

Product Line Design with Frictions

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Motivating picture

The screenshot shows the Amazon website interface. At the top, the Amazon logo is on the left, and navigation links like 'Hello, sign in', 'Account & Lists', 'Returns & Orders', and 'Cart' are on the right. A search bar in the center contains the word 'computer'. Below the search bar, a navigation bar lists various categories: All, Amazon Haul, Medical Care, Amazon Basics, Best Sellers, Books, Registry, Today's Deals, New Releases, Gift Cards, Smart Home, Groceries, Prime, Pharmacy, Customer Service, Music, Amazon Home, and Fashion. Below this, a message states '1-16 of over 100,000 results for "computer"', and a 'Sort by: Featured' dropdown is on the right.

Popular Shopping Ideas

- Desk
- 32-inch Monitor
- Gaming
- Windows
- See more

Eligible for Free Shipping

- ☐ Free Shipping by Amazon
- Get FREE Shipping on eligible orders shipped by Amazon

Delivery Day

- ☐ Get it by Tomorrow

Price

\$0 - \$12,900+

Up to \$100
\$100 to \$200
\$200 & above

Deals & Discounts

- All Discounts

Results

Check each product page for other buying options.

Dell Optiplex 3060 Desktop Computer | Intel i5-8500 (3.2) | 32GB DDR4 RAM | 1TB SSD Solid State | Built in WiFi | Bluetooth | Windows 11 Professional | Home or Office PC (Renewed)

Options: 3 sizes

4.3 ★★★★★ (1K)
1K+ bought in past month

\$373⁹⁹

FREE delivery Thu, Jan 8
Only 16 left in stock - order soon.

See options

More Buying Choices
\$343.00 (11 new offers)

Processor Type	Disk Size	RAM	Processor Speed
Core i5-8500	1 TB	32 GB	3.20 GHz

Overall Pick

HP Rose Gold Ultrabook Laptop with Microsoft Office 365, Intel 2-Core CPU, 1.1TB Storage (1TB OneDrive and 64GB SSD), 8GB RAM, Windows 11, No Mouse

4.4 ★★★★★ (288)
8K+ bought in past month

Ends in 17:08:11

\$265⁶⁷ List: \$349.99

FREE delivery Tomorrow, Jan 6

Add to cart

Display Size	Disk Size	RAM	Operating System
14 inches	64 GB	8 GB	Win 11 Home 5 Mode

Motivation

- Current marketplaces characterized by having many products available
e.g. searching for computer on Amazon: over 100,000 results!
- Impossible for consumers to consider all those options
(even if many of them irrelevant or redundant)
- Seller's profits are impacted by this behavior
⇒ it could influence her product mix decisions

Question:

How does limited consideration impact product line design decisions?

Preview: Model

Mixes random search and price discrimination

- From **Mussa & Rosen (1978)** import **screening & price discrimination**
- From **Burdett & Judd (1983)** import **random simultaneous search**

Key ingredients:

- A monopolist producing a vertically differentiated good,
- Free to choose number of products to offer and their characteristics
- Heterogeneous consumers
- Operating in a within-firm simultaneous search environment

Preview: Results

- Optimal product line is **unbalanced**:
 - ⇒ some products are made more likely to enter consumers' consideration sets than others
- Product quality may increase or decrease relative to full-consideration
- “Premium” items get no quality distortions, while “non-premium” do

Related Literature

- **Screening + Search:** Garrett et al. (2018), Lester et al. (2019), Fabra & Montero (2022), Nocke & Rey (2023)
⇒ **This paper: within-firm search by a monopolist with endogenous products**
- **Limited/partial consideration:** Ursu et al (2021), Safonov (2022), Fershtman & Pavan (2022)
⇒ **This paper: focuses on the seller's problem**
- **Revenue maximization with limited information:** Dhangwatnotai et al (2015), Hart & Nisan (2017, 2019), Babaioff et al (2018), Daskalakis & Zampetakis (2020), Fu et al. (2021), Bergemann et al (2021)
⇒ **This paper: consumers using samples rather than seller**

Model

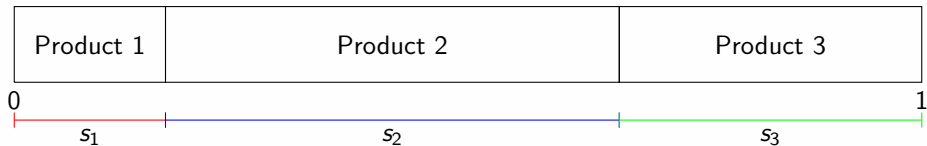
A monopolist and a unit-measure of consumers in a vertically differentiated market

- Monopolist produces good of quality $q \in [0, \overline{Q}]$
- Cost of producing a good of quality q is $\varphi(q)$, increasing and convex
- The monopolist designs a finite **product line** over a unit-measure of slots:
 - A product $i = (q_i, p_i, s_i)$:
 - q_i - quality of product i
 - p_i - price of product i
 - s_i - fraction of slots allocated to product i
 - Slots allocated to product i determine how often product i enters consumers' consideration sets

Model: slots

■ Interpretation of slots:

- Shelf space for offline stores
- Product placement on a website
- Allocation of a fixed advertising budget across different products

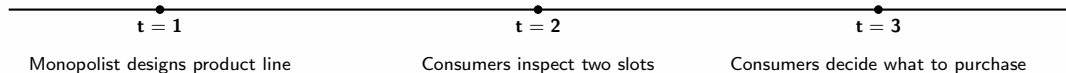


Model: consumers

- Consumers have single-unit demands
- Private valuations
 - Fraction $\mu_\ell > 0$ has low valuation θ_ℓ
 - Fraction $\mu_h = 1 - \mu_\ell$ has high valuation $\theta_h > \theta_\ell$
- Utility from product i : $\theta q_i - p_i$
- **Limited consideration:**
 - Consumers do not observe the full menu
 - Each consumer inspects **two randomly drawn slots**
 - Can choose only among these products (or walk away)

Model: timing

- ① Monopolist designs her product line
- ② Consumers learn their valuation and inspect 2 slots at random
- ③ Consumers choose the best inspected product or walk away



Model: consideration sets

- Frictions lead to the formation of consideration sets
- Slot allocation determines the probability of different consideration sets
- These sets could contain either
 - two different products i and j with probability $2s_i s_j$
 - only one product i with probability $(s_i)^2$
- Random inspection capture attention or processing capacity limitations

Some Remarks

- **No targeting:** same product line for both types of consumers
- **No tracking:** product line is fixed, no conditioning on observed products
- **No uncertainty on the value of a product:** once inspected, real value is learned
- **Fixed search intensity:** sample size is exogenous and fixed

Two Benchmarks

① Full-information product line:

- Maximize surplus for each type and charge their exact valuation

$$q_i^* : \varphi'(q) = \theta_i \quad p_i = \theta_i \cdot q_i^*$$

② Optimal product line under asymmetric information (and full-consideration)

$$q_\ell : \varphi'(q_\ell) = \theta_\ell - \frac{\mu_h}{\mu_l}(\theta_h - \theta_\ell) \quad q_h = q_h^*$$

$$p_\ell = \theta_\ell q_\ell \quad p_h = \theta_h q_h^* - (\theta_h - \theta_\ell) q_\ell$$

- Classic no-distortion at the top, high types having informational rents, and low quality distorted
- Any distribution of slots in which each product receives a positive fraction is equivalent in this case

■ In both cases, matching between products and types is perfect

Limited Consideration: what changes?

- Under search frictions, matching between consumers and products is imperfect
- Therefore, the classic tradeoff behind quality distortions also changes
- Seller has an additional lever to adjust her product line: the allocation of slots or “salience” for each product

Main result

Theorem 1

The optimal product line is unbalanced: the fraction of slots used across products cannot be the same.

- Some products are made more salient than others.
- Salience and distortions reinforce each other, which alter the characteristics of the product line

Main result: intuition

- Consider two products: A and B
- Let V_M be the profits of a menu M under full-consideration
- Suppose $V_{AB} > V_A \geq V_B$

Main result: intuition

- Start from a menu containing only product A
 \Rightarrow profits V_A
- Adding a small fraction of B creates:

Gain: $V_A \rightarrow V_{AB}$

Loss: $V_A \rightarrow V_B$

- If $V_A = V_B$: no loss in including B , better to maximize probability of $\{A, B\}$
 \Rightarrow balanced menu is optimal
- If $V_A > V_B$: optimal menu must balance cost and benefits of including B
 \Rightarrow optimal menu is biased towards A

Main result: intuition

- If products were fixed analysis ends there
- Flexibility allows to adjust the own characteristics of products A and B
- Bias toward A increases incentives to reduce distortions (either in price or quality) in A (and increasing distortions in B)
- With more than two products, a similar argument follows

Also in the paper

- Some intermediate results
 - Products always come in pairs: premium and standard versions
 - No distortion at the top: premium items all have quality $q = q_h^*$
 - Low quality distortions: non-premium items have quality $q < q_\ell^*$
- Optimal product line if consumers inspect a single slot
- Challenge: no revelation principle

Concluding Remarks

- I proposed a model of price discrimination under information and search frictions
- Search frictions **change** the optimal product line
- Optimal menus are always **unbalanced**: firms bias salience toward more profitable products
- Salience becomes an extra tool for the monopolist alongside price and quality

Thanks!



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