Boundedly Rational Consumers

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**Background**

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- Firms’ successes and failures depend on demand, and their explanations must ultimately lie in consumers’ behaviour.
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- Firms’ successes and failures depend on demand, and their explanations must ultimately lie in consumers’ behaviour.
- Empirical evidence shows that demand is heavily affected by market conditions, and firms actively engage in (trying to) shape their own demand.
- Theoretical requirements: explanation of changing market conditions are necessary to explain the evolution of markets, and depend on consumers’ behaviour.
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- Design of a model of consumers' behaviour: simple, flexible and "realistic".
- Test the model under different assumptions on supply and demand.
Assumption 1: Heterogeneous product/service

We define the products on the market as defined in terms of their evaluation in respect of $m$ dimensions $X_i$, each representing one of many “qualities” relevant to buyers. Each product is then represented by a vector of values:

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**Table:** Products’ quality values
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We also assume that consumers are identical in terms of income, technical abilities, possibility of access, or any other other aspect not explicitly considered within the model.
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We assume that consumers may make errors in observing the values of their product. These errors are unpredictable, and evenly distributed in the probability of over- or under-estimating a product. Instead of the true $v^i_X$'s, consumers observe random draws from a normally distributed random function centered on the real value:

$$v_X^* = \text{Norm}(v^i_X, \Delta),$$

where $\Delta$ is the measure of the (inverse) experience of consumers in evaluating products.
Observed values’ distribution function
As we will see the model is based on the direct comparison of two product in respect of one single characteristic, $v_i^x$ and $v_j^x$. We need to be able to assert whether $i$ is superior, inferior or equivalent to $j$ in respect of characteristic $x$. 
Tolerance to errors and approximations

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Two products are defined as equivalent in respect of a characteristic if their difference is below a certain threshold:

\[
v_i^{*x} \approx v_j^{*x} \iff \frac{|v_i^{*x} - v_j^{*x}|}{V_{Max}^{*x}} < \tau
\]
Assumption 2: Bounded rational consumers

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- TTB is shown to replicate very closely both weaknesses and strengths of people actual decisions in everyday choices;
- TTB came out as good at least as good in competing at artificial problems with far more sophisticated (and complex) decisional algorithms.
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TTB reminds an operationalized version of lexicographic preferences:

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As an example, consider a product category defined over three dimensions: price, robustness and design. A consumer may choose firstly to ignore all products appearing as not robust. Among these he may choose the cheapest and, among the few remaining ones, eventually select the best looking one.
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Though extremely simple, the TTB is very flexible and easily extendible. Moreover, it applies to any kind of variable, requiring only the capacity to identify a product as equivalent to the best on a certain dimension, or as dominated.
Assumption 3: defining preferences

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It is common to refer to “preferences” as the explanation of a given consumer’s choice. However, preferences are not the very choice, but the criteria guiding the decisional procedure, which eventually produced the choice. For example, you may have two consumers with different preferences (criteria) choosing the same product, but for different reasons.
Assumption 3: defining preferences

We can therefore define preferences in a precise way:

*Preferences are the relative order of the product characteristics, for descending importance, as used in decisional processes*

Market research companies routinely collect and exploit this information.
Assumption 4: origin of preferences

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Besides obvious effects (e.g. let consumers know that product X exist), we can assume that firms point to modify the criteria used by consumers in order to favour their own product against competitors.
Assumption 4: origin of preferences

We assume that firms attempt to modify the relative order of importance of the product characteristic. In the model we can then define the desired preferences’ profile by each firm, in terms of weights for each characteristic:

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where $k_X^i$ is the importance of characteristic $i$ that firm $X$ would like consumers to have.
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Besides cultural, income, and other factors, we can exploit the strong evidence that consumers’ tend to follow a “herd” behaviour, replicating what they see from their peers. However, consumers cannot observe directly preferences, but the resulting choices.
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In the model we represent the origin of preferences assuming that each consumer, when entering the market, decides his/her preferences by weighting the messages from firms with the observed market shares on the market.
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In the model we represent the origin of preferences assuming that each consumer, when entering the market, decides his/her preferences by weighting the messages from firms with the observed market shares on the market. Technically, the model builds for the consumer the following indicator:

\[ p_i = \sum_{j=1}^{n} (k_i^j s_j)^\delta \]

where \( s_j \) represent the market shares of supplier \( j \), \( k_i^j \) is the marketing level of firm \( j \) in respect of characteristic \( i \), \( n \) is the number of firms, and \( \delta \) is a coefficient flattening or steepening the indicators.
Assumption 4: origin of preferences

The indicators (normalized) are then used as probabilities to extract the first (the most relevant) characteristic, topping the consumer’s preferences, and then all others are drawn in the same way.
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As a result, a characteristic strongly supported by the best-selling firm is likely to come out at the top of consumers’ preferences, while characteristics considered not relevant will fall in the end of the consumers’ decisional process.
Summary of assumptions

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1. Heterogeneous products/services, defined over multiple and diverse characteristics.
2. Consumers’ errors and approximations.
4. Definition and some source of preferences.
The model is able to generate aggregate demand respecting the basic tenets of standard economics, only extended to multiple dimensions. For example, the following figure shows sales for the whole market and for a firm for different levels of the represented firm’s qualities, assuming the product space made of 2 characteristics.
Overall market dynamics
However, static demand functions are theoretical concepts, while in reality we can observe choices of people through time. The model can then be best explored assuming a market for a novel product, and assessing how different conditions can generate different market structures.

We build a model assuming that consumers enter the market according to a s-shaped dynamics. The dynamics is represented with a contagion diffusion dynamics where each consumer introduces a decreasing number of new consumers’ to the market.
Overall market dynamics
Consumers’ learning

We assume that consumers’ *learn* through time, making large mistakes at the beginning and then being increasingly able to assess the true products’ qualities. This is represented by decreasing the parameter $\Delta$ determining the width of the probability function.
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In effect we turn the parameter into a variable $\Delta_{age}$ for each consumer where we set the initial level $\Delta_0$ representing the newbies’ error and the final limit $\Delta_\infty$ as the error constantly made by even expert consumers.
Single consumers’ learning
Exercises

We can now observe and interpret the results produced by different configurations of the model. We will show the number of consumers adopting one among ten products. In the different exercises we will modify the following aspects:

- Products’ values and marketing strategies $v_i^x$’s and $k_i^x$’s;
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- Products’ values and marketing strategies $v_i^X$’s and $k_i^X$’s;
- Learning limits $\Delta_\infty$;
- Tolerance levels $\tau$;
- Relevance of peer’s pressure in preferences formation $\delta$.
Simple monopoly

As initial test let’s consider the supply side composed by all identical products, except one which is superior to competitors in all respects.
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We assume that consumers’ have no tolerance \( \tau = 0 \) and can, with age, perfectly read the true products’ values \( \Delta_{\infty} = 0 \).
Monopoly
Monopoly with errors

Suppose that consumers maintain the possibility to make (small) errors in evaluating products even when they are expert, $\Delta_\infty > 0$. In this case the dominating product keeps the market leadership, but small shares of consumers keep on erroneously choosing dominated products.
Monopoly with errors
Monopoly with tolerance

In this last case on monopoly we introduce the “tolerance”. In respect of the previous exercises we assume that consumer consider as inferior only products whose values is less than $\tau\%$ that of the maximum. We set the value such that the dominant product enjoyes an advantage that, in effect, is not perceived as relevant by consumers.
Monopoly with tolerance
Monopoly with tolerance

The reason lies in the probability distribution of the errors of consumers. When the consumers reach the stage where $\Delta_{age} = 0$ they obviously realise that the advantage of the dominant firm is negligible. However, before that stage, the possibility of errors actually favours the dominant firm, since consumers have a large chance to mis-interpret the gap as larger than the actual one.
Monopoly with tolerance
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Let’s consider now a set of suppliers as “specialized” producers. Each of the 10 competitor enjoys an advantage in respect of one of 10 characteristics of the products, and pursue, accordingly, a marketing strategy promoting that characteristic. Consumers have no tolerance ($\tau = 0$) and perfectly learn to evaluate products ($\Delta_\infty = 0$). We compare the effect of a higher and lower $\delta$, governing the concentration or diffusion of the probabilities when forming the preferences.
Segmentation and concentration

Low $\delta$

High $\delta$
“Perfect” oligopoly

Let’s now consider a large number of firms, initialized with random values of qualities and market strategies. We make a first test assuming consumers with no tolerance and perfect learning ($\tau = 0$ and $\Delta_{\infty} = 0$).
“Perfect” oligopoly
“Noisy” oligopoly

In the same setting we now prevent consumers to reach perfect evaluation, setting $\Delta_\infty > 0$ until period 400, and then we abruptly set $\Delta_\infty = 0$. 
“Noisy” oligopoly
“Chaotic” oligopoly

In this last exercise we set perfect learning, $\Delta_{\infty} = 0$, but introduce a small tolerance, $\tau > 0$, meaning that consumers consider equivalent products on characteristics differing by small values.
“Chaotic” oligopoly
Demand matters

The two complex market configurations are similar in terms of distributional terms: concentration, stability, etc. However, the ranking of firms is very different: firms succeeding in one market have only mediocre performance in the other.

This difference shows that demand matters, and evaluating only on the basis of supply-side features fails to catch crucial aspects. The following graph reports the sales of firms in the two markets.
Comparison
Conclusions

We presented a model for consumers providing a clear distinction between decision making procedure, preferences and actual choices produced.
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Each configuration is rooted in motivations concerning features of the demand side that are potentially observable.
Conclusions

In particular, we identified the following types of market segmentation:

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1. Error-based segmentation. Consumers willing to choose the best in respect of one characteristic actually distribute across a range of firms. However, all users of a given product have the same objective.

2. Complex segmentation. Consumers aim at a several, ordered, goals, generating complex market structures. Users of the same products have different reasons for their choices.
Conclusions

The research may be extended in several directions:

- The basic TTB used can be extended to include a pre-filtering of products removing those not affordable by consumers, or however not fitting a set of minimal requirements.
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- The model may be systematically studied assuming heterogeneous classes of consumers, and extended to include a dynamic supply side.

- Relevant parameters of the model are observable, so that the model may be used for applied purposes.