

Product Line Design with Frictions

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Motivating picture 1

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\$265⁶⁷ List: \$349.99

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Motivating picture 2 (powered by ChatGPT)

The image shows a YouTube video player interface. The video is an advertisement for Velocity Motors, featuring four car categories: Sedans, SUVs, Sports Cars, and Electric cars. The background of the ad is a collage of scenic landscapes. The video player includes a search bar, a play button, a progress bar, and a 'Skip Ad' button. Below the video, there is a recommendation for 'Top 5 Scenic Drives You Need to See' by the channel 'Wanderlust'.

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Theoretical motivation

- Studying a product line design problem when consumers fail to recognize all available alternatives
- For achieving this, I propose a simple consideration set formation model based on a standard random simultaneous search model
- Then embed this model into a classic monopolistic screening setting

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

❶ Seller offers an unbalanced menu

Some products are more likely to enter consumers' consideration sets than others

❷ Optimal menu contains only two products (in our setting with two valuation levels)

One targeted to high valuation consumers, the other to all consumers

Related Literature

- **Screening + Search:** Garrett et al. (2018), Lester et al. (2019), Fabra & Montero (2022), Hämäläinen (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: limited information in consumers' side rather than seller's**

Model: consumers

- Unit-mass of consumers
- Each one with single-unit demands
- Private valuations
 - Fraction $\mu_\ell > 0$ has low valuation $\theta_\ell > 0$
 - Fraction $\mu_h = 1 - \mu_\ell$ has high valuation $\theta_h > \theta_\ell$
- Utility from product with quality q and price p :

$$u = \theta q - p$$

- Forms considerations sets based on seller's product line configuration
- Purchases product with highest utility given her valuation and consideration set

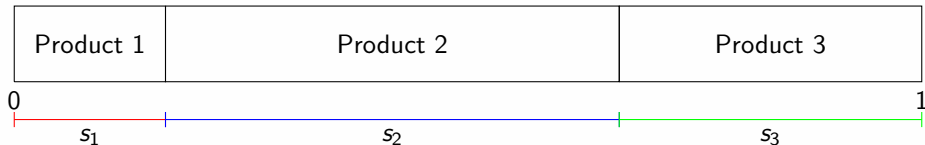
Model: monopolist

- Produces good of quality $q \in [0, \overline{Q}]$ with costs $\varphi(q)$, s. increasing and convex
- Designs a finite **product line** or menu over a unit-measure of slots:
 - A product is a tuple $i = (q_i, p_i, s_i)$:
 - q_i - quality of product i
 - p_i - price of product i
 - s_i - slots allocated to product i

Model: slots

Slots could be interpreted as

- Shelf space for offline stores
- Product placement on a website
- Fixed advertising budget allocation across products
- Time allocation to different products in ads



- Ultimately, slots distribution determine how likely is for a product to enter consumers' consideration sets

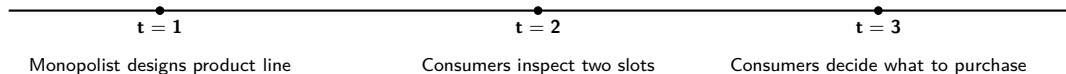
Model: consideration sets

A consumer consideration set is formed as follows:

- Given a menu, consumer inspects two slots at random
- Slots allocated to each product determine how likely is for that product to enter the consumer's consideration set in each draw
- Therefore, this set could be formed by:
 - two different products i and j with probability $2s_i s_j$
 - only one product i with probability $(s_i)^2$

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



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
- **No learning:** consumers know their valuations and don't learn about the product line
- **Fixed search intensity:** sample size is exogenous and fixed

Two Benchmarks

- ① Full-information product line (neither information nor search frictions) provides:
 - Surplus-maximizing quality levels: q_ℓ^* and q_h^*
 - “Full-extraction” prices: $\theta_\ell q_\ell^*$ and $\theta_h q_h^*$
 - ② Optimal product line under asymmetric information only (no search frictions) instead:
 - Distorts quality only for low valuation consumers: $q_\ell < q_\ell^*$ and $q_h = q_h^*$
 - Charges $p_\ell = \theta_\ell q_\ell$ and $p_h \leq \theta_h^* q_h^*$
 - Classic no-distortion at the top, high types having informational rents, and low quality distorted
- In both cases, matching between products and types is perfect

What changes under Limited Consideration?

- Under search frictions, matching between consumers and products is imperfect
- Therefore, the classic tradeoff behind quality distortions also changes
- Seller has additional lever to adjust her product line: allocation of slots or “salience” for each product
- However, seller is always (weakly) worse off compared to the case without search frictions

No revelation principle + additional assumptions

No revelation principle:

- “Types” in this setting have two dimensions
 - ① Valuations
 - ② Consideration sets
- But consideration sets are endogenous to the menu configuration

Additional assumptions:

- No overprovision of quality:

$$\overline{Q} = q_h^*$$

- Selling only to low types is better than selling only to high types:

$$\theta_\ell q_\ell^* - \varphi(q_\ell^*) > \mu_h(\theta_h q_h^* - \varphi(q_h^*))$$

Equilibrium Characterization

- ① For products accepted only by high valuation consumers:

$$q = q_h^*$$

- ② For products accepted by all consumers:

$$q \leq q_\ell^*$$

+ low valuation consumers get zero utility

⇒ classic no distortion at the top and low quality distortions

- ③ Products could be ordered in terms of the utility for high valuation consumers
- ④ Local IC binds and products always offered in pairs (low quality-high quality pairs)

Balanced and unbalanced menus

Definition: a menu is **balanced** if the slots allocated to each product are the same. Otherwise, the menu is **unbalanced**.

- In balanced menus, all products are equally likely to enter consumers' consideration sets
- In unbalanced menus, at least one product must be more likely to be considered than others

Proposition 1

The optimal product line is unbalanced.

Why unbalanced menus are optimal?

Intuition is as follows:

- Start from a menu containing only one product A
- Adding a small fraction of a (particular) product B creates:

Gain: only $A \rightarrow$ screening

Loss: only $A \rightarrow$ only B

- If both equally profitable: no loss in including B , better to maximize prob. of screening
 $\Rightarrow$ balanced menu is optimal
- If A is more profitable: optimal menu must balance cost and benefits of including B
 $\Rightarrow$ optimal menu is biased towards A
- If products were fixed analysis ends here

Why unbalanced menus are optimal?

- Bias toward A increases incentives to reduce distortions (either in price or quality) in A (and increasing distortions in B)
- Therefore, product characteristics are also adjusted
- With more than two products, a similar argument follows

Characterization of the optimal menu

Proposition 2

The optimal menu contains only two products.

- *Premium* version purchased only by high valuation consumers, and
- *Standard* version purchased by both types of consumers

Intuition:

- having more than two products lead to mismatch
- better mixing between smaller menus
- better to use only one of them

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

Pending: application to alternative environments (e.g., taxation and social benefits design, labor contracts)

Summary

Screening + limited consideration:

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

Proposition 1

Optimal product line is **unbalanced**: some products more likely to enter consumers' consideration sets than others

Proposition 2

Optimal product line contains only **two products**: only one premium and one non-premium

Thanks!



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