Product Lines, Product Design, and Limited Attention

(joint work with Carsten Dahremöller)

Markus Fels

SABE Workshop 2012

Approach

Basic Assumption: Decision-makers simplify complex decisions by focusing on a limited number of relevant aspects. The way *how* a decision-maker simplifies is a function of the set of alternatives.

Idea: By strategically designing products and product lines a firm may influence what aspects customers focus on when making their choice.

Main Result: A monopolist can strategically design products to attract attention to more profitable attributes and distract from less profitable (or undesirable) ones. He may employ premium *bait* goods to increase willingness-to-pay for the primary good sold to the customer.

Possible Applications: Exploitation of context effects (compromise effect) by firms; use of nontargeted advertising

A Model of Limited Attention

- DM makes his choice based on decision utility of each alternative

$$\tilde{u}(a) = \sum_{i=1}^{n} m_i v_i x_i^a \tag{1}$$

$m_i \in [0, 1]$: attention parameter associated with attribute i

Attention

- What do we mean with *(in-)attention*?
- We do **not** model perceptional mistakes/biases (Bordalo 2010, Bordalo et al. 2010, 2012).
- We do **not** model a problem of strategic attention allocation/ information refusal (e.g. strategic ignorance: Carillo Mariotti 1999).
- We assume a particular way in which the customer's attention is allocated. We defend this assumption with reference to empirical observations and analytical reasoning.

Attention Hierarchy

There is a hierarchy among attributes w.r.t. the attention they receive. Let $r : I \longrightarrow \{1, .., n\}$ be the function that assigns each attribute its attention rank such that

$$\mu_i > \mu_{i'} \Rightarrow r(i) < r(i')$$
$$\mu_i = \mu_{i'} \text{ and } v_i > v_{i'} \Rightarrow r(i) < r(i')$$

where

$$\mu_i = v_i \left(\max_{a \in A} x_i^a - \min_{a \in A} x_i^a \right).$$

Attention

The attention paid to attribute i is given by

$$m_i = \max\left\{0, 1 - \kappa_{r(i)}/\mu_i\right\} \tag{2}$$

- attribute i is only taken into account if μ_i exceeds the threshold $\kappa_{r(i)}$ associated with its rank

Assumptions.
(i) $\kappa_1 = 0$,
(ii) $\kappa_r < \kappa_{r+1} \ \forall r \in \{1, ..., n-1\}$.

Discussion: Attention

How is attention allocated?
The attention allocation shall reflect the need to simplify a complex problem before it can be solved. The attention allocation has the following properties.

- The level of attention m_i an attribute receives rises with its value to the decision-maker v_i. (Gabaix, 2011, Kőszegi and Szeidl, 2011)
- The level of attention m_i an attribute receives increases the more the alternatives differ in that attribute. (Hossain and Morgan, 2006, Chetty, Looney, and Kroft, 2009, Gabaix, 2011, Kőszegi and Szeidl, 2011)
- The more attributes the DM takes into account, the more difficult it is to consider additional attributes.

Discussion: Attention Process

The attention process described features

- an *attention hierarchy* (Fasolo, McClelland, Todd, 2007)
- *neglect* (Gabaix, Laibson, 2006, Fasolo, McClelland, Todd, 2007, Gabaix 2011)
- both *attention attraction* and *distraction* (Bordalo, 2010)
- *no complete neglect* (⇒ no strictly dominated choices)
- *always over- and underweighting* of dimensions (⇒ limited attention has behavioral implications)

Discussion: Attention Process

- the critical variable for the attention allocation is μ_i
- supposed to measure utility dispersion within a dimension
- yet: a lot of different specifications possible (mean distance, variance, etc.)
- reasons for our choice (range): explicit results, unique results (optimal design), straightforward interpretation of κ and certain results
- BUT: some results quantitatively (!) different for other specifications: optimal level of product qualities relative to full attention-benchmark

Single Product

A product may be equipped with n qualities at some nonnegative level $x_i \geq 0, i = 1..n$. Together with the price, a product may thus feature up to $n + 1$ attributes.

Main Results:

- tendency towards simple products: the optimal product design generally features less than n qualities at positive levels
- if, under the optimal design, the product features only a single quality: price is not fully considered
- however, monopolist is not able to exploit this inattention
- despite the tendency toward simplicity; the level of qualities a product features may be the same as under full attention
- reason: two competing effects on the incentives to invest: (1) inattention (-), (2) endogeneity of attention (+)

Designing a Bait Good

- due to limited attention the monopolist cannot extract the full value the qualities create to the customer
- idea: increase the attention paid to the product's qualities by additionally designing a premium product which features high attribute values
- charge a sufficiently high price to make this premium product unattractive to purchase

Designing a Bait Good

How to optimally manipulate customers' attention?

- trade off:
  1. incentive to attract most attention to most profitable qualities
  2. yet, assigning some attribute a high attention rank may inhibit the extent to which attention can be attracted to all lower-ranking attributes
  3. possible conflict with the incentive to maximize attention to all qualities (by exploiting technological frontiers)

Summary of Results

- develop a model of limited attention that features neglect, attention attraction, and distraction
- firms offer simple products when customer's attention is limited
- firms may employ bait goods to increase WTP via a compromise effect
- design of a bait good will weigh advantages of attracting attention to one quality against disadvantages of distracting from another

Questions/Concerns

- Distinction: Is it necessary/desirable/possible to distinguish between context effects due to perceptional/cognitive limitations (welfare and policy implications, empirical testability)?
- Interaction: How does the simplification method described (pruning of dimensions/attributes) interact with other simplification methods (pruning of alternatives, e.g. elimination-by-aspects)?
- Relevance: Are there decision problems complex enough to necessitate simplification for deliberation, yet not that complex as to induce heuristic/short-cut decision-making?

Thank you for your attention!

Contact: s3mafels@uni-bonn.de

Additional Slides: Single Product

- *n* possible qualities $x_i \in \mathbb{R}^+$; together with the price a product features $n+1$ attributes
- let x_p denote the final wealth, and normalize initial wealth to zero: $x_p \in \mathbb{R}^-$.
- define a *null good* as an alternative with $x_i = 0; \ \forall i = 1, ..., n$
- the monopolist seeks to maximize profits subject to the customer's willingness to buy the product (alternative *a*)

$$\max \Pi \text{ subject to } \tilde{u}(a) \geq 0$$

Additional Slides: Single Quality Product

- costs of producing quality i: $\frac{1}{2}c_i x_i^2$
- suppose the product can only be equipped with a single quality
- under optimal design: price ranks 2nd in the attention hierarchy
- design and price similar to full attention

$$x_i^* = \frac{1}{c_i}\frac{v_i}{v_p}, \qquad P^* = \frac{1}{c_i}\frac{v_i^2}{v_p^2}, \qquad \Pi^* = \frac{1}{2}\frac{1}{c_i}\frac{v_i^2}{v_p^2}$$

but still, $\tilde{u}(a) > 0$

- define the *profitability* of attribute i as

$$\pi_i = \frac{1}{2}\frac{1}{c_i}\frac{v_i^2}{v_p^2}$$

Optimal Design of Single Product

- denote by $\pi^{(t)}$ the profitability of the t-th most profitable attribute

Proposition 1: Optimal Design of a Single Product

If a monopolist intends to supply a single good to the market and the attribute choice is continuous with costs $c(x_i) = \frac{1}{2}c_i x_i^2$ the optimal design will feature
(i) only the most profitable quality ($i : \pi_i = \pi^{(1)}$) if and only if
$\nexists\ m \in \{2, ..., n\} : \sum_{t=2}^{m} \left(\pi^{(t)} - \frac{1}{v_p}\kappa_{t+1}\right) \geq \frac{1}{v_p}\kappa_2$.
(ii) Otherwise, it will feature the m most profitable qualities for which
$\sum_{t=1}^{m} \left(\pi^{(t)} - \frac{1}{v_p}\kappa_{t+1}\right) \geq 0$, while $\pi^{(m+1)} - \frac{1}{v_p}\kappa_{m+2} < 0$.
All qualities $i \in \mathcal{I}$ that the product features are produced at a level $x_i = v_i/(v_p c_i)$.
If the optimal good features only one characteristic, the price must rank second in salience, and is thus not fully considered. If the optimal good features several characteristics, the price ranks first in salience.

Designing a Bait Good

- in addition to before, assume technological limits for each attribute: $x_i \in [0, \bar{x}_i] \ \forall i = 1, ..., n$
- let $\mathcal{I}$ denote the set of qualities the monopolist's primary product (the one intended for sale) features

Proposition 2: Bait Goods Increase Profits

Suppose a monopolist's profit-maximizing design of a single product features at least two qualities: $|\mathcal{I}| \geq 2$. If at least one of these qualities is not produced at the highest technologically feasible level, the monopolist can increase profits by using a bait good.

- a monopolist employing a bait good exploits a *compromise effect*

Designing a Bait Good: Profitability Matters

Example: Optimal bait good does not necessarily maximize attention

- assume $v_p = 1$, suppose there are two qualities, $i = 1, 2$, with $v_1 = 6, v_2 = 5$ and $c_1 = 2, c_2 = 1$
- higher-valued quality is the less profitable one ($\pi_1 = 9, \pi_2 = 12.5$)
- let $\bar{x}_1 = \bar{x}_2 = 10$
- the monopolist would maximize attention paid to the attributes by setting $x_1^b = \bar{x}_1, x_2^b = \bar{x}_2$, this yields a profit of $\Pi \approx 19.75$ from the sale of the primary good
- if the monopolist would lower x_1^b to 8 the profit from the primary good would be $\Pi \approx 19.9$
- reason: more attention is attracted to the more profitable attribute

Designing a Bait Good: Technology Matters

Example: Optimal bait good does not necessarily make the most profitable quality most salient

- suppose $v_p = 1, v_1 = 6, v_2 = 5,\ c_1 = c_2 = 1$
- quality 1 more profitable than quality 2 ($\pi_1 = 18, \pi_2 = 12.5$)
- now suppose $\bar{x}_1 = 10, \bar{x}_2 = 100$
- optimal to set $x_1^b = \bar{x}_1 = 10$, now if quality 2 shall not exceed quality 1 in salience x_2^b may not exceed the value $v_1\bar{x}_1/v_2 = 12$
- with such a bait godd the maximal attainable profit from the primary good is $\Pi \approx 28.686$
- in contrast setting $x_1^b = 10, x_2^b = 100$ yields a profit of $\Pi \approx 28.695$
- reason: assigning a quality some attention rank puts an upper bound on the attention that may be attracted to lower-ranking qualities

Product Design with a Bait Good

- primary good may feature more qualities when accompanied by a bait good
- yet, the qualities it features w/o a bait good it features to a lower extent when offered together with a bait

$$x_i^* = \frac{v_i}{v_p c_i} \left(1 - \frac{\kappa_{r(i)}}{v_i x_i^b} \right)$$

Discussion

- costless bait goods
  - $\longrightarrow$ possible remedy: allow for heterogeneity in value of money v_p (rich vs. poor): the product for the rich may serve as a bait good for the poor
- negative "qualities"
  - $\longrightarrow$ firms may distract from undesirable features of their products
- oligopoly
  - $\longrightarrow$ firms may overproduce a quality for which they have a competitive advantage: development of "unique selling positions"