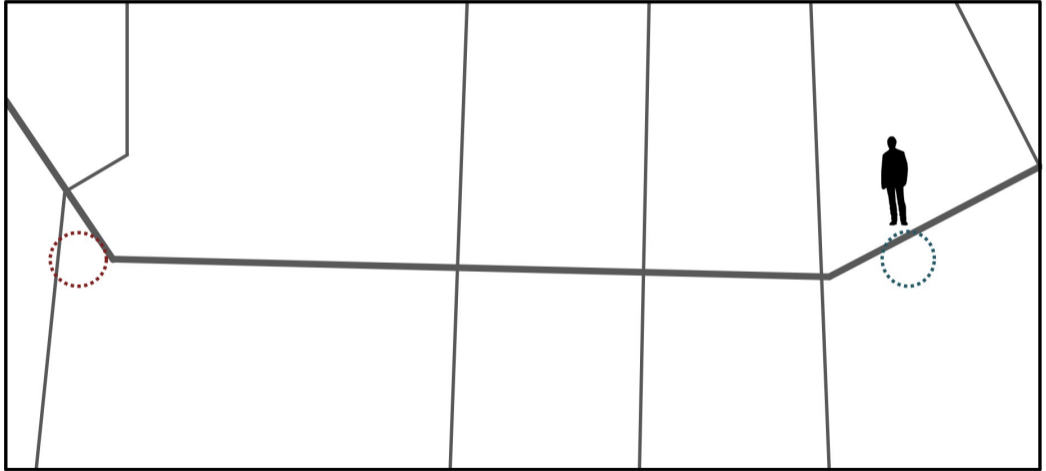
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- Evaluate the adequacy of unilateral optimization

- Challenge: firms (and researchers) lack information on own price response under varying competitive prices
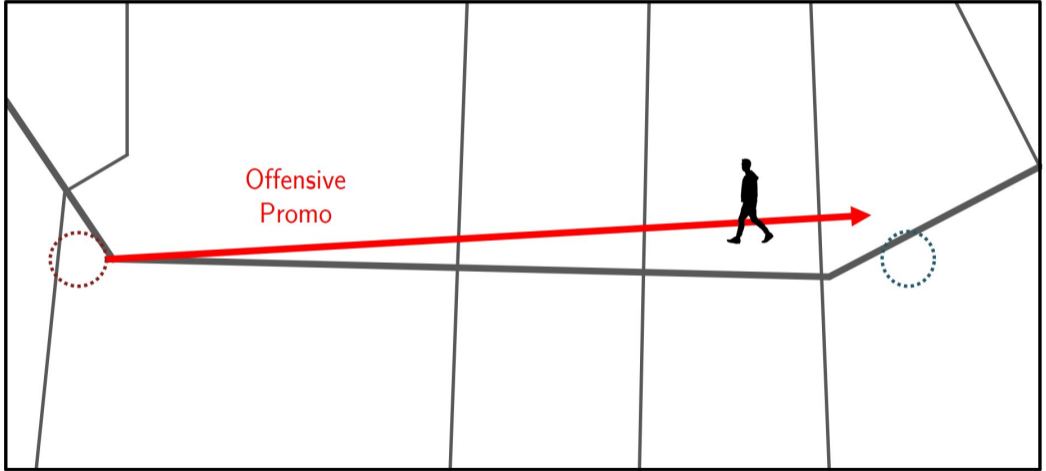
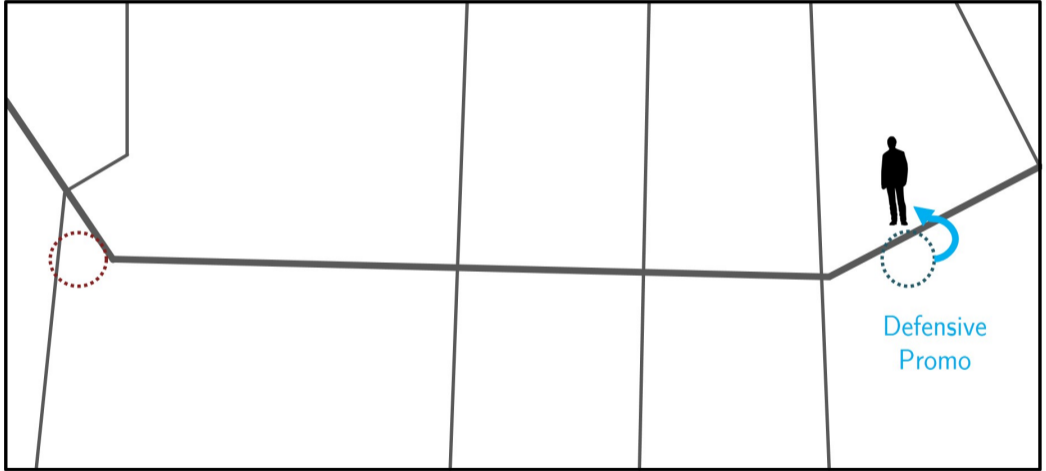FOX | GLOBAL CENTER FOR BIG DATA IN MOBILE ANALYTICS

# Agenda

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Offensive Promo

Defensive
Promo

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Defensive
Promo

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# Experimental design

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

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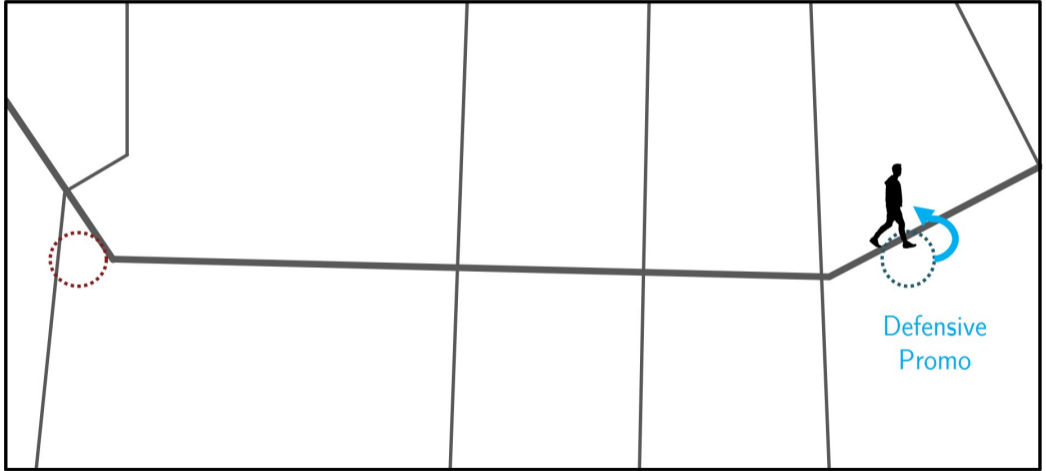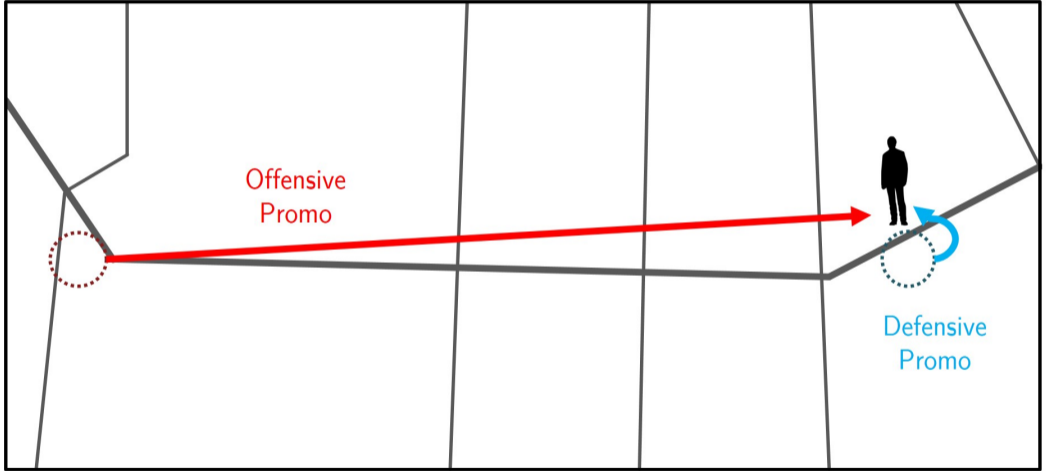
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# Experimental design

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- $N = 500$ per cell, $18,000$ total, mid-day on a Saturday

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# Aggregate response



Purchase Rate

# Aggregate response



Purchase Rate

Legend: Defensive Purchases | Offensive Purchases

X-axis: Offensive Discount (0%, 40%, 60%)
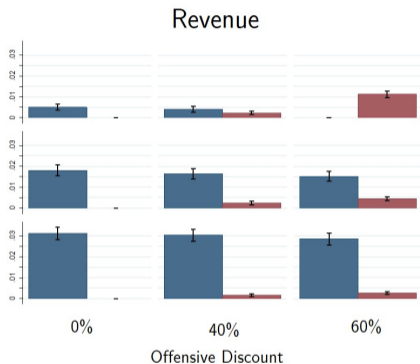Y-axis: Defensive Discount (0%, 20%, 40%)

# Aggregate response



Purchase Rate

Asymmetric cross-promotional effects

# Aggregate response



Asymmetric cross-promotional effects

# Aggregate response



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

# Observations

- Similar pattern across 4 segments

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- Similar pattern across 4 segments

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- Discrete pricing treatments limit observed strategy sets
  - Limited range and resolution

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# Estimating the impact on profits

- Estimate a demand model
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- Derive best response functions
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# Estimating the impact on profits

- Estimate a demand model
  - Probit, MCMC

- Derive best response functions
  - Posterior represents firms' beliefs

- Identify fixed points
  - Compare profits across targeting scenarios

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# Demand model

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

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

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

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# Utility

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

$$u_{hA} = \theta_A^k - \alpha^k p_A + \tilde{\epsilon}_{hA}$$

$$u_{hB} = \theta_B^k - \alpha^k p_B + \tilde{\epsilon}_{hB}$$

$$u_{hC} = \tilde{\epsilon}_{hC}$$

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$$u_{hC} = \tilde{\epsilon}_{hC}$$

- Correlated errors allow for flexible substitution patterns:

$$\eta_h \equiv \left[ \begin{array}{c} \tilde{\epsilon}_{hA} - \tilde{\epsilon}_{hC} \\ \tilde{\epsilon}_{hB} - \tilde{\epsilon}_{hC} \end{array} \right] \sim N\left(0, \Psi\right)$$

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# Estimation

- We can express utilities as:

$$U_h \equiv \left[ \begin{array}{c} u_{hA} \\ u_{hB} \end{array} \right] = B^k X + \eta_h$$

- And choice probabilities as:

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

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

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# Scenarios for comparison

- Competitive equilibrium with uniform pricing

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# Scenarios for comparison

- Competitive equilibrium with uniform pricing

- Competitive equilibrium with targeted pricing

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# Scenarios for comparison

- Competitive equilibrium with uniform pricing

- Competitive equilibrium with targeted pricing

- Unilateral targeting
  - A deviation from uniform pricing, without competitive response

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# Uniform pricing

- Firm $j$'s pricing problem

$$p_j^{uniform} \;=\; \underset{p}{argmax} \left\{ p \sum_{k=1}^{K} \lambda^k \mathbb{E} \left[ Pr \left( j | B^k, p, \Psi^k \right) | \mathbf{D^k} \right] \right\}$$

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

# Uniform pricing

- Firm $j$'s pricing problem

$$
\begin{aligned}
p_j^{uniform} &= \underset{p}{argmax} \left\{ p \sum_{k=1}^{K} \lambda^k \mathbb{E} \left[ Pr\left(j|B^k, p, \Psi^k\right) | \mathbf{D^k} \right] \right\} \\
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\end{aligned}
$$

- FONC

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

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# Targeted pricing

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

$$p_j^\Omega = \underset{p}{argmax} \left\{ \sum_{\omega \in \Omega} p_\omega \sum_{k \in \omega} \lambda^k \mathbb{E} \left[ Pr \left( j | B^k, p, \Psi^{r,k} \right) | D^k \right] \right\}$$

$$\approx \underset{p}{argmax} \left\{ \sum_{\omega \in \Omega} p_\omega \sum_{k \in \omega} \lambda^k \frac{1}{R} \sum_{r=1}^R Pr \left( j | B^{r,k}, p, \Psi^{r,k} \right) \right\}$$

# Targeted pricing

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

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\begin{aligned}
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&\approx \underset{p}{argmax} \left\{ \sum_{\omega \in \Omega} p_\omega \sum_{k \in \omega} \lambda^k \frac{1}{R} \sum_{r=1}^R Pr\left( j | B^{r,k}, p, \Psi^{r,k} \right) \right\}
\end{aligned}
$$

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

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

# Agenda

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# Parameter estimates

| Coefficient | High, A | Low, A | High, B | Low, B |
|---|---|---|---|---|
| $\theta_A$ | -0.344 | 0.25 | -1.066 | -1.413 |
| | (-0.651,-0.028) | (-0.178,0.695) | (-1.344,-0.79) | (-1.737,-0.964) |
| $\theta_B$ | -1.043 | -0.628 | -0.376 | 0 |
| | (-2.002,-0.425) | (-1.499,-0.023) | (-0.741,-0.035) | (-0.311,0.349) |
| $\alpha$ | -0.027 | -0.044 | -0.027 | -0.028 |
| | (-0.033,-0.021) | (-0.053,-0.035) | (-0.036,-0.019) | (-0.043,-0.017) |
| $\rho_{A,B}$ | 0.796 | -0.951 | 0.962 | 0.348 |
| | (0.443,0.931) | (-0.99,-0.826) | (0.926,0.985) | (-0.953,0.955) |

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# Elasticity estimates

| | High, A | | Low, A | | High, B | | Low, B | |
|---|---|---|---|---|---|---|---|---|
| | Both set regular prices of 75 RMB | | | | | | | |
| | $p_A$ | $p_B$ | $p_A$ | $p_B$ | $p_A$ | $p_B$ | $p_A$ | $p_B$ |
| Firm A | -5.33 | 0.15 | -10.17 | 0.00 | -16.99 | 13.17 | -7.88 | 3.72 |
| Firm B | 3.44 | -8.35 | 0.00 | -11.82 | 0.02 | -4.84 | 0.42 | -8.96 |
| | Both set prices of 30 RMB (60% off) | | | | | | | |
| | $p_A$ | $p_B$ | $p_A$ | $p_B$ | $p_A$ | $p_B$ | $p_A$ | $p_B$ |
| Firm A | -1.40 | 0.10 | -2.07 | 0.00 | -7.97 | 5.95 | -3.10 | 0.77 |
| Firm B | 1.52 | -3.44 | 0.00 | -4.33 | 0.01 | -1.25 | 0.03 | -1.91 |

# Best-response functions (targeting on one dimension)
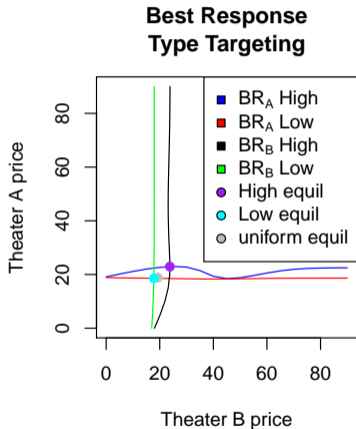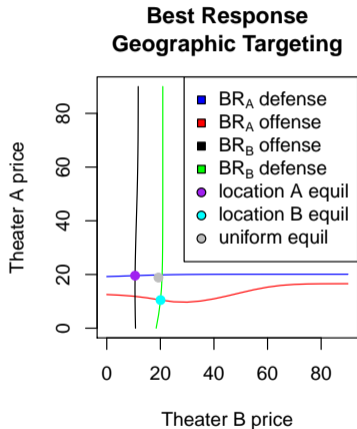
# Equilibrium profits vs. unilateral targeting profits

|  | Equilibrium | |
|---|---|---|
|  | Firm A | Firm B |
| Uniform | 196 | 291 |
| Location | 196 | 298 |
| Type | 198 | 295 |
| Type and Location | 197 | 297 |

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# Equilibrium profits vs. unilateral targeting profits

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|---|---|---|---|---|
|  | Firm A | Firm B | Firm A | Firm B |
| Uniform | 196 | 291 |  |  |
| Location | 196 | 298 | 198 | 302 |
| Type | 198 | 295 | 197 | 294 |
| Type and Location | 197 | 297 | 200 | 304 |

# 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)

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# Uniform pricing equilibrium

|  |  | Firm A | Firm B |
|---|---|---|---|
|  | Price | 19.2942 | 18.8641 |
| Share: | High type, location A | 0.1896 | 0.0168 |
|  | Low type, location A | 0.2795 | 0.0465 |
|  | High type, location B | 0.0005 | 0.2039 |
|  | Low type, location B | 0.0106 | 0.2380 |
| Expected profit per 100 customers messaged | | 196.04 | 291.33 |

# Equilibrium prices

|  | Market | Firm A Price | Firm B Price |
|---|---|---|---|
| Uniform | Pooled | 19.294 | 18.864 |
| by geography | Loc A | 19.575 | 10.564 |
|  | Loc B | 10.485 | 20.064 |
| by type | High | 22.948 | 23.786 |
|  | Low | 18.597 | 17.775 |
| by geography and type | A High | 21.335 | 10.870 |
|  | A Low | 19.146 | 10.546 |
|  | B High | 5.230 | 20.595 |
|  | B Low | 11.874 | 19.322 |

# Importance of considering competitive response

|  | Firm A Profit | Firm B Profit |
|:---:|:---:|:---:|
| Uniform pricing | 196 | 291 |
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# Targeting choice as a strategic game

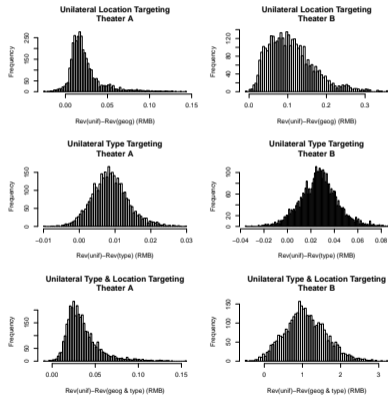| | Firm B | |
|---|---|---|
| Firm A | Uniform pricing | Unilateral targeting |
| Uniform pricing | 196, 291 | 194, 304 |
| Unilateral targeting | 198, 291 | 197, 297 |

# Experimental purchase response by segment

# Experimental revenues by segment

# Posterior profit differences: unilateral/equilibrium vs. uniform pricing

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