Consumer Data and Consumer Welfare: Evidence from the Hotel Booking Market.

Andrey Minaev

University of North Carolina at Chapel Hill

andrey@unc.edu

www.minaev.io

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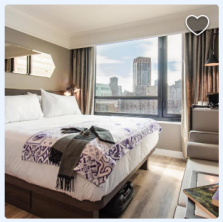
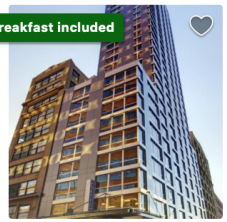
Motivation.

- Platforms like Amazon, Google, Expedia, etc., accumulate consumers' data.
- They claim to use this data to provide better services via better product targeting.
- It raises economic questions.
  - How does it change competition between firms that advertise on platforms?
  - How does consumer welfare change?
- Lack of empirical study on firms' response to better targeting and its effect on consumer welfare.

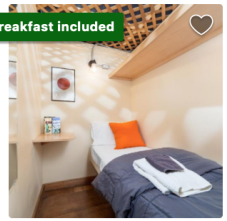
(a) Logged-in to a personal account



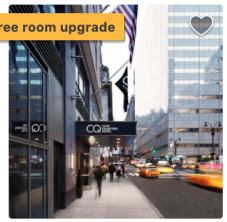
Pestana Park Avenue Genius
Murray Hill, New York · Show on map · Subway Access
Genius Discount
Cozy Room - Disability Access –
1 queen bed
FREE cancellation • No prepayment needed
You can cancel later, so lock in this great price today!
Only 1 room like this left on our site
Excellent 90 reviews 8.8
Location 9.5
1 night, 1 adult
~~$279~~ $251
Select your room



Breakfast included
Fairfield Inn by Marriott New York Manhattan/Financial District
Manhattan, New York · Show on map · Subway Access
Last booked for your dates 8 hours ago
Queen Room –
1 queen bed
Breakfast included
FREE cancellation
You can cancel later, so lock in this great price today!
Very Good 2,228 reviews 8.3
1 night, 1 adult
$150
Select your room

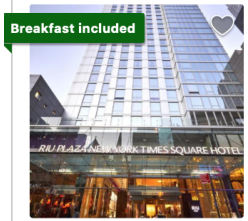


Breakfast included
Chelsea Cabins Genius
Manhattan, New York · Show on map · Subway Access
Booked 2 times for your dates in the last 24 hours
Genius Discount
Single Room with Shared Bathroom –
1 twin bed
Breakfast included
FREE cancellation • No prepayment needed
You can cancel later, so lock in this great price today!
Good 2,813 reviews 7.3
1 night, 1 adult
$69
See availability

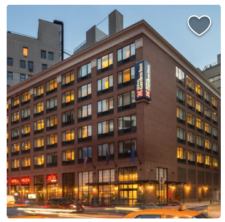


Free room upgrade
Club Quarters Hotel, Grand Central
Genius
Manhattan, New York · Show on map · Subway Access
1 other person looked for your dates in the last 10 minutes
Genius Discount Free room upgrade
Standard Queen Room –
1 queen bed
Pay less and get a better room
FREE cancellation • No prepayment needed
Excellent 1,405 reviews 8.8
Location 9.4
1 night, 1 adult
~~$209~~ $179
Select your room

(b) Logged-out + anonymized

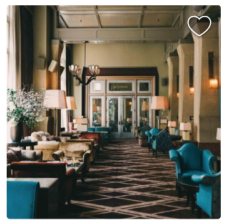


Breakfast included
Riu Plaza New York Times Square
Manhattan, New York · Show on map · Subway Access
1 other person looked for your dates in the last 10 minutes
Booked 2 times for your dates in the last 12 hours on our site
Deluxe Queen Room –
1 queen bed
Breakfast included
FREE cancellation • No prepayment needed
Risk Free: You can cancel later, so lock in this great price today!
Only 5 rooms like this left on our site
Excellent 3,191 reviews 8.7
Location 9.5
1 night, 1 adult
~~$522~~ $339
Select your room



Hilton Garden Inn New York/Tribeca
Manhattan, New York · Show on map · Subway Access
Double Room with Two Double Beds –
2 full beds
FREE cancellation • No prepayment needed
Risk Free: You can cancel later, so lock in this great price today!
Very Good 417 reviews 8.4
1 night, 1 adult
$203
Select your room

Ink 48 Hotel
Manhattan, New York · Show on map
Deluxe Queen Room with Two Queen Beds –
2 queen beds
FREE cancellation • No prepayment needed
Risk Free: You can cancel later, so lock in this great price today!
Very Good 469 reviews 8.3
1 night, 1 adult
$179
Select your room



Soho Grand Hotel Promoted
Manhattan, New York · Show on map · Subway Access
Soho King Room –
1 king bed
FREE cancellation
Risk Free: You can cancel later, so lock in this great price today!
Very Good 928 reviews 8.5
Location 9.3
1 night, 1 adult
~~$634~~ $445
Select your room

Main Idea.

- Compare market outcomes in two situations.
  - Common ranking.

    The platform uses market-aggregated data only. Same ranking for all consumers.
  - Personal ranking.

    The platform uses consumer's personal data. Consumer-specific ranking of products.

- The key component is consumers incur the search costs to learn product quality.
- With search, consumer's consideration set and, hence, demand, depend on ranking.
- Demand change affects firms' pricing.

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Trade-off and Contribution

Trade-off:

- Targeting reduces search expenditures and provides better product match.
- Targeting segments the market thereby softens price competition.

Contribution:

- First empirical paper studying the equilibrium model.
  - Analyze firms' price response to better targeting.
- The personalized ranking is harmful to consumers due to price increase.

Data structure.

- Expedia hotel search and booking data. 200,000 consumers. Nov 2012 – June 2013.
- Data for each consumer query:
  - An ordered list of hotels shown to the consumer with their characteristics.
  - What hotels clicked and what, if any, booked.
  - Query details (stay length, # of rooms, # of adults, etc.).

Approach

- Sequential search model for consumer demand.

  Estimated with a click and purchase data.
- Using demand estimation, calculate hotels' costs.
- Permutation of hotels' positions $\rightarrow$ demand change $\rightarrow$ prices change $\rightarrow$ consumer welfare change.

Optimal consumer search.

- Weitzman (1979) optimal sequential search model. Utility u_{ij}, Reservation Utility r_{ij}.
- Search and purchase decisions are determined by

$$u_{ij} = \delta_{ij} + \epsilon_{ij}, \quad r_{ij} = \delta_{ij} + H_0^{-1}(s_{n_{ij}})$$

- Utility observed prior to search is modeled as:

$$\delta_{ij} = \alpha_i p_j + \boldsymbol{\beta_i}^T \boldsymbol{x_j} + \xi_j$$

- Ursu (2018) showed that position affects search costs only. Ursu (2018) details
- Search cost $s_{n_{ij}} \sim F^{s_{n_{ij}}}(s)$ with mean $\mu_{n_{ij}} = log(1 + exp(\gamma \cdot n_{ij}))$
- Consumer problem is dynamic $\rightarrow$ complicated demand system.

Consumer choice.

Choi, Dai, Kim (2018, ECMA) showed that sequential consumer search model can be translated into a familiar discrete-choice model.

$$w_{ij} \stackrel{\text{def}}{=} \min\{u_{ij}, r_{ij}\}$$

Proposition

The consumer i purchases product j if and only if $w_{ij} \geq \max_{k \neq j}\{w_k\}$

Intuituion

If u_{ij} or r_{ij} are low, the hotel is never booked.

- *If r_{ij}, the hotel is not explored.*
- *If u_{ij}, the hotel is not booked even if explored.*

Consumer demand.

	Mean Utility Parameters	Utility Parameters Standard Deviations
Utility		
Constant	4.1167^{***}	6.2731^{***}
	(0.1742)	(1.152)
Price ($100)	-2.4881^{***}	0.6499^{***}
	(0.1203)	(0.1259)
Star rating	1.2369^{***}	0.0166
	(0.0705)	(0.1703)
Review score	0.1118	0.0916
	(0.0895)	(0.171)
Location score	0.0737	0.9509^{***}
	(0.1006)	(0.0726)
Chain dummy	0.7346^{***}	1.6514^{***}
	(0.2656)	(0.4475)
Search cost		
Position (γ)	0.0625^{***}	–
	(0.0032)	–

Note: Stars indicate estimates significant at the 99% level.

Monte Carlo simulation

Supply side.

Knowing the distribution of consumers' demand elasticity and search costs, find hotels' opportunity costs

$$p_j^* = \underset{p_j}{\operatorname{argmax}} \left[\left(p_j - c_j \right) D_j(p_j) \right]$$

$$c_j = p_j^* + \frac{D_j(p_j^*)}{\left. \frac{\partial D_j(p_j)}{\partial p_j} \right|_{p_j = p_j^*}}$$

The effect of price on demand

- Effect on consideration set
  - Position in ranking
  - Reservation utility r_{ij}
- Effect on purchase probability conditional on consideration set
  - Consumer utility u_{ij}

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Counterfactuals.

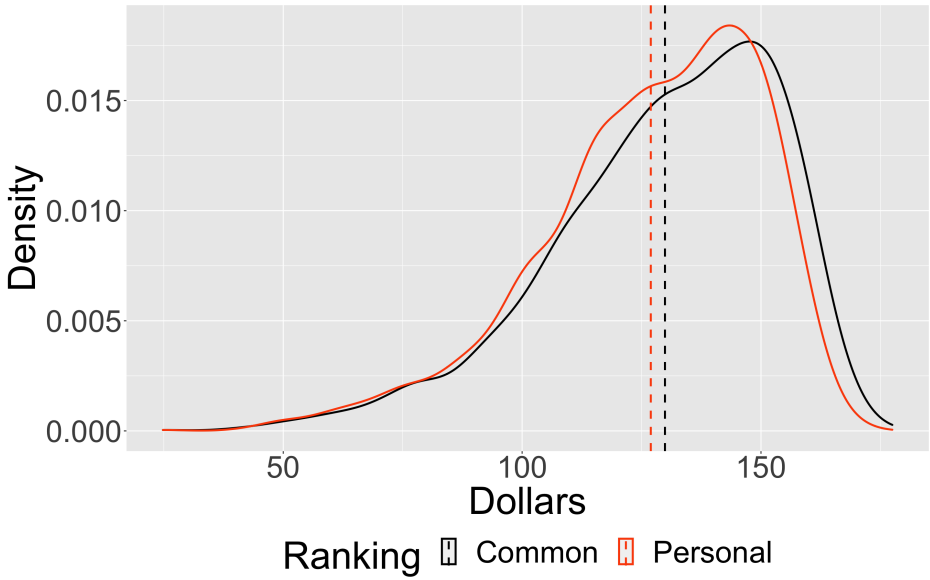
- Compare consumer welfare under common and personal rankings.
- Algorithm:
  1. Model hotels prices under common and personal rankings, using consumer demand estimation and hotels' cost.
  2. Draw consumers from consumer distribution and simulate their decisions under common and personal rankings.
  3. Compare results.

Effect on consumer welfare.

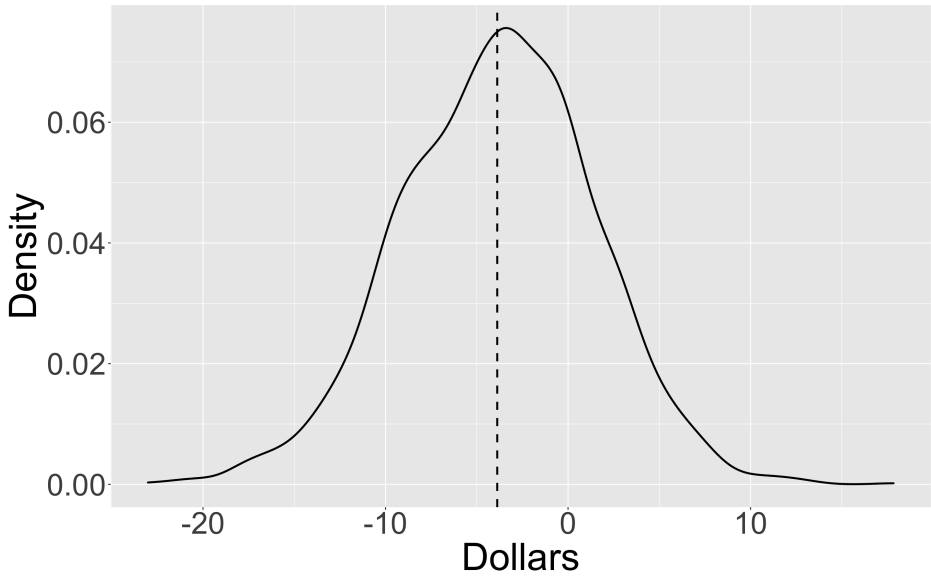
Consumers in average experience 3.1% ($4.2) direct utility reduction.

- Gain 0.5% ($0.7) due to finding a better-fitted hotel.
- Loss 3.6% ($4.9) due to increased transaction prices.

(a) Consumers utility distribution. Personal vs Common rankings



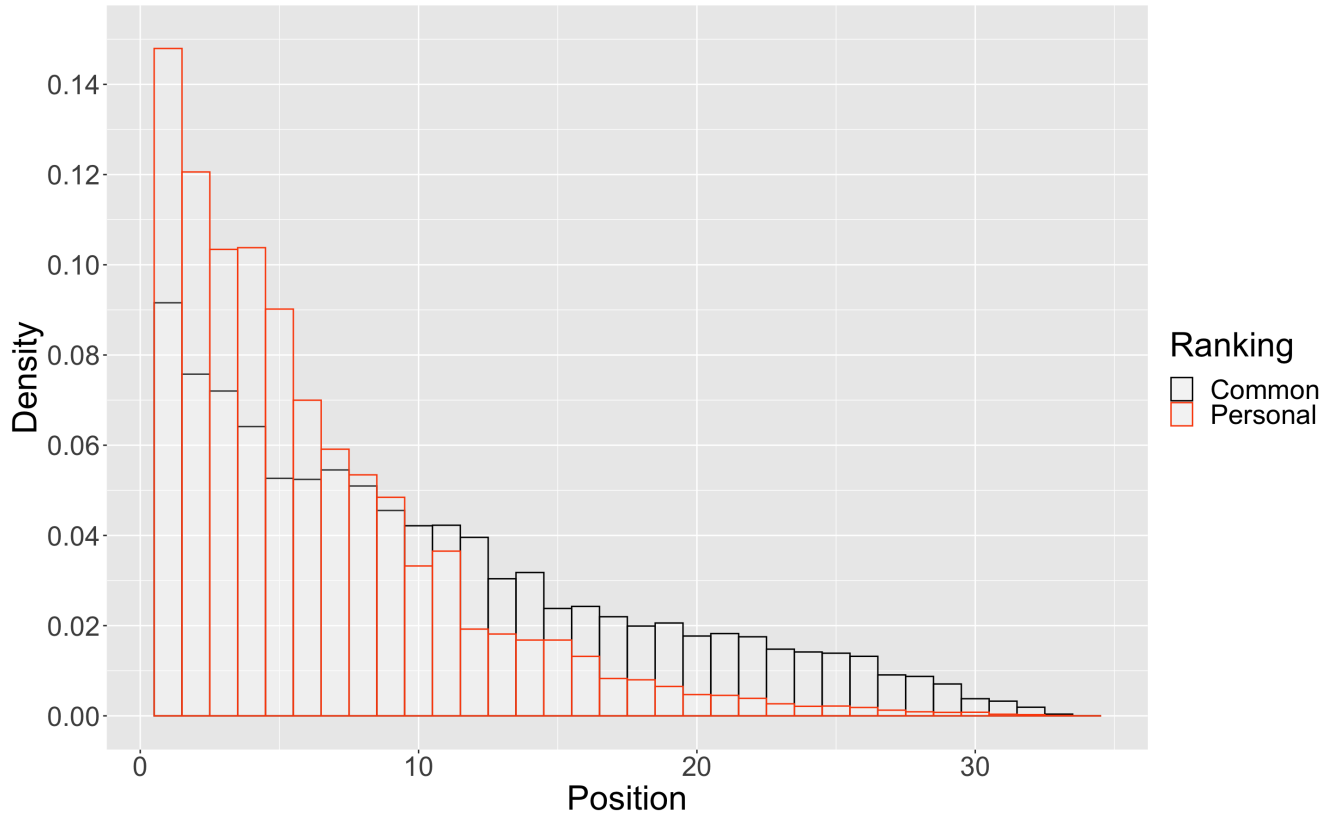
(b) Distribution of utilities difference. Personal vs Common rankings



Effect on consumer welfare.

Consumers in average experience .8% ($1.1) gain due to a reduction in search intensity.

Figure: Positions of booked hotels. Personal vs Common rankings



Concluding remark

- First empirical paper studying the effect of consumer-personalized products ranking in the equilibrium search model.
- The average consumer welfare reduces under the personal ranking in contrast with previous researches. The effect is heterogeneous over consumers. Some of the consumers experience welfare gain.

Data.

	Observations	Mean	Median	SD	Min	Max
Query level						
Number of hotels displayed	206,657	27.12	31.00	8.10	5	38
Trip length (days)	206,657	2.42	2.00	1.98	1	40
Booking window (days)	206,657	39.26	18.00	53.89	0	498
Saturday night (percentage)	206,657	0.50	1.00	0.50	0	1
Adults	206,657	2.00	2.00	0.90	1	9
Children	206,657	0.39	0.00	0.79	0	9
Rooms	206,657	1.12	1.00	0.44	1	8
Total clicks	206,657	1.12	1.00	0.61	1	25
Two or more clicks (percentage)	206,657	0.07	0.00	0.25	0	1
Transaction	206,657	0.66	1.00	0.48	0	1
Random ranking (percentage)	206,657	0.31	0.00	0.46	0	1
Hotel level						
Price	5,511,851	156.49	129.00	101.28	10	1000
Stars	5,383,647	3.31	3.00	0.88	1	5
Review Score	5,505,786	3.86	4.00	0.91	0	5
Chain	5,511,851	0.65	1.00	0.48	0	1
Location Score	5,511,851	3.09	3.00	1.52	0	7
Promotion	5,511,851	0.24	0.00	0.43	0	1

Appendix: Monte Carlo simulations.

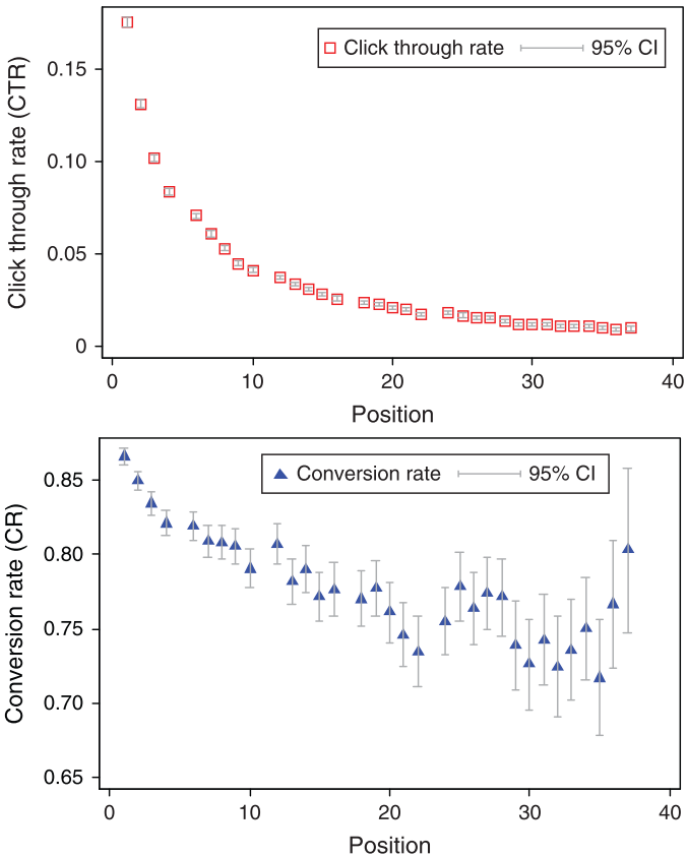
1,000 consumers, each searching among 30 hotels. 10,000 draws from $F^{\theta}(\theta)$.

	True values	Estimated values
Utility		
Price	-1	-0.9608
		(0.0525)
Price heterogeneity	0.3	0.2849
		(0.0430)
Quality	2	1.8941
		(0.0883)
Quality heterogeneity	0.6	0.5335
		(0.0542)
Search cost		
Position	0.1	0.0856
		(0.0065)

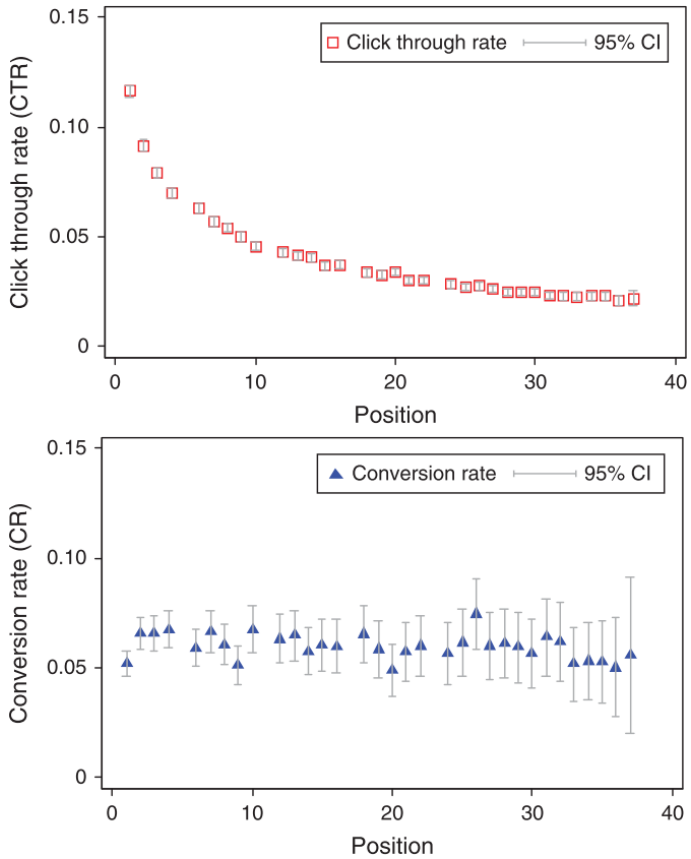
Back

Effect of ranking on clicks and sales.

(a) Expedia ranking



(b) Random ranking



Appendix: Ursu (2018) details.

$$u_{ij} = \delta_{ij} + \epsilon_{ij}, \quad r_{ij} = \delta_{ij} + H_0^{-1}(s_{ij})$$

Position affects	Prediction	Result
δ	Purchase conditional on search is affected by position	Ruled out
ϵ	Reservation utility is increasing in position	Ruled out
s	**Opaque offers increase search costs**	**Ruled in**
δ, ϵ	Purchase conditional on search is affected by position	Ruled out
δ, s	Purchase conditional on search is affected by position	Ruled out
ϵ, s	Reservation utility is increasing in position	Ruled out
δ, ϵ, s	Purchase conditional on search is affected by position	Ruled out

Back

Supply side.

Knowing the distribution of consumers' demand elasticity and search costs, find hotels' opportunity costs

$$\Pi_{jt}(p_{jt}) = \Big((1 - f_j)p_{jt} - c_{jt}\Big) D_j(p_{jt})$$

$$\frac{c_{jt}}{1 - f_j} = p_{jt} - \frac{D_j(p_{jt})}{\frac{\partial D_j(p_{jt})}{\partial p_{jt}}}$$

The effect of price on demand

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  - Position in ranking
  - Reservation utility r_{ij}
- Effect on purchase probability conditional on consideration set
  - Consumer utility u_{ij}

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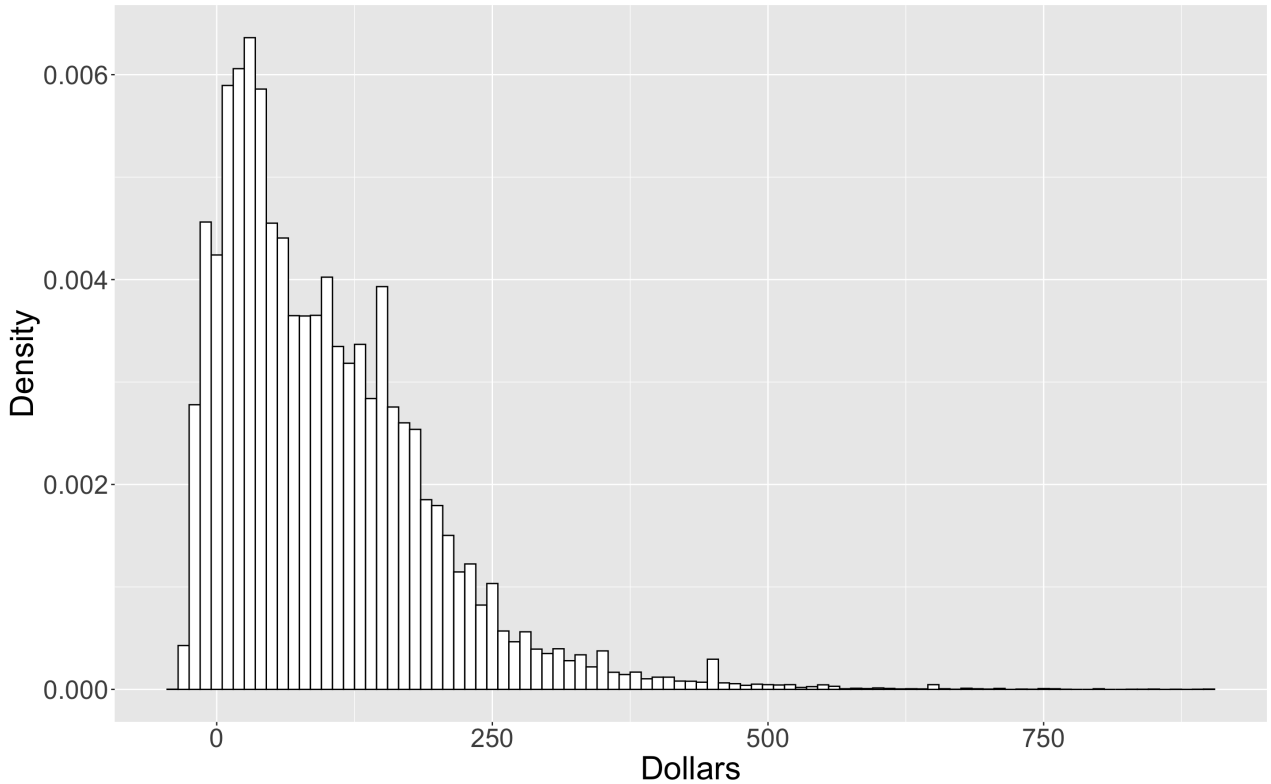
Hotels' opportunity costs histogram.

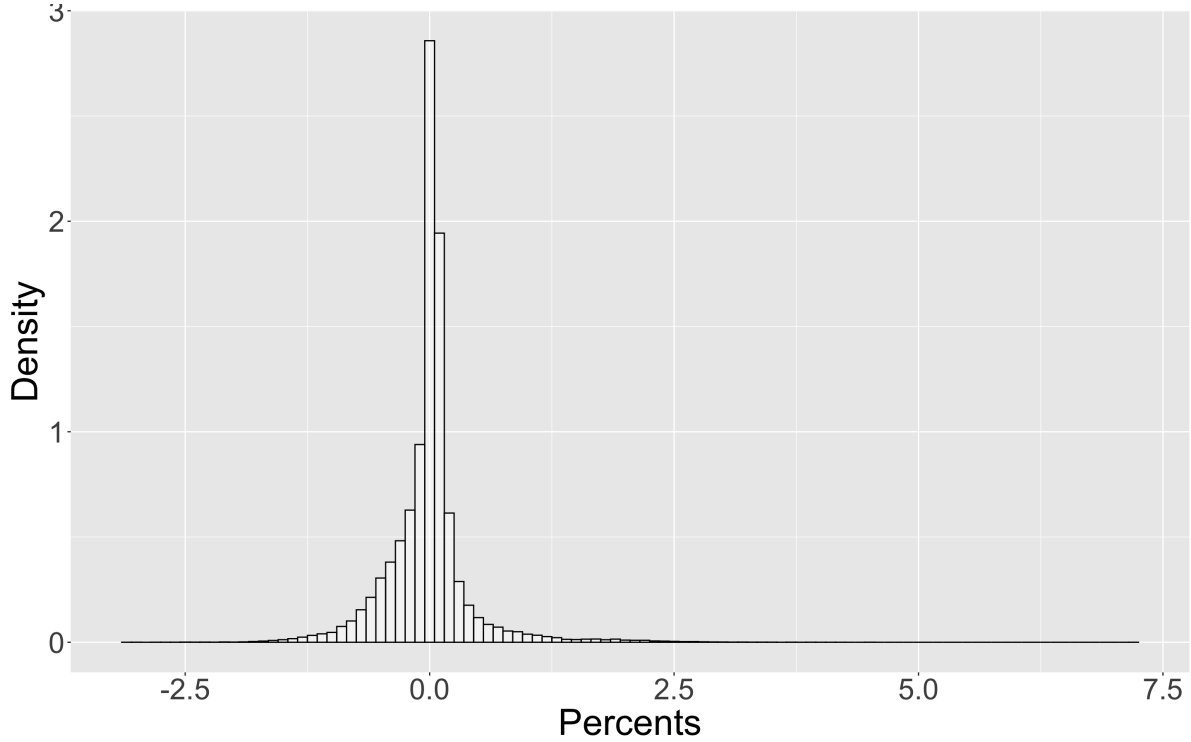
- The opportunity cost is different from the marginal cost of serving the room.
- The opportunity cost might be negative if, for example, the hotel expects an increase in competition in the future.
- The opportunity cost captures the dynamic aspect of optimal pricing decision.



Effect on prices is heterogeneous.

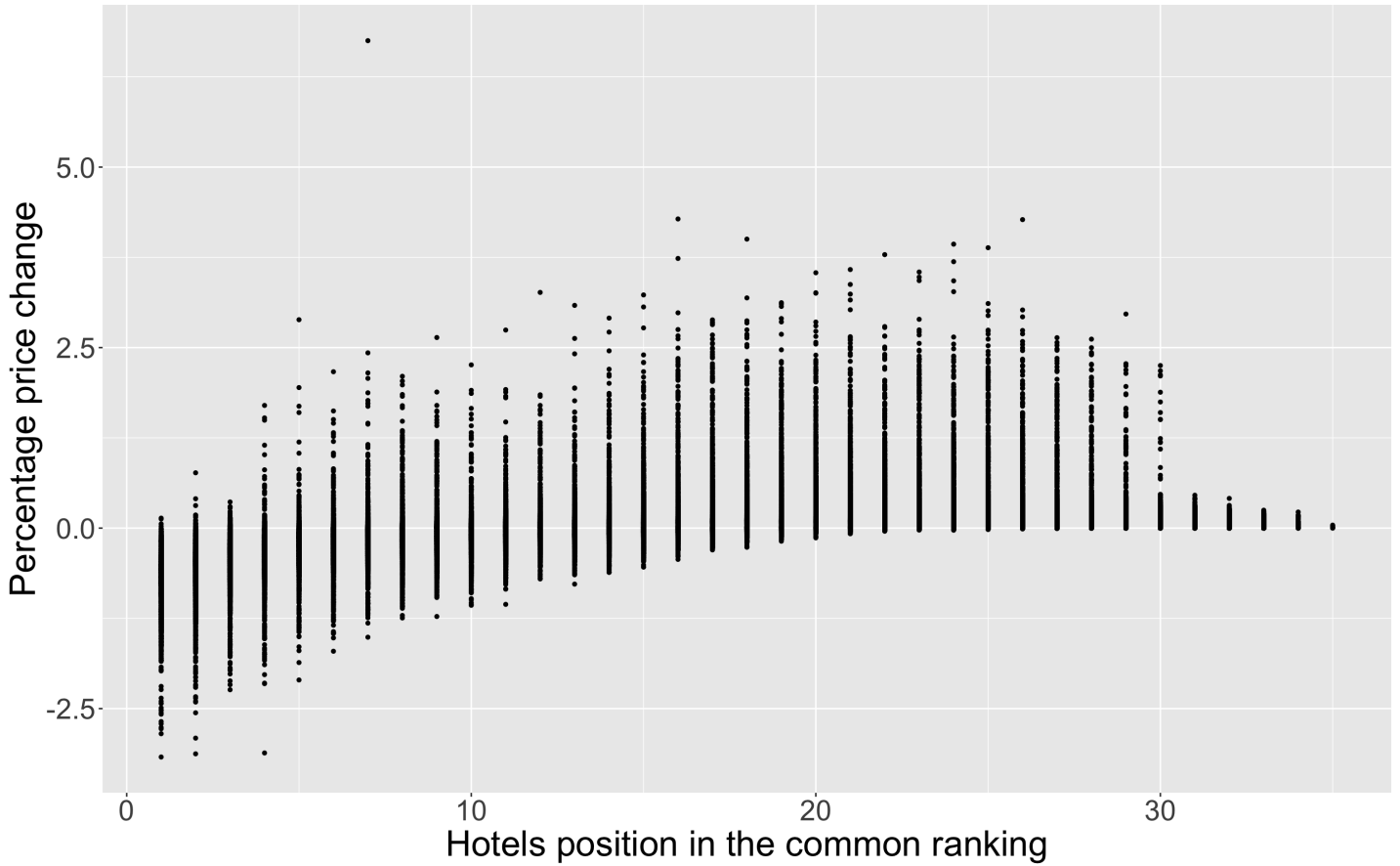
- The average transaction price increased.

Figure: Percentage Price Change. Personal vs Common rankings



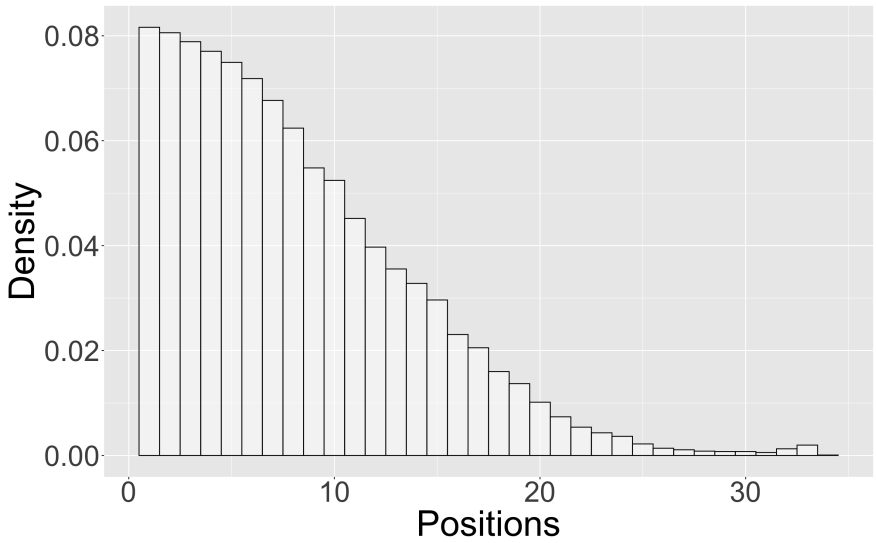
Effect on prices is heterogeneous by position.

- Less prominent hotels have a lower incentive to decrease the price.

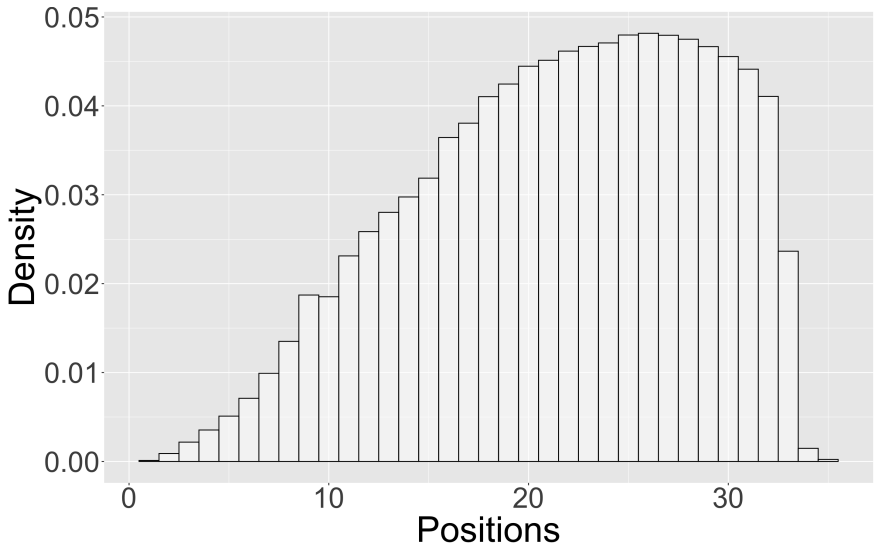


Effect on prices is heterogeneous by position.

(a) Positions of hotels that charges lower prices under the personal ranking



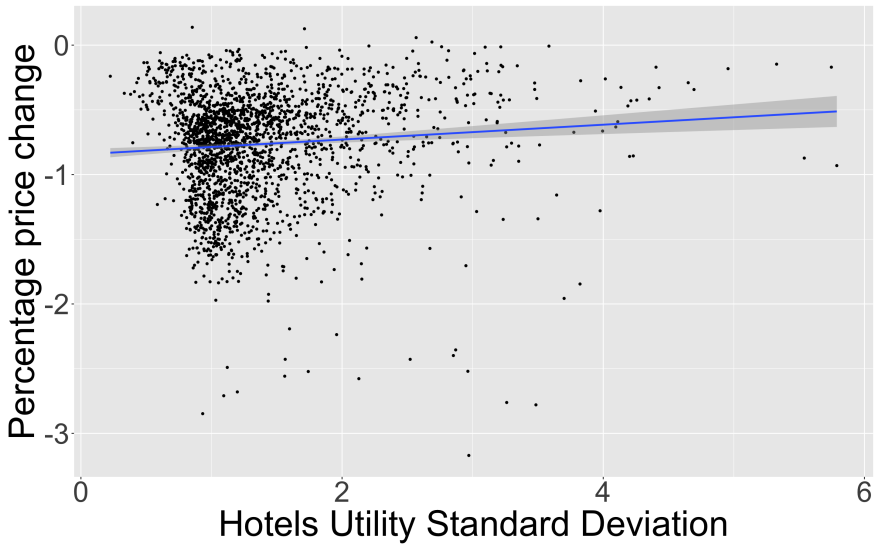
(b) Positions of hotels that charges higher prices under the personal ranking



Price change by the measure of market vertical differentiation.

- As the level of products vertical differentiation increases, the advertising effect becomes less important since consumers have stronger preferences toward one of the products, which leads to higher price difference.

(a) Position #1



(b) Position #15