Uncharted Waters: Selling a New Product Robustly

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Motivation

Rapid technological development has brought more and more new products to us

In selling a new product, often the seller not only sets a price but also provides some information

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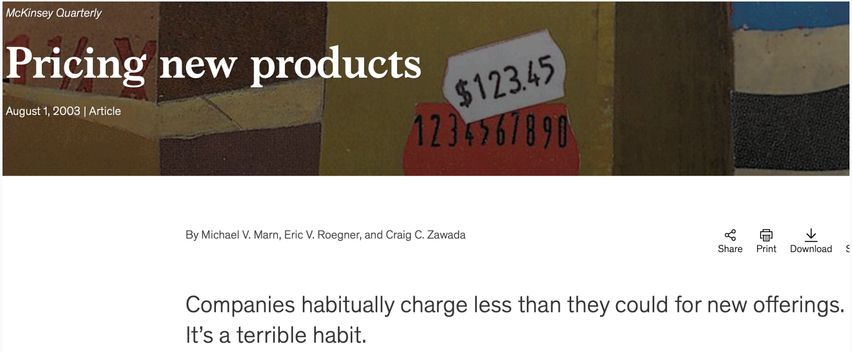
1. Is there a rationale for “charging less than they could” for sellers who set both the price and the information provision policy?



McKinsey Quarterly

Pricing new products

August 1, 2003 | Article

By Michael V. Marn, Eric V. Roegner, and Craig C. Zawada

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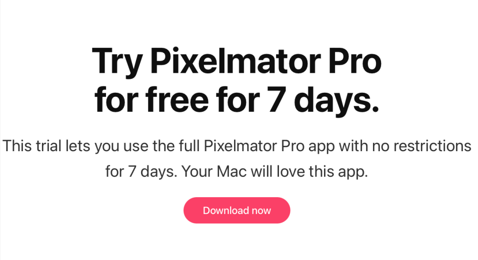
Companies habitually charge less than they could for new offerings. It’s a terrible habit.

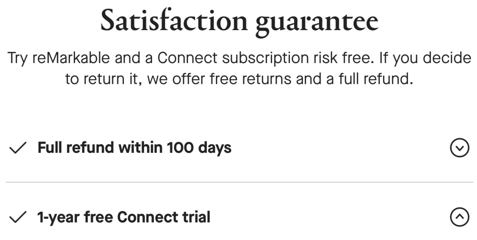
Motivation

In selling a new product, often the seller not only sets a price but also provides some information

2. Why do we see a lot of variations in information provision policies among new products?



(a) Innovative image editing app "Pixelmator"



(b) e-ink tablet "reMarkable"

This Paper

What would a seller of a new product do if she can design both the price and information? Literature

- Key features of the model:
  - after seeing the price and information, a buyer can costly search for an alternative product
  - the seller has limited information regarding the buyer's knowledge of her alternatives
  - seeking robustness, the seller evaluates any selling strategy by its worst case profit
- Main tradeoff: search deterrence versus surplus extraction
- Takeaways:
  - optimal to provide full information when search cost is high, otherwise partial information
  - price is nonmonotone in the search cost, info provision is more precise as search cost increases
- Implications:
  - rationale for the large variations in information provision policies among new products
  - technologies that lower search cost may increase price and make information provision noisier
  - a lower price may be used, pairing with info provision, to ensure effective search deterrence

Outline

- Model (formally)
- Main result (very informally)
- Implications (if time permits)
- Comparative statics

The Model

Model

- (Risk neutral) Buyer's match value with the product is $x \in \{0, 1\}$, with prior $\mu = \mathbb{P}(x = 1)$
- Seller knows μ, and her production cost is normalized to zero
- Seller sets a price p and provides information using a signal
  - upon observing a signal realization, Buyer updates her beliefs and forms posterior exp. value w
  - hence, by providing information, Seller affects Buyer's posterior value distribution H
  - in fact, we can allow Seller to directly choose posterior value distribution H so long as $\mathbb{E}_H[w] = \mu$
  - Seller's strategy can be summarized by (p, H)
- Seeing price and information, Buyer's net payoff from buying is $w - p$
- Buyer can draw an outside option v from a distribution G on $[0, 1]$ at cost $s \geq 0$; $s < \xi := \mathbb{E}_G[v]$
- Buyer knows G, but Seller does not: she only knows that G is on $[0, 1]$ and its mean is ξ
- Free recall: Buyer can return to buy at Seller costlessly
  - the price does not change when Buyer comes back (anonymity)

Robust Optimization

To deal with the uncertainty, Seller takes a robust/maxmin approach

- maximizes the minimal profit across all outside option distributions on $[0, 1]$ with mean ξ
- she chooses price p and information provision policy H to maximize her payoff as if there is an adversarial nature who observes (p, H), then chooses G on $[0, 1]$ with mean ξ to minimize Seller's payoff

Timeline

Timeline:

- Seller chooses a price p and an information provision policy H
- Nature chooses outside option distribution G
- Buyer observes p, draws a posterior expected value w from H, and she also observes G
    - buys immediately if the net payoff from Seller's product, $w - p$, is large enough
    - otherwise pays search cost s, draws an outside option with value v from G
    - if searches, will go back to Seller when $w - p > v$

Main Results

Using Information Provision to Deter Search

- Recall: providing information $\iff$ designing Buyer's posterior value distribution
- Seller can deter search by "pooling mass" at the posterior value at which Buyer is exactly indifferent between searching or not
- Whenever this posterior value realizes, the Buyer buys without search

Examples

- Deterring search make Buyer more likely to buy without search and increases Seller's demand
- For Buyer to forgo search, sufficiently high surplus must be provided $\implies$ Require a lower price in some cases

Robustly Optimal Selling Strategy

Proposition

- For small s, it is optimal to provide partial information and not deter search.
- For large s, it is optimal to provide full information (which "fully" deters search).
- For intermediate s, when ξ is relatively small compared to μ, it is optimal to provide partial information and deter search.

Robustly Optimal Selling Strategy: Intuition

Small s: partial information + no deterrence is optimal

- deterrence policy unprofitable: has to be accomplished by using a very low price
- Seller does not deter search $\Longrightarrow$ extract more surplus by charging a much higher price
- provide partial information in a way that "hedges against" Nature

Large s: full information (deterrence) is optimal, optimal price $p_r = s/\xi$

- as s gets large, no need to concede too much surplus in deterring the buyer's search
- deterring search would also increase her demand
- providing full information identifies those who highly value the innovative feature of the product and make sure they buy without search

Intermediate s: a "convex combination" between the previous two can be optimal (partial information + deterrence) when ξ is relatively small compared to μ

Implications

New Products

Three kinds of new products:

- evolutionary products: existing products made slightly better

  example: smart thermostat

- revolutionary products: a completely new concept

  example: 3D-printer

- alternatives to existing products: revolutionary on some aspects at the cost of losing some existing features

  example: portable speaker

Search cost measures how difficult it is for a buyer to find the best alternative

Implications

Evolutionary products: low s

$\implies$ providing partial information is optimal

(recall the image editor “Pixelmator”)

Alternatives to existing products: high s

$\implies$ divide potential consumers into “lovers” and “haters”, and serve the former only

(recall e-ink tablet “reMarkable”)

Revolutionary products: μ sufficiently high compared to ξ

$\implies$ create some “die-hard fans”, and the rest of the potential consumers get noisy signals

(think about some Apple products and Tesla)

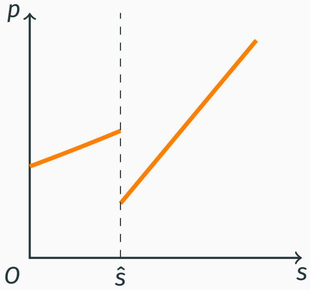
Comparative Statics

Comparative Statics

Proposition

(i) The price is non-monotone in the search cost s.

(ii) The info provision policy generically becomes more informative as the search cost increases.



Implications:

- Techno. advancements may help lowering the search cost

  $\Longrightarrow$ but for new products, the price may increase and information provision can be noisier

- Charging a lower price, paired with info provision, can help Seller to effectively deter search

Summary

Summary

I characterize the robustly optimal way of selling a new product when the seller

- sets a price and chooses how much information to provide about the product
- faces uncertainty over the buyer's alternatives and seeks robustness to it

The seller trades off between search deterrence and surplus extraction

- full information optimal when search cost is high, otherwise different kinds of partial information provision policies can be optimal
- the price is non-monotone in the search cost
- information provision is likely to become more precise as search cost increases

Concrete implications for the sale of (different kinds of) new products

- decreased search cost $\Longrightarrow$ price may increase, information provision can be come noisier
- the results shed light on the variety of price-info combinations we observe across new products

Thank you!

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Backup Slides

Related Literature

Selling a new product with information provision: Boleslavsky et al. (2017), Feinmesser et al. (2021)

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On a higher level, this paper lies at the intersection of two strands of literature:

- Robust pricing: e.g., Carrasco et al. (2018), Du (2018), Hinnosaur and Kawai (2020)
- Pricing with info provision and consumer search: Anderson and Renault (2006), Wang (2017), Lyu (2021)

Search deterrence tactics:

- Price-based tools: Armstrong and Zhou (2016)
- Search obfuscation: e.g., Bar-Issac et al. (2010), Ellison and Wolitzky (2012)

Also related to information design under non-probabilistic uncertainty:

- Dworczak and Pavan (2022), Hu and Weng (2021), Kosterina (2022), Sapiro-Gheiler (2021)

The optimal information provision policy features similarities to robust contracting (e.g., Carroll and Meng, 2016) and information design contests (e.g., Boleslavsky and Cotton, 2015, 2018; Au and Whitmeyer, 2023)

Information as Experiment

Model

Seller provides information by an experiment (S, χ)

- a signal σ realizes according to $\chi(x)$ when the match value is $x \in \{0, 1\}$
- Buyer updates using Bayes rule, and gets a posterior $\mathbb{P}(x = 1 \mid \sigma)$
- the law of iterated expectation requires $\mathbb{E}\left[\mathbb{P}(x = 1 \mid \sigma)\right] = \mathbb{P}(x = 1) = \mu$
- "merging" all signals that leads to the same posterior w: $\mathbb{E}_H[w] = \mu$
- conversely, for any given H with $\mathbb{E}_H[w] = \mu$, let $S = \text{supp}(H)$ and

$$p_1(\sigma) = h(\sigma)\sigma/\mu, \quad \text{and} \quad p_0(\sigma) = h(\sigma)(1 - \sigma)/(1 - \mu),$$

for all $\sigma \in S$, where p_x and h are the "generalized pdf" of $\chi(x)$ and H, respectively

Seller's Objective

- There exists $a \in [\xi - s, 1 - s/\xi]$ that depends on both G and s such that Buyer buys without search whenever $w - p \geq a$; call a the stopping threshold
- If instead $w - p < a$, Buyer investigates the o.o., and returns to buy from Seller if $w - p > v$
- Hence, Buyer buys from Seller when $w - p \geq \min\{a, v\}$, or $w \geq p + \min\{a, v\}$
    - Prob. of eventual purchase when price is p and outside option is v is $1 - H(p + \min\{a, v\})$
- Seller's revenue for a fixed distribution over outside options G is

$$p\,\mathbb{E}_G[1 - H(p + \min\{a, v\})]$$

- Seller solves

$$\max_{(p,H)} \min_G \, p\,\mathbb{E}_G[1 - H(p + \min\{a, v\})]$$

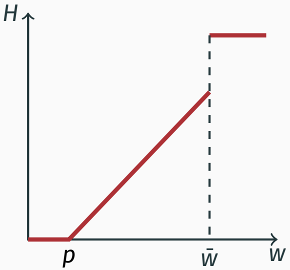
Two Key Properties

1. Linearity of H hedges well against Nature
   - the demand that Seller faces when H is linear is constant in G:
   $$\mathbb{E}_G[1 - H(p + \min\{a, v\})] = 1 - H\left(p + \mathbb{E}_G[\min\{a, v\}]\right) = 1 - H(p + \xi - s)$$
   - guarantees that there is no choice of G that Nature can take significant advantage of

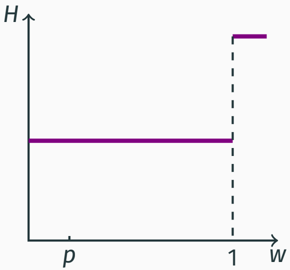
2. Mass point in H to deter search? Only possible when $p \leq s/\xi$
   - if Seller knows G and hence a, mass point at $w = p + a \leq 1$ can deter search b/c $w - p = a$
   - but here, for a mass point w, Nature may choose G s.t. $a = w - p + \varepsilon$ to offset
   - a mass point at w is resistant to this only when $w \geq p + \underbrace{1 - s/\xi}_{\text{largest } a}$
   - such a mass point is only possible if $p + 1 - s/\xi \leq 1$, or $p \leq s/\xi$

$\Rightarrow$ Highlights the trade-off between demand and surplus extraction Back

Using Information Provision to Deter Search



(a) Deterring search by "pooling mass"



(b) Full information

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