Disentangling Attention and Utility Channels in Recommendations

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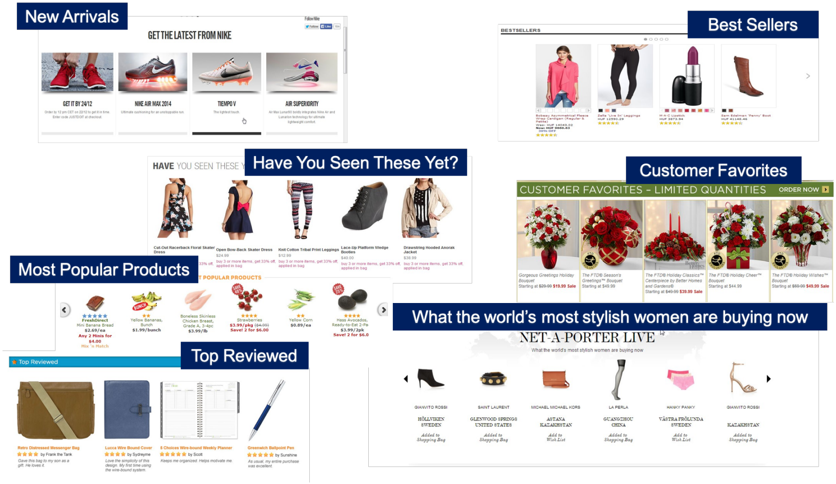
Recommendation

Online Shopping

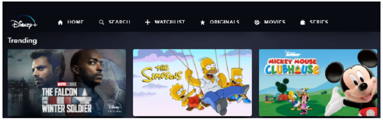


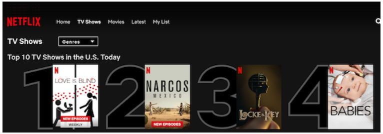
Endorsements

- “Amazon’s Choice”
- “Superhost”
- “Etsy’s picks”
- “Best Seller”
- “Editor’s pick”
- ...

Others


110


HOME
SEARCH
WATCHLIST
ORIGINALS
MOVIES
SERIES
Trending
THE FALCON AND THE WINTER SOLDIER
MICKEY MOUSE CLUBHOUSE


NETFLIX
Home
TV Shows
Movies
Latest
My List
TV Shows
Genres
Top 10 TV Shows in the U.S. Today
LOVE IS BLIND
NARCOS
MEXICO
NEW EPISODES
BABIES

Basic Observation

- Recommending a product often increases the sales of recommended products
    - Senecal and Nantel (2004): Wine/Calculators
    - Gupta and Harris (2010): Computer
    - Adomavicius et al (2018): Digital Music
    - Kawaguchi et al. (2019): Vending machine
    - Farronato et al. (2020): Home services
    - Rietveld et al. (2021): Microloans
    - Bairathi et al. (2022): Freelance
    - ...

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    - ...
- But HOW?

Two Channels

- Recommendation influences the awareness set of consumer
  - Recommendation signage: Best Seller, Award Winner (e.g. Goodman et al, 2013)
  - (electronic) Word-of-mouth (e.g. Gupta and Harris, 2010)
  - Uninformative advertising (e.g. Mayzlin and Shin, 2011)
- Recommendation affects consumer's valuation
  - Consumer's Rating (Cosley et al, 2003)
  - Willingness to Pay (Adomavicius et al, 2018)
  - Consumer's utility (Kawaguchi et al, 2021)

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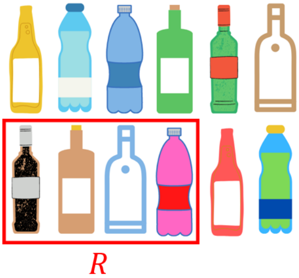
How does recommendation affect choices through attention and utility?

What we do (today)

- Two channels in one model
- Accommodating observed phenomena
- Behaviorally distinguishing channels
- Full characterization (skipped)
- Evaluating recommendation (skipped)
- Auctioning recommendation (skipped)

Decision Problem



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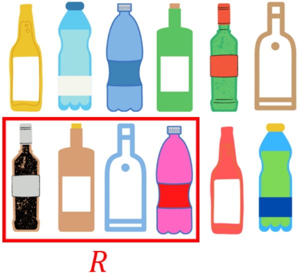
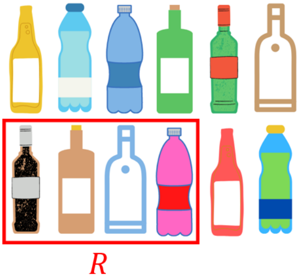


- X: Grand set of alternatives
- $S \subseteq X$: Set of available alternatives
- $R \subseteq S$: Recommended set of alternatives

Decision Problem



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- $\rho_S(x, R)$: Stochastic choice data

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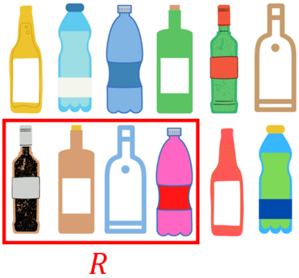


- X: Grand set of alternatives
- $S \subseteq X$: Set of available alternatives
- $R \subseteq S$: Recommended set of alternatives
- $\rho_S(x, R)$: Stochastic choice data
  - The probability that x is chosen when R is recommended in the set S
  - $\sum_{x \in S \cup \{o^*\}} \rho_S(x, R) = 1$, where o^* is a default/outside option.
- Domain of choice problem (skipped)

Parametric Recommendation Model: Primitives

- Each alternative $x \in X$ has four parameters

$$u_R(x) = \begin{cases} u'(x) & \text{if } x \in R \\ u(x) & \text{otherwise} \end{cases} \qquad \gamma_R(x) = \begin{cases} \gamma'(x) & \text{if } x \in R \\ \gamma(x) & \text{otherwise} \end{cases}$$

  - $u_R(x) \in (0, \infty)$: The utility of x given recommended set R
  - $\gamma_R(x) \in (0, 1)$: The likelihood to consider x given recommended set R

Parametric Recommendation Model: Two-stage Choice procedure

Suppose a set $R \subseteq S$ is recommended,

1. Within the choice set S, a consideration set $A \subseteq S$ emerges with probability (Manzini and Mariotti, 2014),

$$\prod_{y \in A} \gamma_R(y) \prod_{z \in S \setminus A} (1 - \gamma_R(z))$$

2. Within the consideration set A, the DM chooses an alternative x with probability (Luce 1959)

$$\frac{u_R(x)}{u_R(A)}$$

Parametric Recommendation Model

- The attention and utility parameters

$$u_R(x) = \begin{cases} u'(x) & \text{if } x \in R \\ u(x) & \text{otherwise} \end{cases} \qquad \gamma_R(x) = \begin{cases} \gamma'(x) & \text{if } x \in R \\ \gamma(x) & \text{otherwise} \end{cases}$$

Definition

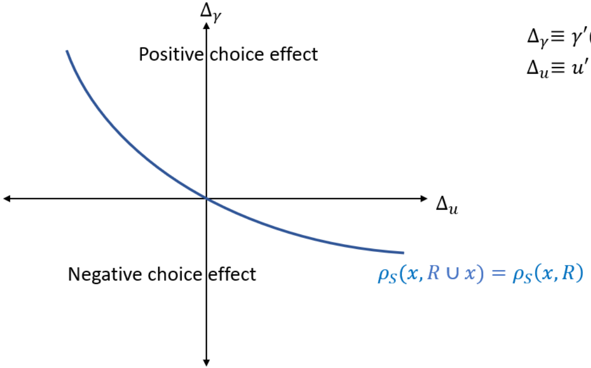
A probabilistic choice rule $\{\rho_S\}$ has a parametric recommendation representation if there exists functions $u_R : X \to \mathbb{R}_{++}$ and $\gamma_R : X \to (0,1)$ such that for $x \in X$,

$$\rho_S(x, R) = \sum_{x \in A \subseteq S} \underbrace{\left[\prod_{y \in A} \gamma_R(y) \prod_{z \in S \setminus A} (1 - \gamma_R(z)) \right]}_{\substack{\text{Prob. of } A \text{ being} \\ \text{the consideration set}}} \underbrace{\frac{u_R(x)}{u_R(A)}}_{\substack{\text{Prob. of } x \text{ being} \\ \text{chosen in } A}}$$

- Manzini and Mariotti (2014) and Luce (1959)

Accommodating Observed Behaviors

Choice Effect

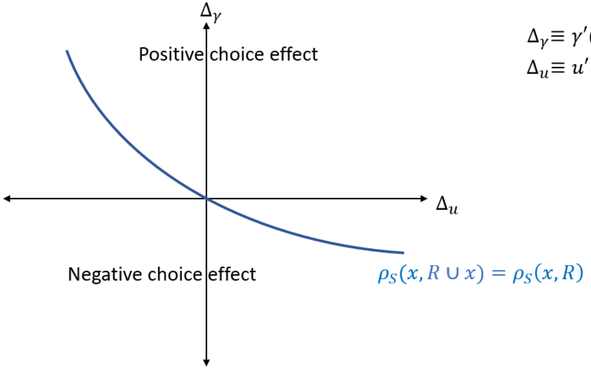


$\Delta_\gamma \equiv \gamma'(x) - \gamma(x)$

$\Delta_u \equiv u'(x) - u(x)$

The zero-choice-effect curve

Choice Effect



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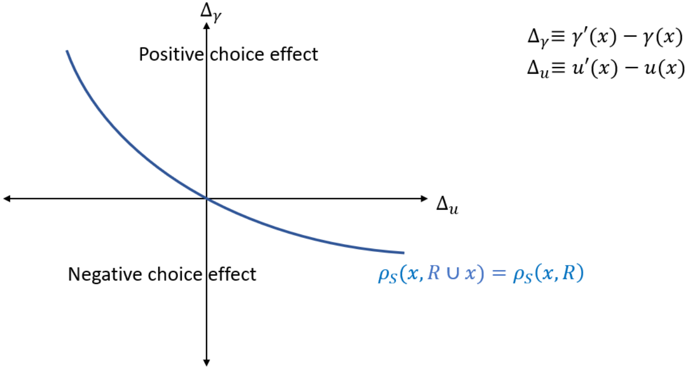
The zero-choice-effect curve

- Positive choice effect (coined by Kawaguchi et al., 2021): e.g. Goodman et al. (2013), Häubl and Trifts (2000), Rowley (2000), Senecal and Nantel (2004), and Vijayasarathy and Jones (2000, 2001)

Choice Effect



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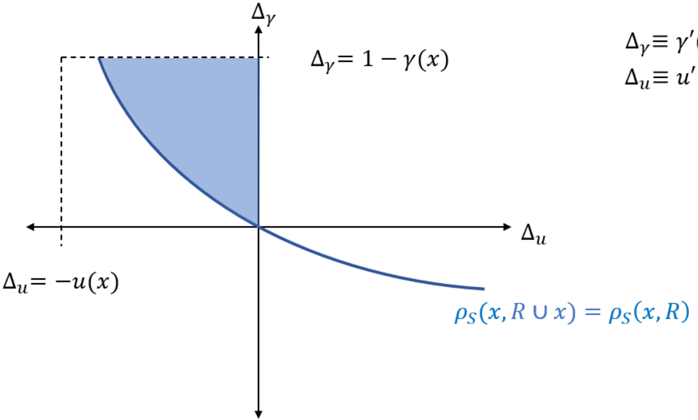
- Negative choice effect(?)

Positive Effect of Negative Publicity



$\Delta_\gamma \equiv \gamma'(x) - \gamma(x)$
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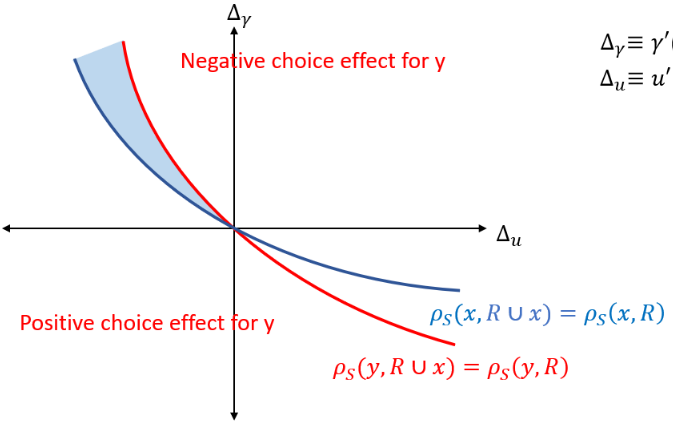
- Negative utility but positive attention effect
  - e.g. Allard et al. (2020), Berger et al. (2010), and Huang et al. (2023)

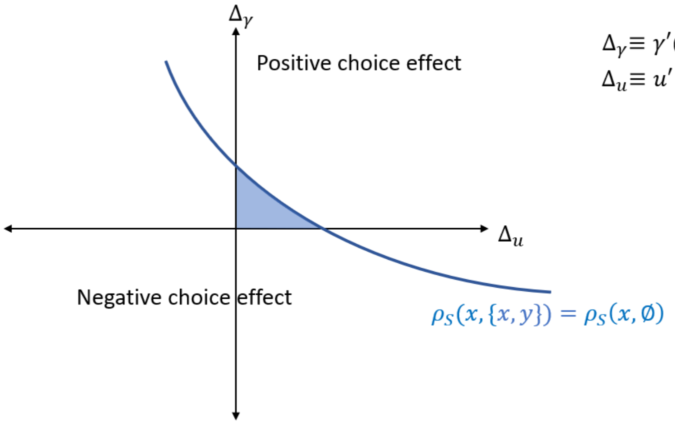
Spillover Effect



$\Delta_\gamma \equiv \gamma'(x) - \gamma(x)$
$\Delta_u \equiv u'(x) - u(x)$

- Recommending x also makes other products more likely to be chosen
  - e.g. Bairathi et al. (2022) and Kawaguchi et al. (2021)

Crowding-Out Effect



$\Delta_\gamma \equiv \gamma'(x) - \gamma(x)$
$\Delta_u \equiv u'(x) - u(x)$

- Supposing positive attention and utility effect for y
- A possible theoretical prediction

Behaviorally Distinguishing Channels

An Axiom

Increasing Recommendation Return to Size. For $x \in R \subseteq S \subseteq L$,

$$\frac{\rho_L(x, R)}{\rho_L(x, R \setminus x)} \geq \frac{\rho_S(x, R)}{\rho_S(x, R \setminus x)}$$

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Interpretations:

- Recommendation Return (Hence the name)

$$\frac{\rho_L(x, R) - \rho_L(x, R \setminus x)}{\rho_L(x, R \setminus x)} \geq \frac{\rho_S(x, R) - \rho_S(x, R \setminus x)}{\rho_S(x, R \setminus x)}$$

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Interpretations:

- Recommendation Return (Hence the name)

$$\frac{\rho_L(x,R)-\rho_L(x,R\setminus x)}{\rho_L(x,R\setminus x)} \geq \frac{\rho_S(x,R)-\rho_S(x,R\setminus x)}{\rho_S(x,R\setminus x)}$$

- Regularity Comparison

$$\frac{\rho_L(x,R)}{\rho_S(x,R)} \geq \frac{\rho_L(x,R\setminus x)}{\rho_S(x,R\setminus x)}$$

where both $\frac{\rho_L(x,R)}{\rho_S(x,R)}$ and $\frac{\rho_L(x,R\setminus x)}{\rho_S(x,R\setminus x)} \leq 1$ by *regularity*.

Positive Utility

Increasing Recommendation Return to Size. For $x \in R \subseteq S \subseteq L$,

$$\frac{\rho_L(x, R)}{\rho_L(x, R \setminus x)} \geq \frac{\rho_S(x, R)}{\rho_S(x, R \setminus x)}$$

Theorem

Let (u_R, γ_R) be a parametric recommendation representation of $\{\rho_S\}$. Then, $u'(x) \geq u(x)$ for all x if and only if $\{\rho_S\}$ satisfies **Increasing Recommendation Return to Size**.

Positive Attention

Positive Choice Effect at Singleton. For all x, $\rho_x(x, x) \geq \rho_x(x, \emptyset)$.

Theorem

Let (u_R, γ_R) be a parametric recommendation representation of $\{\rho_S\}$. Then, $\gamma'(x) \geq \gamma(x)$ for all x if and only if $\{\rho_S\}$ satisfies **Positive Choice Effect at Singleton**.

Positive Choice Effect

Within the model....

$$\Delta_\gamma \geq 0 \text{ and } \Delta_u \geq 0 \text{ imply positive choice effect}$$

Positive Choice Effect

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Not assuming the model....

Remark

For any choice probabilities $\{\rho_S\}$, **Increasing Recommendation Return to Size** and **Positive Choice Effect at Singleton** imply a positive choice effect (singleton recommendation).

Positive Choice Effect

Within the model....

$$\Delta_\gamma \geq 0 \text{ and } \Delta_u \geq 0 \text{ imply positive choice effect}$$

Not assuming the model....

Remark

For any choice probabilities $\{\rho_S\}$, **Increasing Recommendation Return to Size** and **Positive Choice Effect at Singleton** imply a positive choice effect (singleton recommendation).

- Idea:

$$\frac{\rho_L(x,x)}{\rho_L(x,\emptyset)} \geq \frac{\rho_S(x,x)}{\rho_S(x,\emptyset)} \geq .... \geq \frac{\rho_x(x,x)}{\rho_x(x,\emptyset)} \geq 1$$

$$\Rightarrow \rho_S(x,x) \geq \rho_S(x,\emptyset)$$

Identify parameters

Theorem

Suppose (u_R^1, γ_R^1) and (u_R^2, γ_R^2) are two parametric recommendation representations of the same choice probabilities, then $\gamma_R^1 = \gamma_R^2$ and $u_R^1 = \alpha u_R^2$ for some scalar $\alpha > 0$.

- Attention parameters are uniquely identified.
- Utility parameters are identified up to a positive scalar multiplication.

Wrapping up

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- Accommodating observed phenomena
- Behaviorally distinguishing channels
- Full characterization (skipped)
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Thank you for your attention!!!