Consumer Search and Choice Overload

Volker Nocke $^1$  Patrick Rey $^2$

$^1$University of Mannheim  $^2$TSE

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Motivation

- **Steering** is prevalent in online (and also present in offline) markets
  - Recommendations / rankings are a necessity because of large # of products
  - Evidence that retailers/platforms often divert search by consumers
  - Steering is increasingly scrutinized by agencies and policy-makers
    - EU: Google shopping (2017); US DOJ: Google complaint (2020 - )
    - EU: DMA and DSA; US: Congress

- Lack of (informative) recommendations can create “choice overload”
  - Can discourage consumers
  - Experimental evidence
    - Lyengar and Lepper (2000): Jam tasting booth in upscale grocery store
    - Boatwright and Nunes (2001): Experiment run by online grocery
Main Insights

- Issues
  - What drives consumers’ decisions to start / keep searching?
  - Best positioning strategy?
  - Is there choice overload?

- Findings
  - Trade-off between extensive and intensive search margins
  - Divergence of interest
    - *perfect* positioning is best for consumers
    - *garbled* positioning may be more profitable
      - ... despite apparently aligned interests
        - no self-preferencing
        - no bias in favor of specific products
        - no price discrimination motive
  - Choice and *garbling* overload
Setting

- Set $\mathcal{I}_N \equiv \{1, \ldots, N\}$ of available products
  - Each product $i$ characterized by match probability $\mu_i$ (popularity)
  - $1 > \mu_1 > \cdots > \mu_N > 0$

Supply

- Monopolist chooses
  - which products to offer ($\mathcal{I} \subseteq \mathcal{I}_N$)
  - their prices $(p_i)_{i \in \mathcal{I}}$
  - their positions (more on this later)
- Constant and identical marginal costs (normalized to zero), no fixed costs

Demand

- Unit mass of consumers, each with unit demand
- Consumers differ in
  - search cost $c$, $\sim$ c.d.f. $G(\cdot)$ over $\mathbb{R}_+$
  - match-conditional valuation $v$, $\sim$ c.d.f. $F(\cdot)$ over $\mathbb{R}_+$
- $c$ and $v$ are i.d. across consumers but the same across products
Setting

- Positioning: firm assigns (possibly randomly) products to *distinguishable slots*
  - Supermarkets: aisles, shelves, ...
  - Online platforms: recommendations, rankings, ...

- Search: consumers choose which slots to inspect and in which order
  - Having observed $c$, consumer decides whether to inspect a slot
  - If not, leaves the market
  - If yes
    - incurs $c$, observes the price and whether he has a match; if so, also learns $\nu$
    - consumer decides whether to purchase the product
      - if yes, pays the price and leaves the market
      - if not, decides whether to inspect a second slot
    - and so on
Setting

- **Timing:**
  
  **Stage 1** Firm chooses size $n$ of product line (publicly observed)
  
  **Stage 2** Firm privately chooses $I$ (s.t. $|I| = n$), positions and prices; consumers sequentially decide which slots to inspect (if any)

- For this presentation: role of *positioning* (downplay role of prices)
  
  - Focus on monopoly pricing equilibria (*PBE with passive beliefs*)
    
    $$p^m \equiv \arg \max_p p[1 - F(p)]$$
    
    $$\pi^m \equiv p^m[1 - F(p^m)] \text{ (profit conditional on match)}$$
    
    $$s^m \equiv \int_{p^m}^{\infty} [v - p^m]dF(v) \text{ (exp. CS conditional on match)}$$
  
  - Unique pure-strategy equilibrium features monopoly pricing intuition: no profitable price discrimination
  
  - [Alternative: free services (zero lower bound)]
Consider pure-strategy continuation equilibria, given the assortment size $n$

**Proposition (perfect positioning)**

For any $n \in \mathcal{I}_N$, there exists a unique pure-strategy continuation equilibrium:

- **the firm offers the most popular products ($\mathcal{I} = \mathcal{I}_n$) at the monopoly price $p^m$**
- **consumers follow a myopic search pattern**
  - inspect products by decreasing order of popularity
  - those with $c \leq \mu_k s^m$ inspect up to $k$ products until finding a match

Intuition: the interests of consumers and of the firm are *aligned*

- If the firm positions the more popular products in the first slots, 
  ... consumers with search cost $c \leq \mu_k s^m$ inspect only the first $k$ slots
- The firm thus has an incentive to position the popular products in first slots
Perfect Positioning

- Overall game also has a unique pure-strategy equilibrium
  The firm offers *all* available products

- Perfect information: resulting search pattern is efficient
  Conditional on monopoly pricing, consumer surplus is maximal

- Yet, can be profitable to *garble* the information provided to consumers
  - Discourages participation (*extensive* search margin)
  - But encourages active consumers to keep searching (*intensive* search margin)
No Positioning

- Suppose that the firm uniformly randomizes over its positioning strategy.

Let \( \alpha_k \) denote the probability of a match on \( k^{th} \) inspection, conditional on having had *no match* on previous inspections.

**Lemma (increasing optimism)**
- \( \alpha_k \) is strictly increasing in \( k \)
- Active consumers keep searching until finding a match

Intuition: when an inspection does not yield a match, the consumer assigns a higher probability to the inspected product being one of the less popular ones.

- It follows that the optimal search rule is *not* myopic.

**Remark (search addiction)**
*Some consumers who do not want to start searching may choose to keep searching if coerced to do a first search, the result of which turns out to be unsuccessful.*
No Positioning

The marginal consumer is $c_n^N \equiv M_n s^m / \Gamma_n$, where $M_n$ is the probability of a match and $\Gamma_n$ is the expected number of inspections.

Proposition (no positioning)

For any $n > 1$, there exist no positioning continuation equilibria:

- the firm offers the $n$ most popular products
- consumers with search cost below $c_n^N$ inspect slots until finding a match

Intuition

- If consumers keep searching until finding a match, the firm is:
  - indifferent about its positioning strategy
  - willing to randomize uniformly

- In the absence of positioning, consumers
  - are indifferent about their search sequences
  - any (random or deterministic) search sequence can be sustained in equilibrium
  - in particular, consumers can uniformly randomize or follow a given sequence
Impact of an increase in the assortment size $n$ (if no positioning for any $n$)?

**Corollary (choice overload)**

Absent positioning, expanding the product line reduces consumer participation

$c_n^N$ is strictly decreasing in $n$

- Consumers who are barely willing to search are harmed
- Consumers with sufficiently low search costs however benefit from more choice
No Positioning vs. Perfect Positioning

- Perfect and no positioning are two (polar) forms of *steering*
  - Active consumers all inspect the slots in the same order
    some may however stop earlier than others
  - Perfect positioning: active consumers strictly prefer doing so
    - *extensive search*: maximizes participation
    - some *do* stop earlier than others
  - No positioning: active consumers are indifferent but willing to do so
    - *intensive search*: they all keep searching until finding a match
    - however, fewer start searching

- From now on: focus on steering equilibria
  - Characterize their general structure
  - Characterize worst and best equilibria
Steering Equilibria

Lemma (block structure)

For any $n$ and any steering continuation equilibrium, there exists

$$\mathcal{N} = \{n_1, \ldots, n_{|\mathcal{N}|} = n\} \text{ and } \hat{c} = (\hat{c}_1, \ldots, \hat{c}_{|\mathcal{N}|})$$

such that $\hat{c}_k > \hat{c}_{k+1}$ and:

- The firm assigns products from $\mathcal{B}_k^{\mathcal{N}} \equiv \{n_{k-1} + 1, \ldots, n_k\}$ to slots in $\mathcal{B}_k^{\mathcal{N}}$ and does so randomly whenever $|\mathcal{B}_k^{\mathcal{N}}| > 1$

  \[
  \begin{align*}
  &1, \ldots, n_1, n_1 + 1, \ldots, n_2, \ldots, n_{|\mathcal{N}|-1} + 1, \ldots, n \\
  &\mathcal{B}_1 \quad \mathcal{B}_2 \quad \cdots \quad \mathcal{B}_{|\mathcal{N}|}
  \end{align*}
  \]

- Active consumers inspect the slots in increasing order those with $c \leq \hat{c}_k$ inspect up to $n_k$ slots until finding a match

Intuition

- If some consumers stop early, then any product allocated to a later block must be less popular than any product allocated to an earlier block
- Within blocks: intensive search $\rightarrow$ requires garbled positioning
- Between blocks: some consumers drop out even if they had no match
Intensive Search

- The firm’s profit is given by:

\[
\Pi (\mathcal{N}, \hat{c}) \equiv \sum_{k=1}^{|\mathcal{N}|} \Pi_{\mathcal{I}}^I (\mathcal{N}, \hat{c}_k)
\]

where, using \( \lambda_i \equiv 1 - \mu_i \), \( \Lambda (\mathcal{I}) \equiv \prod_{i \in \mathcal{I}} \lambda_i \) and \( M (\mathcal{I}) \equiv 1 - \Lambda (\mathcal{I}) \):

\[
\Pi_{\mathcal{I}}^I (\mathcal{N}, \hat{c}_k) \equiv \Lambda (\mathcal{I}_{n_{k-1}}) \ G (\hat{c}_k) \ M (B_k^\mathcal{N}) \ \pi^m
\]

- Additive separability
  - given \( \mathcal{N} \), profit only depends on \( \hat{c} \)
  - \( c_k \) (participation) depends only on (garbled) positioning used in block \( B_k^\mathcal{N} \)

- We can thus focus on intensive search within individual blocks
Worst Intensive Search

Lemma (worst intensive search)

Among the equilibria with intensive search over \( \mathcal{B} \) (s.t. \( |\mathcal{B}| > 1 \)), the no positioning equilibrium minimizes firm’s profit as well as consumer surplus

Intuition

- If no positioning, consumers are willing to randomize uniformly over their search sequences \( and \) keep searching until finding a match
- Conversely, if consumers do so, their expected surplus is independent of the firm’s positioning strategy
- Hence, consumers can always secure the payoff obtained under no positioning
- Any directed intensive search equilibrium gives them higher expected surplus
- Hence, more consumers participate, which also increases the firm’s profit
Best Intensive Search

- For a given block $B$, what is the best intensive search equilibrium?

- Difficult problem
  - $|B|!$ possible slot assignments $\rightarrow |B|! - 1$ positioning probabilities
  - active consumers must keep searching until finding a match
  - they must prefer the targeted search sequence to any other

\[ \rightarrow \text{no less than } \sum_{k=1}^{|B|} \frac{|B|!}{(|B|-k)!} - 1 \quad (> > |B|! - 1) \text{ incentive constraints} \]

- In general, the optimal search sequence is moreover hard to characterize
  depending on the positioning strategy, finding no match in one slot may make
  the consumer more or less optimistic about finding a match at the next slot
Best Intensive Search

Yet, the best intensive search equilibria exhibit a rather simple structure

- **Problem**
  - Encouraging participation: position popular products in first slots
  - Inducing intensive search: position popular products in last slots

- **Solution:**
  - Assign popular products with “just” enough probability to induce marginal consumers to keep searching
  - Achieves the same profit as if the block were holding a single product with (geometric) average no-match probability $\bar{\lambda}(B) \equiv \frac{|B|}{\prod_{i \in B} \lambda_i}$

**Proposition (best intensive search equilibrium)**

Among the equilibria with intensive search over $B$, those maximizing the firm’s profit as well as consumer surplus induce consumers with search cost $c \leq \hat{c}(B) \equiv [1 - \bar{\lambda}(B)] s^m$ to participate.
Most Profitable Block Structure

- Consider “merging” two successive blocks $B_1$ and $B_2$ into $B \equiv B_1 \cup B_2$

\[
1, \ldots, n_1, n_1 + 1, \ldots, n_2 \rightarrow 1, \ldots, n_1, n_1 + 1, \ldots, n_2
\]

Corollary (garbling overload)

For any adjacent blocks $B_1$ and $B_2$: $\hat{c}(B_1) > \hat{c}(B)$

- Merger creates a trade-off between extensive and intensive search margins

\[
\hat{c}(B_2) \quad \hat{c}(B) \quad \hat{c}(B_1)
\]

\[\underline{\text{search cost } c}\]

\[\underline{\begin{aligned} & \text{keep searching} \\ & \text{drop out} \end{aligned}}\]

- cost of discouraging participation

\[
[G(\hat{c}(B_1)) - G(\hat{c}(B))] M(B_1) (> 0)
\]

- benefit of inducing active consumers to keep searching until finding a match

\[
[G(\hat{c}(B)) - G(\hat{c}(B_2))] \Lambda(B_1) M(B_2)
\]
Most Profitable Block Structure

- Drivers?
  - popularity of the various products
  - distribution of consumers’ search costs

- Fix the distribution of search costs
  The following proposition shows that combining two blocks can be desirable only when their products are neither too different nor too similar:

**Proposition (directed search: product popularity)**

Combining $B_1$ and $B_2$ is not profitable if:

(i) $\bar{\lambda}(B_1)$ is close to 0 or $\bar{\lambda}(B_2)$ is close to 1

(ii) $\bar{\lambda}(B_2)$ and $\bar{\lambda}(B_1)$ are close to each other

Sketch of the proof
Most Profitable Block Structure

- Fix the distribution of search costs
- Suppose the search cost distribution has a constant hazard rate $\gamma > 0$

$$G(c) = 1 - \exp(-\gamma c)$$

Proposition (directed search: cost distribution)

$$\exists \hat{\gamma}(B_1, B_2) \text{ s.t. combining } B_1 \text{ and } B_2 \text{ is profitable if and only if } \gamma > \hat{\gamma}(B_1, B_2)$$

- Intuition: $\uparrow \gamma \rightarrow \uparrow$ relative importance of intensive over extensive margin

$$\hat{c}(B_2) \quad \hat{c}(B) \quad \hat{c}(B_1)$$

- keep searching
- drop out

- search cost $c$

Proceeding by induction, the most profitable equilibrium involves

- complete garbling for $\gamma$ sufficiently large
- perfect positioning for $\gamma$ sufficiently small
Extensions

- Disclosure
- Aggregate uncertainty
- Platforms
- From sales to clicks
Conclusion

- Garbling incentives
  - The firm can have an incentive to “garble” its positioning strategy
  - Even with interests apparently aligned with consumers'
    - per sale rather than per click → favour more popular products
    - same expected profit per sale
    - so price discrimination motive
    - no self-preferencing
  - More likely if
    - products are neither too popular nor too unpopular
    - products are not too similar either
    - distribution of search cost has high hazard rate
Conclusion

- Choice overload under directed search
  - From *choice overload* to *garbling overload*
    - expanding the range of garbled positioning
    - discourages participation
    - fosters search intensity
  - Choice overload can still be present (always the case under random search)
    - consider adding product 3 to block $B = \{1, 2\}$
      - if leads to $\{1, 2, 3\}$: choice overload
        - reduces participation
        - intensifies search
      - if leads instead to $\{1\}, \{2, 3\}$: boosts participation
Related Literature

- **Sequential search (Wolinsky *QJE* 1986)**
  - multiproduct firms
    - within-firm sequential search
      - Hagiu & Jullien (*RAND* 2011): controlled search, per click
      - Petriškaitė (*RAND* 2018): obfuscation
    - here: exogenous search costs, induced search, per sale, no price discrimination
  - platforms
    - positioning auctions: Chen & He (*EJ* 2011), Athey & Ellison (*QJE* 2011)
    - here: positioning by the platform

- **Choice overload and contextual inference**
  - Kamenica (*AER* 2008)
  - Villas-Boas (*MS* 2009), Kuksov & Villas-Boas (*MS* 2010), Ke, Shen & Villas-Boas (*MS* 2016)
  - here: directed search, garbling overload
Best Intensive Search: Sketch of the Proof

- Let $\beta_k$ be the probability of no match with the first $k$ slots, for $k \in I_{|B|-1}$
  - inspecting up to $k$ slots yields a match with probability $1 - \beta_k$
  - the expected number of inspections is $\hat{\Gamma}(\beta) \equiv 1 + \beta_1 + \cdots + \beta_{k-1}$
  - the value can therefore be expressed as (with the convention $\beta_0 = 1$):
    \[
    V_k(c) = (1 - \beta_k) v - \left( \sum_{i=1}^{k} \beta_{i-1} \right) c
    \]
  - the marginal consumer, $\hat{c}$, is such that $V_{|B|}(\hat{c}) = 0$
  - he is willing to inspect all slots if, for $k \in I_{|B|-1}$, $V_{|B|}(\hat{c}) \geq V_k(\hat{c})$, or:
    \[
    [\beta_k - \Lambda(B)] s^m \geq \left( \sum_{i=k}^{|B|-1} \beta_i \right) \hat{c} \quad (IC_k)
    \]

- Consider the following relaxed problem
  - choose $\beta = (\beta_0, \beta_1, \ldots, \beta_{|B|})$ so as to minimize $\hat{\Gamma}(\beta)$
  - subject to $\beta_0 = 1$, $\beta_{|B|} = \Lambda(B)$, and $(IC_k)_{k \in I_{|B|}}$
Best Intensive Search: Sketch of the Proof

**Lemma (lower bound on expected number of searches)**

The expected number of searches in block $B$ cannot be lower than

$$\Gamma (B) \equiv \frac{1 - \Lambda (B)}{1 - \lambda (B)}$$

Furthermore, this lower bound can be achieved only if, for $k \in \mathcal{I}_{|B|}$:

$$\beta_k = \beta^l_k (B) \equiv (\bar{\lambda} (B))^k$$

- Maximizing participation amounts to minimizing expected number of searches
  - requires minimizing no-match probabilities
  - incentive constraints ($IC_k$) are all binding
- The marginal consumer
  - is kept indifferent between inspecting another slot or not
  - is such that

$$\hat{c} = \frac{1 - \beta^l_{|B|} (B)}{\Gamma (B)} s^m = \frac{1 - \Lambda (B)}{\Gamma (B)} s^m = [1 - \bar{\lambda} (B)] s^m = \hat{c} (B)$$
Best Intensive Search: Sketch of the Proof

Lemma (implementation)

If the firm adopts the positioning strategy $\hat{\rho}(B)$ then, for every $k \in \mathcal{I}_{|B|}$:

- $\beta_k = (\bar{\lambda}(B))^k$
- inspecting the first $k$ slots maximizes the match probability of $k$ inspections

It follows that

- active consumers inspect slots by decreasing order of popularity
- consumers with $\hat{c}(B)$ are willing to participate
Product Popularity: Sketch of the Proof

- If $B_2$ offers highly unpopular products (i.e., $\bar{\lambda}(B_2) \sim 1$):
  - the benefit of inducing active consumers to inspect these products is negligible
  - the cost of reduced participation is instead non-negligible

- Likewise, if $B_1$ offers highly popular products (i.e., $\bar{\lambda}(B_1) \sim 1$):
  - almost all active consumers obtain a match in $B_1$
  - the benefit of inducing the few unlucky ones to keep searching is thus again negligible compared to the cost of reduced participation
Interestingly, combining the blocks is not profitable either
... when they offer similar products (i.e., \( \bar{\lambda}(B_1) \sim \bar{\lambda}(B_2) \))

- the participation thresholds are also similar: \( \hat{c}(B_1) \sim \hat{c}(B) \sim \hat{c}(B_2) \)

- the cost and benefit of combining the two blocks are both small

- however, the per-consumer cost of reduced participation is given by the probability of having a match in the first block

- the per-consumer benefit of intensive search is instead given by the probability of having a match only in the second block

- for blocks of equal size, the latter is smaller and the participation thresholds are not only similar but moreover evenly spaced:

- the argument extends to unequal sizes