Measuring Consumer-Welfare Changes When Platforms Change their Lists of Search Results

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Research Question and Motivation

Research Question

1. If Amazon changes how it lists its products, how does consumer welfare change?
2. More broadly, how do we interpret welfare measures in a search environment?

Motivation

1. Amazon does this to boost its own products.[1]
2. Is this an unfair restrain of trade?
3. Analyze through damage to consumers.

[1] WSJ article. Google too!

Detailed Research Setting with Example

Consumer shops for a face moisturizer online...

Name	Example
Discrete Choice	Consumer wants to purchase at most one moisturizer
Costly Search	Won't shop every moisturizer sold online from every platform
Consideration Sets	Decides to shop first 50 results on Amazon *or* until she finds three she likes
Listing Order Matters	If Amazon pushes its own products to top, more likely to search Amazon products over others

Goal: Measure welfare change over change in listing order/algorithm

Key Takeaways

1. Valuable, new formula that identifies average equivalent variation from arbitrary search listing changes
    a The formula can be used on its own to measure welfare or the assumptions used in its derivation can be used to interpret utility differences in other papers
2. Identification requires
    a. knowledge of all consumer's price and quantity trade offs
    b. Utility to be quasi-linear for point identification of utility
    c. consideration sets to be independent of prices but can depend on all good characteristics and unobservables
    d. doesn't require modeling the search process
3. Application to Online Travel Agency (OTA):
    a. Estimate Average welfare loss of $8.11 going from Proprietary Ordering to Random Ordering
    b. Estimation of average welfare loss of $23.87 when OTA removes the top five hotel bookings from search result lists

Talk Overview

The remainder of these slides are organized as follows.

1. Distinguish work from existing literature
2. Explain research environment and choice of welfare measure
3. Present the main results
4. Provide some simpler results for intuition on main results
5. Discuss empirical example

Econometric Welfare Literature

This paper is most similar to Bhattacharya (2015) who

- found exact welfare formulas for single price increase
- environment of discrete choice demand (point identification)
- very weak preference restrictions

But

- *assumes consumers have perfect knowledge and access to all products*
- *no way for search process or platform to affect welfare*

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In same preference environment, I find exact welfare measures *allowing*

- limited consumer knowledge and product access
- platforms to affect product choices
- much simpler, more intuitive derivations

Empirical Literature on Welfare and Search Platforms

Empirical Literature Estimating Welfare in Search Models

1. **Search Ranking Changes:** Ursu (2017), Athey and Ellison (2011)
2. **Platform Changes:** Lewis and Wang (2013), Dinerstein et al. (2017) and Fradkin (2018)
3. **Advertising and Search:** Honka, Hortaçsu, and Vitorino (2017) Seiler and Yao (2017)
4. **Changing Search Costs:** Honka (2014), Ershov (2016) and Moraga-Gonzalez, Sándor, and Wildenbeest (2017)

Comparison with This Paper

1. LHS literature rely on explicit model of search process
2. Choice of search model has strong consequences on counterfactual welfare
3. In my paper, search method unconstrained
4. I can do this as I am working in context of exogenous treatment: A/B test
5. My identification results rely for rich heterogeneity in unobservable preferences and search behavior

Recent Literature on Inattentive Consumers

Literature on Inattentive Consumers goes back (at least) to Manski (1975)

1. Classically, inattention has been studied as products entering consideration sets randomly (with exogenous probability)
2. Thus inattention was antithetical to search (where products endogenously determined)

Recent advances in literature have narrowed gap between search and inattentive consumers literature:

- Goeree (2008), Barseghyan, Molinari, and Thirkettle (2019), Abaluck and Adams (2018), Iaria, Crawford, and Griffith (2020) and Barseghyan, Coughlin, et al. (2019)
- focus on the point (or partial for last) identification of preferences and consideration set distributions; welfare measures in these papers, if explored, are based on differences in before-and-after-average utility and are not tied to compensating variation or equivalent variation.
- All but last assume consideration sets are independent of preferences conditional on observables.

In contrast, this paper

- First to study the identification of classically interpretable welfare measures with endogenous consideration sets

Brief History of Consumer Welfare and Interpreting Welfare in a Search Setting

Consumer welfare was a contentious tool for some time:

a. Classically, many researchers disagreed with using consumer welfare in empirical settings; see Stahl (1983), Bergson (1975) and discussion therein.
b. Acceptance of Consumer Surplus grew especially thanks to Willig (1976):
    - showed—in full information environment—area under curve approximated the readily interpretable compensating and equivalent variations.
c. Now, most measures of consumer surplus are readily accepted as meaningful, even in settings where Willig's results have not been extended.

How welfare can misbehave in a search environment:

1. Classically, we compensate for a price increase by raising income
2. But a price increase in a search setting may lead to re-optimized search behavior that improves average welfare.
3. Thus, compensation for a *price increase* may require an *income decrease* in a search setting.

My paper looks at these issues critically and provides a framework for interpreting consumer welfare in a search setting

Extra Power A/B Test (Experiment) Gets You

Careless Consumers:

- only consider first page of Amazon results

Careful Consumers:

- know available products before start search on Amazon
- search as many pages as necessary to find desired product

Amazon Listing Strategies

`list_encourage`:

1. Puts best product matches on first page

`list_exploit`

1. Puts own product matches on first page

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Common data feature: most consumers only shop 1 page of results

1. Data won't distinguish between *Careless* + `list_exploit` and *Careful* + `list_encourage`
2. Without A/B test, welfare consequence of alternate platform list is a modeling choice
3. In contrast, A/B test will allow you to make correct conclusions

Notation

Data Assumptions - Overview

Product Data

- Goods $\mathcal{J} = \{0, 1, \ldots, J\}$
- Product characteristics $(0, X_1, \ldots, X_J)$
- Market Prices $(0, p_1^m, \ldots, p_J^m)$
- $p_{-j}^m := (0, p_1^m, \ldots, p_{j-1}^m, p_{j+1}^m, \ldots, p_J^m)$; all prices but the jth good's price

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- α
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Consumer Data

- Start with assumption that average (or aggregate) consumer demand *known*
- It is *not* necessary to observe consideration sets

Consumer Primitives: Multinomial Preferences and Consideration Sets

Utility for good j is quasi-linear

- $u_j(y - p_j, \eta) = y - p_j + \tilde{U}_j(\eta)$
- η is unobservable preference; e.g. brand preference
- y is income; need not be observable under quasi-linearity

Weaker assumption of utility $u_j(y - p_j, \eta)$ monotonic is also considered

Consideration sets $\mathcal{C}(\alpha, \zeta, \eta) \subseteq \mathcal{J}$

- Price Independence: independent of income and prices
- α is search listing order
- ζ is unobservable factors that influence $\mathcal{C}$ but not preferences
    - e.g. price beliefs and taste for shopping

Welfare Measure - Equivalent Variation

Equivalent Variation S^{EV} for consumer is solution in S to

$$\max_{j \in \mathcal{C}(\alpha_0, \zeta, \eta)} u_j(y - S - p_j^m, \eta) = \max_{j \in \mathcal{C}(\alpha_1, \zeta, \eta)} u_j(y - p_j^m, \eta)$$

(Compensated Initial Utility) = (Final Utility)

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$$\text{(Compensated Initial Utility)} = \text{(Final Utility)}$$

- Interpretation: How much income need to remove under initial listing to lower utility as much as new listing order lowers utility.

Under *quasi-linearity* and *Price Independence*

$$S^{EV} = \max_{j \in \mathcal{C}(\alpha_0,\zeta,\eta)} u_j(y - p_j^m, \eta) - \max_{j \in \mathcal{C}(\alpha_1,\zeta,\eta)} u_j(y - p_j^m, \eta)$$

e.g. under *assumptions*, S^{EV} is just change in utility over two periods

What if We Drop Price Independence?

Note assuming quasi-linearity without *Price Independence* in general leaves

$$S^{EV} \neq \max_{j \in \mathcal{C}(\alpha_0, \zeta, \eta)} u_j(y - p_j^m, \eta) - \max_{j \in \mathcal{C}(\alpha_1, \zeta, \eta)} u_j(y - p_j^m, \eta)$$

That is, without Price Independence, utility differences need not equal equivalent (or compensating) variation Detailed Example

This leaves empirical researchers with three options:

1. Test for Price Independence in your model; method opted for in this paper.
2. Allow for consideration sets to depend on prices in your model, but interpret the utility differences in a world where consumers aren't allowed to re-adjust consideration sets after price changes
3. Derive an interpretation of your chosen welfare measure, given the dependence between prices and consideration sets you allow for in your model; it probably won't be compensating variation or equivalent variation.

Demand

Individual demand for good j

$$q_j(p_j, p_{-j}, \alpha, \eta, \zeta) := \begin{cases} 1 & \text{if } j = \arg\max_{k \in \mathcal{C}(\alpha,\eta,\zeta)} u_k(y - p_k, \eta) \\ 0 & \text{otherwise} \end{cases}$$

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Abbreviation: *Individual demand for good j under* α_t and quasi-linearity

$$q_j^t(p_j, \eta, \zeta) := q_j(p_j, p_{-j}^m, \alpha_t, \eta, \zeta)$$

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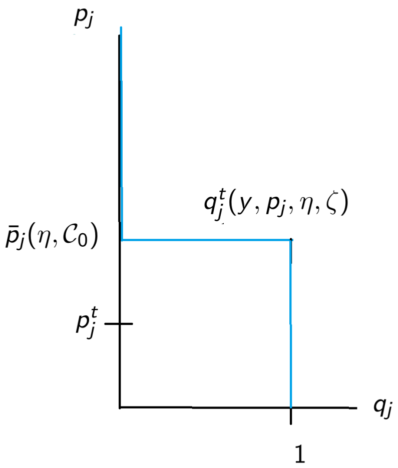
$$q_j^t(p_j, \eta, \zeta) := q_j(p_j, p^m_{-j}, \alpha_t, \eta, \zeta)$$

- fixes prices for all other goods at market level
- suppresses α_t
- income drops out because utility quasi-linear

Picture of Simple Individual Demand



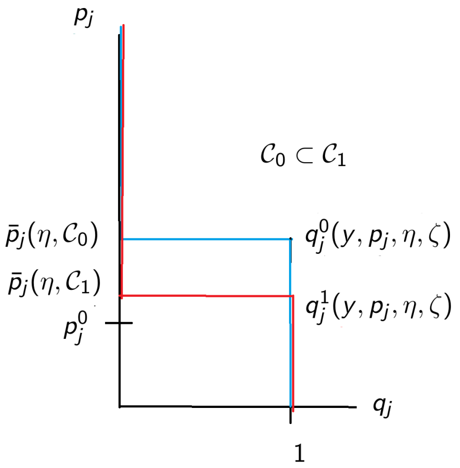
Key Aspect of Demand

- Top of individual demand line called
  - Reservation Price
  - Willingness to Pay (WTP)
- WTP is $\bar{p}_j$ such that

$$q_j^t(p_j, \eta, \zeta) := \begin{cases} 1 & \text{if } p_j < \bar{p}_j \text{ and } j \in \text{Consideration Set} \\ 0 & \text{otherwise} \end{cases}$$

- WTP depends on utility for other goods in consideration set
- e.g. as consideration sets grow, WTP (weakly) falls

Demand Changes when Consideration Sets Change Even if Product Choice Unchanged



Data Assumptions - Demand Data

Aggregate demand

$$Q_j(p_j, p_{-j}, \alpha) = \int q_j(p_j, p_{-j}, \alpha, \eta, \zeta) dF(\eta, \zeta)$$

Assumed known for all prices

- $(\eta, \zeta) \sim F$ (distribution unobservables)

Main Identification Results

Welfare For Arbitrary Listing Change

Denote *total welfare under listing rule* α_t by Ω_t and define it with the following formula.

$$\Omega_\alpha := \lim_{p_2,\ldots,p_J \to \infty} \int_{p_1^m}^{\infty} Q_1(p, p_{-1}, \alpha) dp + \tag{1}$$

$$\lim_{p_3,\ldots,p_J \to \infty} \int_{p_2^m}^{\infty} Q_2(p, (p_1^m, p_{-(1,2)}), \alpha) dp \tag{2}$$

$$+ \cdots + \int_{p_J^m}^{\infty} Q_J(p, p_{-J}^m, \alpha) dp \tag{3}$$

Theorem

Under Quasi-linearity and Price Independence, the average welfare change μ^W *for a change in platform listing rule from A to B is*

$$\mu^W = \Omega_A - \Omega_B$$

Example for Intuition Details to Follow

Notes on Welfare Formula for Arbitrary Listing Changes

1. Formula works by adding the value of each good consumers have in their consideration sets
2. Formula does not require consideration sets to be observed
3. This is the formula that is used in the empirical part of the paper.

Welfare Bounds Under Monotonicity

Theorem (Probable Addition of Goods)

Suppose the listing rule changes exogenously from A to B such that a previously unconsidered collection of goods $\mathcal{R}$ can enter consideration sets.[2] *Then, under Monotonicity and Price Independence, the average compensating variation of this change in listing rule is such that*

$$-\max_{j \in \mathcal{R}} \lim_{p_k \to \infty \forall k \in \mathcal{R} \setminus \{j\}} \int_{p_j^m}^{\infty} Q_j(y, p_j, (p_{\mathcal{R}\setminus\{j\}}, p^m_{-\mathcal{R}}), B) dp_j \geq \mu^{CV} \tag{4}$$

$$\geq -\sum_{j \in \mathcal{R}} \lim_{p_k \to \infty \forall k \in R \setminus \{j\}} \int_{p_j^m}^{\infty} Q_j(y, p_j, (p_{\mathcal{R}\setminus\{j\}}, p^m_{-\mathcal{R}}), B) dp_j.$$

Intuitively, the upper bound on $\mu^C V$ is the are under demand gained from the “best” good in $\mathcal{R}$. The lower bound is the sum of the value each good would bring if it were to be the only good in $\mathcal{R}$.

[2] Specifically, I mean for every (y, η, ζ), $\mathcal{C}_A \subseteq \mathcal{C}_B \subseteq \mathcal{C}_A \cup \mathcal{R}$ and $\mathcal{C}_A \cap \mathcal{R} = \emptyset$.

Notes on Welfare Bounds Under Monotonicity

1. Under Monotonicity, welfare formulas can only bound welfare changes under the probabilistic addition or subtraction of goods from consideration sets.
    a. simultaneous addition and subtraction creates problems
2. Welfare bounds can be improved to equalities if data assumptions are significantly strengthened
    a. Assume demand data is known for each group of consumers that share common consideration set under listing rules A and B
    b. This will allow exact welfare identification even under the case of simultaneous product additions and withdrawals

Identification Results: Welfare from Removing One Product

Welfare Consequence of One Product Removed from Search List

α_{all}	Amazon lists all products
α_{1less}	Amazon puts product 1 on last page of search list

Theorem

- *Assume (for slides) list change only reduces probability product 1 is shopped*
- *Then average equivalent variation is exactly*

$$\int_{p_1^m}^{\infty} \left[Q_1(p_1, p_{-1}^m, \alpha_{all}) - Q_1(p_1, p_{-1}^m, \alpha_{1less})\right] dp_1 \tag{5}$$

If Amazon removes product 1 completely, then average equivalent variation is

$$\int_{p_1^m}^{\infty} Q_1(p_1, p_{-1}^m, \alpha_{all}) dp_1$$

i.e. welfare found with simple integral of demand curves

Proof of Welfare Loss from One Good Loss from Listings

Fix 1 Consumer (y, η, ζ). Consider Two Possible Cases

1. Demand for good 1 same under full listing and listing without good 1
    - Then $q_1^{all}(p_1, \eta, \zeta) - q_1^{1less}(p_1, \eta, \zeta) = 0$ for all p_1
      and $S^{EV} = 0$ since product choice same ✓

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    - It must be $q_1^{all}(p_1, \eta, \zeta) = 1$ on $[p_1^m, \bar{p}_1]$
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    - Therefore

$$\int_{p_1^m}^{\infty} [q_1^{all}(p_1, \eta, \zeta) - q_1^{1less}(p_1, \eta, \zeta)] dp_1 = \bar{p}_1 - p_1^m$$

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    - Likewise, $-\bar{p}_1 + \tilde{U}_1(\eta) = \max_{j \in \mathcal{C}_{all} \setminus \{1\}} -p_j + \tilde{U}_j(\eta)$ by definition of $\bar{p}$

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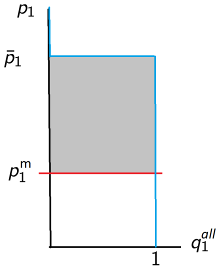
so

$$\begin{aligned} S^{EV} &= \left[\max_{j \in \mathcal{C}_{all}} -p_j^m + \tilde{U}_j(\eta)\right] - \left[\max_{j \in \mathcal{C}_{all} \setminus \{1\}} -p_j^m + \tilde{U}_j(\eta)\right] \\ &= \left[-p_j^m + \tilde{U}_1(\eta)\right] - \left[-\bar{p}_1 + \tilde{U}_1(\eta)\right] \\ &= \bar{p}_1 - p_1^m \checkmark \end{aligned}$$

Area Under Demand Curve In Case Where Demand Changes

$$\int_{p_1^m}^{\infty} [q_1^{all}(p_1,\eta,\zeta) - q_1^{1less}(p_1,\eta,\zeta)]dp_1 = S^{EV}$$

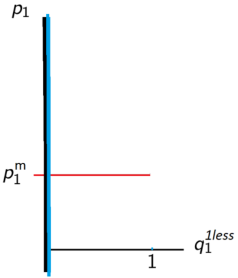
because changing demand means



$$= \int_{p_1^m}^{\infty} q_1^{all}(p_1, p_{-1}^m, \eta, \zeta)dp$$
$$= (\bar{p}_1 - p_1^m) \times 1$$
$$= S^{EV}$$

while

$$= \int_{p_1^m}^{\infty} q_1^{1less}(p_1, p_{-1}^m, \eta, \zeta)dp$$
$$= 0$$



Finishing Proof: Adding Up Over All Consumers

Since $S^{EV} = \int_{p_1^m}^{\infty} [q_1^{all}(p_1, p_{-1}^m, \eta, \zeta) - q_1^{1less}(p_1, p_{-1}^m, \eta, \zeta)] dp_1$ in all cases,

$$\mu^{EV} = \int S^{EV} dF(\eta, \zeta)$$
$$= \int \int_{p_1^m}^{\infty} [q_1^{all}(p_1, p_{-1}^m, \eta, \zeta) - q_1^{1less}(p_1, p_{-1}^m, \eta, \zeta)] dp_1 dF$$
$$= \int_{p_1^m}^{\infty} \int [q_1^{all}(p_1, p_{-1}^m, \eta, \zeta) - q_1^{1less}(p_1, p_{-1}^m, \eta, \zeta)] dF dp_1$$

(Tonelli's Theorem)

$$= \int_{p_1^m}^{\infty} [Q_1(p_1, p_{-1}^m, \alpha_{all}) - Q_1(p_1, p_{-1}^m, \alpha_{1less})] dp_1 \quad \checkmark$$

Example 2: Welfare Gain from Two Products Added to Search List

Example 2: Welfare Gain from Two Product Addition

For Simplicity and Space, in this example *all consumers*

- Consider $\{0, 1\}$ under α_0
- Consider $\{0, 1, 2, 3\}$ under α_{more}

Example 2: Welfare Gain from Two Product Addition

For Simplicity and Space, in this example *all consumers*

- Consider $\{0,1\}$ under α_0
- Consider $\{0,1,2,3\}$ under α_{more}

Benefit from $\alpha_0 \to \alpha_{more}$ is

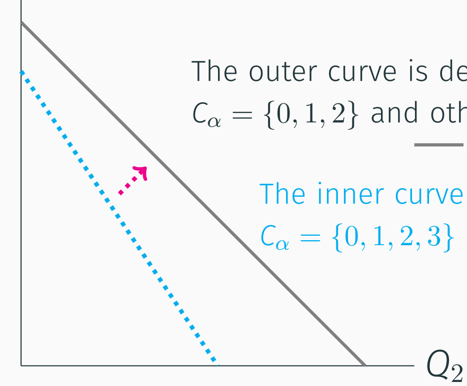
$$|\mu^W| = \lim_{p_3 \to \infty} \int_{p_2^m}^{\infty} Q_2(p,(0,p_1),\alpha_{more})dp + \int_{p_3^m}^{\infty} Q_3(p,p^m_{-3},\alpha_{more})dp$$

$$\{0,1\} \to \{0,1,2\} \qquad \{0,1,2\} \to \{0,1,2,3\}$$

- Under Quasi-linearity, benefit of $\{0,1\} \to \{0,1,2,3\}$ is
  - benefit of $\{0,1\} \to \{0,1,2\} +$
  - benefit of $\{0,1,2\} \to \{0,1,2,3\}$
- Price limit simulates removing 3 from $\{0,1,2,3\}$

Simulating Demand Under $\{0, 2\}$ with Price Limit $p_1 \to \infty$

As $p_3 \to \infty$, the demand for Good 2 with $C_\alpha = \{0, 1, 2, 3\}$ shifts upward to overlap with the demand for good 2 with $C_\alpha = \{0, 1, 2\}$

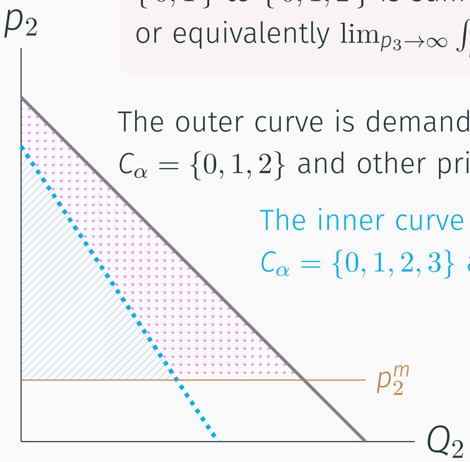


The outer curve is demand for Good 2 when $C_\alpha = \{0, 1, 2\}$ and other prices are p^m_{-2}

The inner curve is demand for Good 2 when $C_\alpha = \{0, 1, 2, 3\}$ and other prices are p^m_{-2}

Welfare Gain from $\{0, 1\} \rightarrow \{0, 1, 2\}$

The Welfare Gained from Consideration Sets Going from $\{0, 1\}$ to $\{0, 1, 2\}$ is sum of pink dots and blue stripes or equivalently $\lim_{p_3 \rightarrow \infty} \int_{p_2^m}^{\infty} Q_2(p, (0, p_1), \alpha_{more}) dp$



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Application

Data

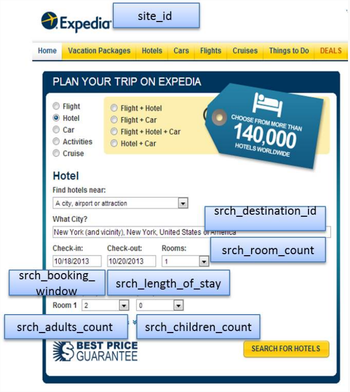
Source

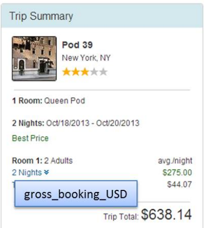
- IEEE's International Conference on Data Mining 2013 competition
- Competition for best performing LeToR algorithm
- provided by Expedia.com
- hosted on Kaggle.com

Structure

1. Search for Hotel Booking
2. One Page Search Results called "Search Impression"
3. Search Impression created with "Random" or "Proprietary" algorithm
4. Max number of results per page is 32 (before data cleaning)

Expedia Shopping GUI





Intermediate Step: Demand Estimation

1. Assume search impression is exactly consideration set
2. Assume utility has structure

$$u_{ijt} = \gamma(y - p_{jt}) + \beta' X_{jt} + \eta_{ijt}$$
$$u_{i0t} = \gamma y + \eta_{i0t}$$

   a. $\eta_{ijt} \sim^{iid}$ Standard Gumbel over i, j and t given consideration sets
   b. Assume prices and X_{jt} independent η_{ij} given consideration sets
   c. X_j contains `star_rating, brand, promotion, location_score`
3. Assume consideration sets independent of prices
4. Data Cleaning
   a. Focus on bookings in largest geographic market
   b. Remove offerings that were booked less than 50 times
   c. Remove listings with recorded price over 1500
   d. Final set: 90,553 rows; 4,698 search impressions
5. Calculations done using R (see R Core Team 2017) with help from Croissant (2019) package
6. While application leverages search impression information in demand estimation strategy, consideration set information not needed for identification results

Density of Search Impression Length

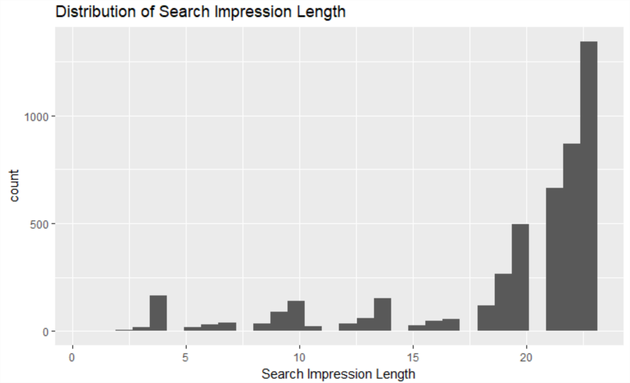


Figure 1: This figure shows the variation of search impression length over all consumers after data cleaning

Demand Estimate, for Reference

Table 1: This table includes demand parameter estimates. Standard errors are listed in parenthesis below coefficient estimates.

	Dependent variable:
	Hotel Booked
property star rating	0.513***
	(0.048)
property brand boolean	0.418***
	(0.053)
property location score 1	−0.922***
	(0.043)
price in usd	−0.010***
	(0.001)
promotion flag	0.266***
	(0.047)
Observations	4,694
Note:	*p<0.1; **p<0.05; ***p<0.01

Welfare Gain From Random to Proprietary Listing

Result:

- Average welfare improves by \$8.11 per person
- For comparison, average room price per night is \$129.29
- Bootstrap 95% confidence interval of \$6.11 to \$9.74

Sensitivity to Price

Looking at ranking response and demand response to 3 standard deviation price increase:

Product	Average Price (Standard Deviation)	Estimated Ranking Change	Estimated Demand Change
A	\$61.63 (\$36.27)	.735 positions	-65.7%
B	\$53.90 (\$33.14)	.672	-62.6%
C	\$89.55 (\$46.92)	.951	-75.4%
D	\$167.37 (\$82.55)	1.67	-91.7%
E	\$107.31 (\$52.04)	1.05	-79.2%

Recall ~ 32 item per page max. The following results suggest ranking is far less sensitive to price than demand, and therefore Price Independence approximately holds for this data.

Welfare Loss From Removing Top 5 Products: A-E

Product	Estimated Market Share	Estimated Marginal Welfare Loss	Bootstrap 95% Con. Int.
A	.0530	$5.35	[$4.75, $5.96]
B	.0454	$4.88	[$4.36,$5.39]
C	.0432	$4.92	[$4.59, $5.28]
D	.0382	$4.49	[$3.97, $5.09]
E	.0344	$4.23	[$3.86,$4.62]
Total	.214	$23.87	[$21.85, $26.06]

Conclusion

1. Identified a general formula for welfare changes under arbitrary search listing changes
2. Showed welfare changes can calculated from demand information alone
   a. it is not necessary to explicitly model the search process in the context of an exogenous listing change
3. Application to data from an Online Travel Agency (OTA) yields:
   a. Estimated average welfare loss of $8.11 going from Proprietary Ordering to Random Ordering
   b. Estimated average welfare loss of $23.87 when OTA removes the top five hotel bookings from search result lists

Appendix

Intuition for Welfare Formula under Arbitrary Listing Change

- Only 1 consumer (η, ζ):
- $J = 5$
- $3, 4 \prec 0 \prec 2 \prec 1 \prec 5$ at market prices.
- Under α_1, she considers $\{0, 1, 2, 3, 4, 5\}$

Intuition for Welfare Formula under Arbitrary Listing Change

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Then
$$\begin{aligned}
\Omega_1 = & \lim_{p_2,\ldots,p_5 \to \infty} \int_{p_1^m}^{\infty} Q_1(p, p_{-1}, \alpha_1) dp + \\
& \lim_{p_3,\ldots,p_5 \to \infty} \int_{p_2^m}^{\infty} Q_2(p, (p_1^m, p_{-(1,2)}), \alpha_1) dp \\
& + \cdots + \int_{p_5^m}^{\infty} Q_5(p, p^m_{-5}, \alpha_t) dp \\
= & \left[-p_1^m + \tilde{U}_1(\eta) - \tilde{U}_0(\eta)\right] + 0 + \cdots + 0 + [-p_5^m + \tilde{U}_5(\eta) + p_1^m - \tilde{U}_1(\eta)] \\
= & -p_5^m + \tilde{U}_5(\eta) - \tilde{U}_0(\eta)
\end{aligned}$$

Intuition for Welfare Formula under Arbitrary Listing Change

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= & -p_5^m + \tilde{U}_5(\eta) - \tilde{U}_0(\eta)
\end{aligned}
$$

If, under α_0, she considers $\{0, 2\}$, then

$$
\begin{aligned}
\Omega_0 - \Omega_1 &= [-p_2^m + \tilde{U}_2(\eta) - \tilde{U}_0(\eta)] - [-p_5^m + \tilde{U}_5(m) - \tilde{U}_0(\eta)] \\
&= \text{Change in Utility} \\
&= S^{EV} \checkmark
\end{aligned}
$$

Return to Theorem

Detailed Example of Utility Differences Not Equaling Equivalent Variation without Price Independence

When consideration sets depend on price, utility is not continuous in price! Must add $\sup$ to definition:

$$S^{EV} = \sup\{S \in \mathbb{R} : \max_{j \in \mathcal{C}(\{y - p_k - S\}_{k \in \mathcal{J}}, \eta, \zeta, A)} u_j(y - p_j - S, \eta) \geq \max_{j \in \mathcal{C}(\{y - p_k\}_{k \in \mathcal{J}}, \eta, \zeta, B)} u_j(y - p_j, \eta)\} \quad (6)$$

For simplicity,

- single consumer (y, η, ζ) in market
- two platforms, Affordable Store and Big Mart
- Two goods for sale; $\mathcal{J} = \{0, 1, 2\}$.
- Affordable Store sells good 1 on its platform and Big Mart sells good 2 on its platform
- The consumer forms her consideration set using the following rule: she considers goods exclusively from Affordable Store if good 1 is available on Affordable Store and has price no lower than \$20. Otherwise, she considers all goods on each platform.

Continuation of Detailed Example of Utility Differences not Equaling Equivalent Variation without Price Independence

The consumer's utility for each good is as follows:

$$\begin{cases} u_0(y, \eta) = y \\ u_1(y - p_1, \eta) = y - p_1 + \gamma \\ u_2(y - p_2, \eta) = y - p_2 + \gamma + \delta \end{cases}$$

where $\delta > 3$ and $\gamma > 20$.

Suppose that under listing rule A

- good 1 is available for \$22 on Affordable Mart
- good 2 is available for the same price, \$22, at Big Mart
- Thus, consideration set is $\{0, 1\}$, she purchases good 1 and her utility is $y - \$22 + \gamma$.

Suppose that under listing rule B,

- Affordable Store removes good 1 from its platform.
- Thus, the consumer expands her consideration set to include good 2 and receives utility $y - 22 + \gamma + \delta$.

Thus $S^{EV} \geq -2 > -3 > -\delta = u(\text{ rule } A) - u(\text{ rule } B)$

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