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Markets for Heterogeneous Products: a Boundedly Rational Consumer Model

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Markets for Heterogeneous Products: a Boundedly Rational Consumer Model*

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Abstract

The paper is based on the acknowledgement that properties of markets stemming from features of demand are too frequently overlooked in the economic literature, and a re-balancing is necessary to properly account for theoretical and empirical phenomena.

We sustain that one of the most relevant reasons for the neglect of the role of demand is the lack of an adequate representation of consumers. This claim is particularly relevant for evolutionary economics since its critique to the mainstream approach stopped at the representation of firms. The standard utility maximization approach to consumers' theory is even less defensible than the related assumption of producers' rationality, given the lack of competitive pressure on consumers.

As a contribution to this theoretical gap, the paper presents a model for consumer based on the assumption of bounded rationality and inspired to the literature on experimental psychology. The proposed model can be applied to multi-dimensional products/services and relies on intuitive and potentially observable parameters, allowing for a wide range of theoretical and empirical applications. Moreover, the intrinsic structure of the model provides a clear definition of preferences, meant as *ex-ante* decisional criteria, distinguished from *post-hoc* justification of any decisional result.

Though structurally simple, the proposed model is very flexible and allows for a clear exploration of the impact of specific demand features on the produced results. Several experiments show that the model can be successfully applied both to generate standard results and to implement complex configurations such as those of generated by large markets with heterogeneous products.

Among the results presented, the most relevant concerns the identification of two classes of market segmentation, generated by the identical suppliers and demand's exogenous factors, but different consumers' decisional mechanisms. The results produced are observationally equivalent, but are shown to have radically different properties, and are proposed as initial elements of a taxonomy for the classification demand classes, likely to explain common properties across different markets.

Keywords: Evolutionary Economics, Consumer Theory, Bounded Rationality, Marketing and Preferences, Simulation Models, Market Structure

JEL-classification: C63, D11, D81, L10, L15, M30

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Contents

1 Introduction

One of the major changes of evolutionary economics (Nelson and Winter, 1982) in respect of mainstream thinking is shifting the focus of the analysis from the properties shown by agents' behaviour (e.g. optimising), independently from where those properties are coming from, to what agents actually do (e.g. apply routines), in order to study the consequences that such behaviour generates. Indeed, one of the most relevant reasons for this change is the increasingly evident inadequacy of standard assumptions of agents' rationality and homogeneity, as used in mainstream literature. In particular, these assumptions prevent the very representation and study of innovation and technical change, where un-resolvable uncertainty and heterogeneity are the necessary ingredients of a minimally realistic representation of observed events. It is therefore not surprising that evolutionary economics' main successes stems from its analysis of innovative dynamics, rejecting perfect rationality and representative agents. Evolutionary thinking is rather funded on the assumption of boundedly rational, heterogeneous agents, where even slight differences in external conditions, timing, cumulated experiences etc. lead to differentiated behaviours, sustaining the variety engine that together with selection and transmission of traits compose the evolutionary framework.

However, most of evolutionary scholars focus their attention on the supply side of markets, relying on an extremely sketchy representation of markets' internal functioning, and specifically of demand. This is a curious since the most diffused defence of the perfect rationality hypothesis is the 'as if' used by Milton Friedman, sustaining, in a ironic twist, and extremist version of the selection concept: no matter what people actually do, only the best will survive the competitive test, and therefore economists can focus on the only (supposedly optima) surviving behaviour, whether it stems from design or purely by chance. However convincing, this argument can be applied only to agents subject to competitive pressure, and sub-optimal consumers can hardly be supposed to be driven out of a market. Assuming the perfect rationality of consumers therefore lacks both any empirical and methodological foundation. Yet, notwithstanding the importance of consumers' behaviour in shaping the observed configuration of markets, their development patterns and their variety, most of the evolutionary economic literature maintained a rather primitive representation of consumers.

The limitations on the analysis of consumers forces consequently to limit the scope of the overall analysis. The most prominent example is the almost universal assumption of "homogeneous" products, imposed by the impossibility by the under-developed consumers' theory to deal with differentiated products. In fact, modelling products in multi-dimensional spaces would require a model of consumer able to deal with the potentially complex trade-off among different qualities, and among these and prices. Furthermore, assuming homogeneous products requires a centralized pricing mechanism, since, price differentiation of identical products would lead necessarily to a monopoly.

The homogeneity assumption is not only a problem of realism, but it is also a severely limiting factor in the possibility of analysing product-embodied innovations, hardly a negligible aspect of the innovative activities. This is particularly important for evolutionary theory keen of its Schumpeterian roots. Even though it gives a prominent role to innovation, in most of cases it is reduced to treat the case of process, costs reducing innovations, preventing, for example, the representation of new market segments.

The goal of this work is to show that the demand side of markets is as relevant for economic understanding on industrial phenomena as the supply side. Moreover, far from being a subject for psychologists and sociologists, we also sustain that demand fully deserves to be analysed from an economic perspective. For this purpose we propose a model for consumers' compatible with the assumptions of heterogeneous products and bounded rationality. Such model is not meant primarily to be "realistic" (whatever measure of realism may be used), though we will show that it is both founded on available evidence of empirical behaviour and compatible with the standard tenets of economic analysis. The major objective of the proposed model is to show that the analysis of demand is a necessary step in any study concerning industrial economics. For this purpose we will present experiments with an extremely simplified supply side facing a demand side composed by sets of consumers represented with the proposed model. We will show that it is possible to generate a large variety of market configurations that, by constructions, are motivated by demand properties only. The analysis of these tests shows the link between the (few) core relevant aspects of demand and the rich variety of properties it is able to generate. Moreover, the relevant properties are shown to be not only theoretically founded, but also empirically observable, therefore opening the possibility to link theoretical analysis with empirical applications.

The exercises discussed are meant to show that different types of demand are able to generate different market configurations, and therefore an analysis of industrial evolution not including an explicit discussion of the demand properties is bound to be incomplete. To support this claim we conclude the paper showing two exercises with identical supply sides and generating highly similar market configurations (i.e. distribution of firms' size). Under standard conditions, that is, analysing only the supply side and looking at the distributional properties of the market, the two systems would be indistinguishable. Conversely, we will show they are radically different, because in the two cases the groups of customers choosing any given firm are composed in completely different ways, and, consequently, are likely to react differently to the same event. This result supports the conclusion thati in order to describe the relevant properties of a market, it is not sufficient to provide distributional and supply-side properties, but it is necessary (and viable) to also evaluate the demand-side features of the market.

The rest of the paper is developed as follows. The next section presents the most prominent literature inspiring the present work. In section 2 we present a model for consumers' behaviour, made of a generalized model of decision making under uncertainty modified with the requirements for consumers' perception of heterogeneous products' qualities. We also introduce, as a non-necessary but interesting possibility, a mechanism by which producers influence consumers' preferences through marketing activities. Section 2.8 shows how the proposed model is compatible with the standard requirements of economic analysis, building the equivalent of an aggregate demand function composed by consumers represented by the proposed model. However, aggregate demand functions, though useful for a compact representation, are a too limiting instrument in assessing dynamic properties as typically required in evolutionary studies. Therefore, we further explore the model by presenting two further applications, both representing the dynamics of the evolution of a market, analysing the properties stemming from demand's features. The first, in section 3, presents simple contexts in order to discuss in detail the implications of the proposed model, showing that many of the phenomena empirically observed can be fully interpreted only by including the analysis of demand. The second, in section 4, applies the previous results to show how neglecting the analysis of demand can lead to arbitrary errors. It reports the results by two simulations containing identical producers and exogenous features of consumers, and differing only by the mechanisms of consumers' decision making, generating two extreme cases from the proposed model. It is shown that the distributional properties generated by the two settings are substantially identical, and therefore an analysis based on producers and their economic results would not be able distinguish the two cases. Conversely, including the analysis of demand we can show that the two settings are actually radically different, selecting different types of dominant firms and implying different innovative policies, ultimately supporting the claim that “demand matters”. The last section draws the conclusions.

2 An Evolutionary Model of Consumer

In this section we briefly introduce the literature in the evolutionary economic approach concerning demand, and then we present the proposed model for consumer behaviour. The section concludes discussing the properties of a demand function built on the proposed model, showing that it provides the expected features of a generalized demand function applied to a multi-dimensional product space.

2.1 Evolutionary demand

Evolutionary economic literature has mostly focus on technological innovation and firms' behaviour, paying relatively minor attention to demand issues until recently (Nelson, 1994; Metcalfe, 2001). Some authors have highlighted the relevance of demand-side issues for the emergence of new wants (Witt, 2001) and for sustainability of variety as the engine of growth (Saviotti, 2001). Concerning the analysis at industrial level, few works have explicitly considered the role of consumers. For example, a recent work highlights the importance of variety of preferences and of “experimental” users for the success of innovations (Malerba *et al.*, 2007). Consumers' properties and demand distribution are also attracting the attention to those concerned with particular applications (Windrum *et al.*, 2009). Other contributions discuss indirectly demand issues by studying the formation of market segments (Windrum and Birchenhall, 1998; Klepper and Thompson, 2006). However, little attention has been paid to the actual behaviour of consumers (see, for an interesting exception, Aversi *et al.*, 1999). Consequently, little work has been done to in the direction of producing a generalised evolutionary model of demand.

As a starting point for developing an evolutionary model of consumer we use the results obtained in experimental and cognitive psychology (Devetag, 1999). Besides its realism[1], the proposed model qualifies as an implementation of Simon's boundedly rational behaviour (Simon, 1982). The consumer is assumed to make two logically distinct actions, although potentially they can take place at the same time: preferences formation (the development of general criteria for decision making) and the actual decision procedure (how the decision is reached). The choice procedure adopted is borrowed from the literature on experimental psychology exploring how everyday decision makers reason under conditions of uncertainty (Gigerenzer and Goldstein, 1996; Gigerenzer, 2000; Gigerenzer and Selten, 2000).

The original model, developed to account for controlled, experimental evidence, is modified to be adapted for the specific requirements of a consumer's model. In particular, the psychological literature is obviously not concerned with how the preferences used in the choice procedure are actually developed, although some authors discuss related issues. For

[1]Though this is not the context for methodological discussions, it is worth to stress that we do not consider realism as the core criterion for supporting theoretical contributions. Rather, we sustain that a theoretical model should be evaluated in terms of its *explicative* power, that is, in its capacity to provide generalised explanations to classes of observed phenomena. The validation of the model should be based on the consistency of the general explanation with as many as possible of those proposed for specific events, to be considered instances of the general phenomenon.

example, in experimental studies the process of creating preferences is widely recognized to be influenced by the context in which they are applied: "*[...] there is a growing body of evidence that people's preferences depend on the context of choice, defined by the set of options under considerations*" (Shafir *et al.*, 1993, p.21). Economic literature has long considered consumers' preferences as exogenous, due to cultural, social, etc. factors not liable of economic analysis. We adopt an intermediate position, by considering one of element of the "context" in which consumers perform their choices, which seems empirically of high economic importance. This is the set of "reasons" for a particular choice due to pressure from two, interacting, sources. One is the socially diffused pressure, whereas more popular choices get higher consideration from purported decision makers. The second comes from producers via marketing, here generically defined as any action taken by firms to influence potential buyers. The inclusion of marketing in a theory of consumer seems all the more justified by the immense importance that "sales and marketing expenses" have in modern companies, typically as high, and even higher, than the costs for production, administration and R&D, and that are largely ignored in economic theory.

The preferences sets pressed for by each producer is likely to be incompatible with that of competitors', and therefore we need to provide a mechanism by which consumers' absorb the contradictory marketing pressures. For this purpose we rely on the social context of consumers, assuming that the credibility of the image of a company depends on its diffusion in the society. The impact of the social dimension on consumption activities has long be noted (see, e.g. Cowan *et al.*, 1997), and for the specific requirements of representing the social impact on individual behaviour we adopt the convention that firms' market share are used as to weight conflicting marketing pressures, assuming that consumers' adopt more likely criteria already adopted by their peers (Smallwood and Conlisk, 1979). It is worth to note that the inclusion of marketing-induced preferences is not central to either the model proposed nor to the results discussed, but it is included to show how the proposed model may be extended to account for (partial) endogeneity of preferences. Obviously, though not discussed here, any other factor influencing preferences may be introduced.

2.2 An Evolutionary Model of Consumer

The appeal of optimization to represent agents' behaviour is largely motivated by the possibility that, assuming the result (i.e. the optimum), we can neglect the means by which it is reached. However, besides the "standard" criticism to the use of optimality in Economics (Nelson and Winter, 1982), its use for consumer raises further scepticism. Firstly, while it is possible to conceive some optimization target for firms, although disputable[2], in most of cases this is not possible for consumers. Nor, of course, any "*as if*" argument can be invoked, since inefficient consumers are not subject to selection. Secondly, consumers, in respect of producers, should be assumed to be less committed to, and less expert of, the products and services they trade. In fact, in most of cases (and the most economically relevant) the role of a purchase in the buyer's overall life and income is negligible, and therefore consumers can hardly be expected to devote huge amounts of time and attention on a purchase. Of course, people do not like to waste money or buy lemons, as long as they can prevent it, and therefore some form of rationality is called for.

In the following it is presented a model of boundedly rational agents representing the behaviour of consumers that, besides being compatible with evidence on actual consumers' behaviour, is also sufficiently general and simple to use in theoretical applications. A

[2]For example, optimising short-term profits may undermine longer term measures of success, or vice-versa.

primary requirement for the model is that it must be able to evaluate heterogeneous products. A central argument of evolutionary theory concerns innovations, a large part of which takes the form of product-embodied innovation, generating markets with with differentiated products. Consequently, a generalised model of consumer must be able to be applied in markets where products can differ along several aspects, besides prices.

As we will see, the decisional algorithm adopted provides the opportunity for a clear definition of preferences. Though the proposed model may admit any variety of preferences' formation, we will propose a specific mechanism in order to raise the attention to a widely diffused evidence scarcely recognised in economics. This is the role played by firms in influencing consumers, that we will refer generally as "marketing", an activity that seems extremely relevant for real firms, but that economic theory practically ignores.

In the rest of this section we present the model by starting with the representation for the objects of trade in a market. Then it is presented the choosing procedure proposed, its implied definition of preferences and how they are represented in the model. Finally, it is presented a "demand function" built with such consumers in order to test the proposed model, whose application will discussed in the following sections.

2.3 Product Representation

We can generally assume that the set of products offered in a market can be represented as vectors over a set of dimensions, or characteristics (see, e.g., Lancaster, 1966; Saviotti and Metcalfe, 1984; Gallouj and Weinstein, 1997).

	Char. 1	**Char. 2**	**...**	**Char. m**
Prod. A	v_A^1	v_A^2	...	v_A^m
Prod. B	v_B^1	v_B^2	...	v_B^m
...	...	...	...	...
Prod. N	v_N^1	v_N^2	...	v_N^m

Table 1: Products' quality values

In Table 1 the generic value v_X^i is the measure of product X in respect of characteristic i. This value must be interpreted as a measure of the quality for the "service" that the product provides in respect of a specific use[3]. Of course, it makes sense to compare only values along the same characteristic which, without loss of generality, are assumed to be all positive aspects. For example, a characteristic may not be "price", but rather "cheapness", possibly defined as the inverse of price. As we will see below, the absolute values for products' qualities are not important, since the procedure used needs only to make comparisons determining whether one product is superior, inferior or equivalent to another product in respect of one dimension. Such property of the model avoids distortions and limitations due to the choice of different units of measures, besides extending the analysis to non real-valued characteristics. Note that a product can be defined absolutely superior to another only if all its values are superior to all the values in the vectors of the other competing products. In general, this representation permits to represent different trade-offs, with some product scoring better than competitors on certain characteristics and worse on others.

Such representation is very general, and can be used for many purposes. For example, it is possible to segment users according to a "minimal requirement" on each dimension. This, for example, can be used for selecting consumers who, although potentially interested,

[3] Although we will mainly refer to "products", the proposed model works as well for markets of services.

cannot afford the price for a given product, or the ones who necessitate minimal qualities in order to consider a product. In the following, however, we will consider the dimensions only as long as they are used for preferring one specific product over the competitors, assuming that the whole set of products on offer satisfies the minimal conditions for being considered for an actual purchase by all buyers.

Note that such representation is readily available to represent product embodied innovation, which can cause the increase of quality along one or more dimensions. But it is also possible to represent an innovation as the increment of the very set of dimensions, in case the innovation introduces new services in addition to an existing product.

2.4 Products' Values Perception

Concerning the level of qualities of product, we distinguish between what the real values of products' qualities are, and what consumers *think* they are, and use in their decisional processes. In most cases buyers are not experts in the technology embedded in the products, or do not consider worth to make extensive research for finding the exact quality values. Moreover, sellers may be reluctant to make public detailed information concerning their products, preferring to remain vague on their true products' qualities.

We consider two types of "distortions" from real values to perceived ones. The first consists in a random error, so that the observed value of a product's quality is a draw from a normal distribution centered on the real value, and whose variance depends on the consumer's "expertise". Consumers are represented as using, in place of the actual values v_X^i for product X along characteristic i, a random draw from a normal distribution:

$$\hat{v}_X^i = Norm(v_X^i, \Delta^i)$$

The normal random function has the mean value equal to the true value of the product, and a buyer's specific deviation Δ^i.

To appreciate the effects of the use of stochastic errors in the model, consider the model only performs two-by-two comparisons between products on a single dimension per time, in order to assess which product is superior (or if they are equivalent). Therefore, the role of Δ^i in the decision is to determine the probability that a consumer confronted with two products is able to correctly identify the one with better quality in respect of a given characteristic.

For example, consider two products, X and Y, scoring "objectively", in respect of characteristic i, $v_X^i = 11$ and $v_Y^i = 10$ respectively. Varying Δ^i the modeller can determine how frequently product X is correctly identified as superior. Though this probability can be formally computed, as the difference of the cumulative distribution functions for the perceived values of the two products, it is sufficient here to show a numerical estimation. Figure 1 reports the estimation of such probability, computed numerically from a sample of 100,000 draws and reporting the frequency of correct comparisons for different levels of Δ_i.

The figure shows that for small values of Δ^i, lower than about 0.5, more than 90% of the times the consumer perceives as superior the truly best product. Such correct perception drops while incrementing the error, until, for values of Δ^i approaching five times the true quality difference, the best product is perceived as such only 5% more frequently than the inferior competitor. It is worth to note that there are two possible interpretations for the role of this parameter, from an individual or from a population perspective.

Firstly, we can interpret Δ^i as a measure of the ignorance of consumers in assessing the true ranking of products (in respect of one characteristic). Though some characteristics

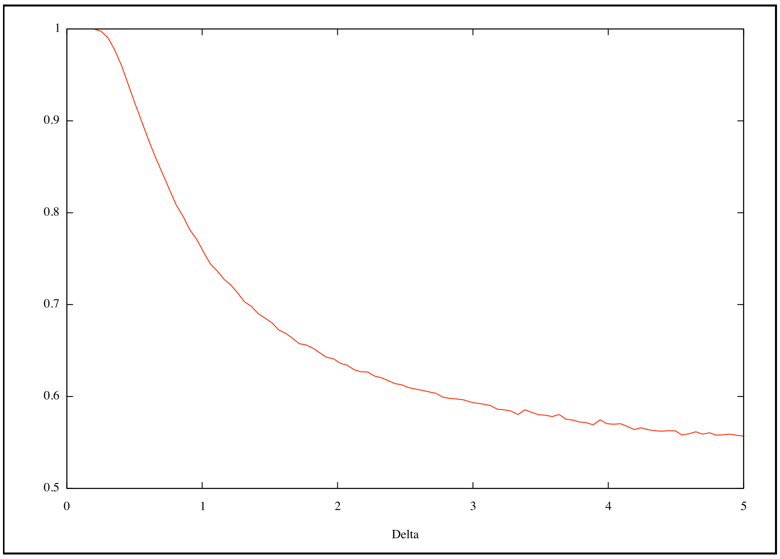


Figure 1: Probability that product X will be correctly evaluated as superior as compared to Y in respect of a range of values of Δ^i. Data produced as frequency of correct comparisons from a sample of 100,000 draws for each value of Δ^i from two independent normal functions with parameters $norm(11, \Delta^i)$ and $norm(10, \Delta^i)$.

may be hard to misread (say, the price), others, such as technological aspects, robustness, etc. are much more difficult to properly compare. Tuning Δ^i it is possible to represent the probability that consumers will correctly evaluate characteristics' values. For example, for the characteristic "price" we may set $\Delta^i = 0$, since no error can be made on reading this feature. Conversely, aspects requiring specific skills to be properly assessed, or vaguely defined, it may be possible to set higher levels of Δ^i for consumers expected to be less expert in that particular evaluation.

The second interpretation consists in considering Δ^i as a measure of the variety of consumers concerning the comparison of two products in respect of a given characteristic. In this case, having a large Δ^i signifies that, over a population of consumers, we will expect roughly half of them considering superior each product, independently from the true values. In this case the parameter signals not much the incapacity of consumers to read the true products' values, but the frequency distribution of consumers assessing a product as preferable to the other.

Both interpretations can be appropriate for specific implementations. For clarity we will continue to refer to the parameter Δ^i as "error". Moreover, for simplicity we will assume that the same error value applies to all characteristics for a given consumer, ignoring the possibility to use different values for different characteristics by the same consumers.

Besides perception errors, the model also assumes that buyers use a margin of tolerance when comparing products in respect of a characteristic. It is assumed that if the difference between the (observed) values of two products is smaller than a given threshold, then the two products are considered as equivalent. Assuming, as before, that product X appears to be superior to product Y on one characteristic, the model introduces the concept of equivalence as:

$$\hat{v}_X \approx \hat{v}_Y \iff \frac{\hat{v}_X - \hat{v}_Y}{max(\hat{v}_X, \hat{v}_Y)} < \tau$$

where τ is a coefficient in the [0,1] range. You can interpret τ as a measure of the tolerance that the consumer adopts for small differences in values. When $\tau = 0$, then even minor differences are considered as relevant to assess the superiority of one product, while, conversely, a high value of τ indicates that almost every value of Y, concerning the characteristic used, would not qualify product Y as inferior.

It is worth to note that the combined effect of the perception errors and tolerance relieve the sensitivity of the results to the choices of units of measures and to possible arbitrary evaluations. Furthermore, as will be clarified below, the model proposed may actually dispense altogether by any quantitative measure of characteristics qualities. The only requirement is to set the probabilities that a product is considered as superior, inferior or equivalent to any other in respect of each characteristic. Such information is much more reliable and easier to collect than numerical evaluations for product characteristics, most of which have qualitative nature. This is a great advantage in respect of statistical techniques such as hedonic pricing, which are known to be extremely sensitive to the numerical assessment of qualitative aspects. However, in the following we will continue to use numerical values for simplicity of presentation.

2.5 Boundedly Rational Decisional Strategy

The most challenging issue concerning a consumer model is how to represent the choosing behaviour. In Gigerenzer and Goldstein (1996) (see also Gigerenzer, 2000; Gigerenzer and Selten, 2000) it is convincingly sustained that the Take-The-Best strategy (TTB) is, both, experimentally supported by observation of actual people's behaviour and very efficient under the normally occurring circumstances of uncertainty and poor information. Concerning the general case of choosing one alternative options among many, each defined over a set of characteristics, this strategy is composed by the following steps:

1. Choose one characteristic, among the m available.
2. If one single option scores highest in respect of that characteristic, that is your choice.
3. Otherwise, if more than one option scores similarly, remove the dominated options, and restart from 1. with another characteristic.

The authors proposing this strategy as a representation for human behaviour concerning decision making in normal circumstances argue convincingly that it is an algorithm respecting the principles of bounded rationality (Simon, 1982), which seems quite adapt to represent the generality of consumers' behaviour. In fact, most of the purchasing decisions, and by far the ones of larger economic impact in modern markets, are made by people buying items whose costs and importance is very limited in respect of their overall life and income. Therefore, they have relatively little interest in investing time and intellectual resources just for being sure of picking the optimal choice, and would rather risk to choose a dominated alternative, possibly a little more expensive in price or of slightly lower quality, but by far easier to be decided upon. Concerning the realism of TTB, there is a huge amount of literature suggesting that, when people face the choice between different alternatives "*[...] they resolve the conflict by selecting the alternative that is superior on the more important dimension, which seems to provide a compelling reason for choice*" (Shafir *et al.*, 1993, p.15). TTB is nothing more than a generalization of this "reason-based" procedure, extending to consider more than two dimensions and the possibility of equivalence of some alternatives in respect of some dimension[4].

[4] Another interesting property of TTB, not used here, is that it can deal with missing values, that is, when people ignore some of the characteristics' values on the available choices.

The result produced by the TTB algorithm is obviously determined by the order in which characteristics are used to make a decision. It is obvious, in fact, that in general one obtains different choices depending on which characteristics are initially used to select upon the available alternatives. This provides a useful insight in order to provide a clear definition for a concept that is central to the theory of consumer, but more frequently appealed to justify whatever consumers' behaviour is observed, rather than properly defined: consumers' preferences.

The concept of preferences technically refers to the criteria applied by a consumer to choose a product. However, the lack of a clear definition generates confusion between the criteria and the actual choices made by a consumer. For example, the TTB clearly recalls the lexicographic preferences. However, while the TTB uses the lexicographic ordering of the criteria to reach a decision, the "lexicographic preferences" literature in economics refers to the ordering of the actual choices.

Adopting the TTB as a representation for consumers' behaviour allows to provide an explicit definition of preferences, clearly distinguished from the results of consumer's decisional process. The natural definition of preferences is: the relative importance of products' characteristics used to reach a decision.

For example, suppose only two characteristics exist on a given product: quality and cheapness. Then there are two possible preferences: highest quality or lowest price. The "quality oriented" buyers will prefer the cheaper products only among those scoring highest in quality, while "price oriented" buyers will buy the best product among the cheapest ones. In the general case of many dimensions the number of preferences is given by the number of all possible permutations of the characteristics[5].

Having defined the consumers' preferences and their space, it is possible to exploit this proposal in order to investigate the origin of preferences.

2.6 Marketing Induced Preferences

Economists universally consider consumers' preferences as exogenous, referring to psychological, social and other determinants of consumers' behaviour as falling outside the realm of economics. Unfortunately, this reasonable assumption is frequently (mis-)used as a justification for avoiding the economic analysis of consumers' altogether: every consumers' behaviour may possible, justified only by their exogenous preferences. Economic analysis, therefore, cannot but register consumers' decisions as expressed in their purchases results, and declare itself unable to explain demand's events.

The decisional algorithm proposed above allows a more elaborated approach. Preferences are defined by the *criteria* used to reach a decision, distinct from the actual decision made. Even maintaining the assumption of the exogeneity of preferences, our definition provides detailed indications on how to collect such information, that is, the relative importance of a product's characteristics for consumers. Indeed, such information is routinely collected and used by market research companies for techniques such as the conjoint analysis (Green and Srinivasan, 1978). This would already be a step in "deepening" our understanding of demand by explain at least one step from exogenous preferences to observed behaviour.

[5]Notice the difference between preferences and tastes. While preferences are the criteria applied to reach a decision, the tastes consist in the ordering of the instances of a characteristic. For example, two different users may give high importance to the characteristic "colour" in their preferences. However, they may differ for their tastes, so that the option scoring "white" is chosen by one consumer and rejected by the other. Thanks to Marco Guerzoni for raising the attention to this point.

The assumption of exogeneity of preferences, however popular among economists, sits uncomfortably with empirical evidence collected in experimental and cognitive psychology. Preferences seem to be "*[...] actually constructed - not merely revealed - during their elicitation.*" (Shafir *et al.*, 1993, p.34), which is hardly compatible with exogeity. Furthermore, it has long been known that it is possible to influence people's responses by manipulating the presentation of alternative choices, the so-called *framing effect* (Tversky and Kahneman, 1981; Kahneman *et al.*, 1982). This means that an interested party would be able to steer people's decision towards an option and away from others. Concerning consumption, firms are obviously interested in affecting consumers' decisions, and there is plenty of evidence, ignored by economic theory, that they are full aware of the possibility.

The activities of firms generally considered in economic theory are those concerning the production process (e.g. production functions and costs), products' qualities (R&D), and the internal organization of the firm (agency theory). However, even a casual observation of real companies shows that one of the highest item of expenses on the balance sheets is "marketing", "sales promotion", etc. The importance of such non-production, non-research and non-organizational expenses is strikingly consistent across a wide range of sectors and countries. For example, it is well known that pharmaceutical companies (at least in the US) spend much more on marketing than on R&D. Also, during the dot com bubble, start-up's where encouraged to devote to marketing initiatives at least 50% of their seed money.

The proposed definition of preferences offers the opportunity to fill the gap that economic thinking has left in explaining such common and widespread phenomenon. Marketing can be developed in many different forms: packaging, commercials, sponsorships, etc. In any case it presses buyers for adopting a particular perspective of the product that exalts its product against competitors'. In our setting this translates in an effort to convince buyers that some characteristics are more important then others, so urging potential consumers to develop a specific set of preferences. Obviously, we can expect producers to design the desired preferences so that their product gets the best chances to be adopted in respect of competitors'.

Formalising this intuition, we assume producers to have their own "ideal" ranking, that they would like to push through consumers, exalting their own product against competitors'. Consider for each producer a vector of values containing a value for each characteristic.

	Char. 1	**Char. 2**	**...**	**Char. m**
Prod. A	k_A^1	k_A^2	...	k_A^m
Prod. B	k_B^1	k_B^2	...	k_B^m
...	...	...	...	...
Prod. N	k_N^1	k_N^2	...	k_N^m

Table 2: Producers' marketing strategies

The generic element k_X^i in Table 2 must be interpreted as the relative importance that the producer gives to the characteristic for its marketing strategy. The more important a characteristic, the higher its value compared to the other characteristics for the same producer. In the following, when describing how buyers develop their preferences, the exact meaning of these values will be clearer. For the time being, consider that, in principle, a coherent producer should set its k_X^i higher the more its product is better than competitors' in respect of the characteristic i.

2.7 Social Influences

We have seen how suppliers can influence consumers, but we still need to specify how a consumer determines its preferences out of the set of marketing pressures from the whole set of suppliers. In other terms, what makes more effective the marketing pressure from one firm in respect of competitors' (assuming they pursue incompatible marketing strategies)?

In Smallwood and Conlisk (1979) the authors propose a model where buyers choose their purchases randomly with probabilities proportional to the competitors' market shares. The justification for this is obvious: there is no better advertising that just having many users showing your product around. This method seems even more adapt to represent the relative diffusion not of products, but of preferences. Consumers pass each other "perspectives" of the product, and the probability of choosing one given perspective is likely to depend on the number of fellow consumers that adopted it in the past. In other terms, households are sensitive to each other's "life styles", as implemented in the relative importance of different aspects of products. Cowan *et al.* (1997) support this view, suggesting that consumers act according two principles: distance yourself from lower class elements, and imitate those among upper class ones. In our case, the aspiration effect consists in being influenced by the decisional criteria observed in the society.

As a first attempt to implement this kind of behaviour we can therefore assume that consumers' preferences are determined by choosing randomly among suppliers' marketing strategies weighted with their market shares. Formally, the algorithm used to determine a buyer preferences is the following. We define preferences as the ordered set of integers representing the m characteristics defining the product:

$$< c_1, c_2, \ldots, c_m >, c_i \in \{1, 2, \ldots, m\}$$

For example, if $m = 3$, the possible sets of preferences is composed by all the permutations of the characteristics :

$$< 1, 2, 3 >; < 2, 1, 3 >; < 1, 3, 2 >; < 3, 1, 2 >; < 3, 2, 1 >; < 2, 3, 1 >$$

The model determines the preferences for a consumer using the following indicators:

$$p_i = \sum_{j=1}^{n} (k_j^i s_j)^{\delta} \tag{1}$$

where s_j represent the market shares of supplier j, k_j^i is the marketing level of firm j in respect of characteristic i, n is the number of firms, and δ is a coefficient flattening or steepening the indictors[6].

In short, the indicators (1) show the importance that the supply side of a market as a whole gives to the i^{th} characteristic, using market shares as weights to balance the producers' marketing strategies. The more firms (weighted with their market shares) will press for one characteristic, the more likely users will consider it important for their preferences.

The results we want to obtain is to assign the preferences to a consumer. Let's begin with the first, highest ranking, characteristic in the preferences, c_1. This is obtained drawing randomly one of the m characteristic each with probability:

[6] A value of δ approaching 0 means that the indicators for all characteristics will tend to be equal. Conversely, higher and higher values of δ will make one p_i close to 1 (the one with higher marketing support) and all the others near 0.

$$\Pr(i = c_1) = \frac{p_i}{\sum_{h=1}^{m} p_h}$$

The same indicators are used for obtaining the probabilities to draw the second characteristic in the preferences, just setting to 0 the indicator p_{c_1}:

$$\Pr(i = c_2) = \begin{cases} 0 & i = c_1 \\ \dfrac{p_i}{\sum_{h=1, h \neq c_1}^{m} p_h} & i \neq c_1 \end{cases}$$

The same procedure is used to assign the probabilities to all the remaining characteristics for the ranking positions, each time setting to 0 the indicators for the characteristics already used, and renormalizing accordingly.

2.8 A multi-dimensional demand function

The TTB, however convincingly rooted in experimental and empirical evidence, may appear as quite troublesome for use in a theoretical context. The most prominent reason is that it is clearly a non-compensative algorithm: whatever improvement you make on a low-ranking characteristic, this is not going to affect the eventual result of the algorithm. Consequently, any demand curve built upon consumers represented with the TTB may be expected to be "badly behaved" from an economist's perspective.

Such conclusion is, in fact, wrong, for several reasons. Firstly, the proposed algorithm differs from the original TTB in a number of features, namely the stochastic perceived values and the use of tolerance levels. Secondly, the modified TTB does not intend to represent an individual demand function, consisting in the relation between quantity demanded for any level of price of a good. Conversely, the proposed algorithm represents the consumer behaviour in choosing one among many alternatives, assuming the quantity being one unit. Consequently, the proposed model of consumer may be used to build an individual demand function, once is fed with a budget constraint, and applied to determine quantities of goods, but it is not a substitute for a demand function itself. Rather, it may be considered as a "generative" algorithm resulting in a behaviour that may be used to build a demand function. In this sense, the model may be seen as a boundedly rational alternative to the discrete choice theory approach (Anderson *et al.*, 1992).

We skip the issue of individual demand functions, and focus instead on how the proposed model can be used to provide a "well behaved" demand curve for a market that is not only compatible with the tenet of theoretical economic models, but also directly linked to the everyday use of "demand" as meant in empirical studies and industrial applications.

The textbook concept of demand curve is based on the universal assumption of homogeneity, so that the price is the only possible aspect differentiating products. Conversely, the vast majority of markets in the real world is made of heterogeneous products differentiated along a number of characteristics, with price being only one of them. We may define the features expected by a demand function as a function from the space of products (i.e. all the vectors representing the characteristics' values for all the products) to the vector of quantities or market shares sold for each producer. In the following we will ignore the wealth effect that a variation of price can cause to the demand of a given product and assume that there is a number of consumers willing to buy one of a set of products on offer, provided they satisfy some minimal requirements.

We can ask a demand function to respect the following conditions:

- Other things being equal, the improvement of one product on one characteristic should increase its sales.
- Other things being equal, the improvement of one product on one characteristic should decrease the sales of other products.
- Other things being equal, the improvement of one product on one characteristic should increase the total sales of the market.

We can test the proposed algorithm for consumers to provide a well behaved market demand by considering a number of consumers and evaluating the total sales for each product. We apply the algorithm as described in the previous section adding a “pre-screening” function. That is, a consumer firstly observes all products on offer and assess which of the products reaches a minimum level of values on each characteristic (as perceived by the consumer). This stage, preceding the actual decisional process, ensures that grossly inadequate product, such as a hugely priced item, enters in the competition with other, accessible, products. On those products that satisfy all minimum requirements the consumer then applies the modified TTB to decide which product to buy. Notice that in the pre-screening stage there is no application of preferences, and a product is discarded even if it fails to reach the minimal requirement on one characteristic only.

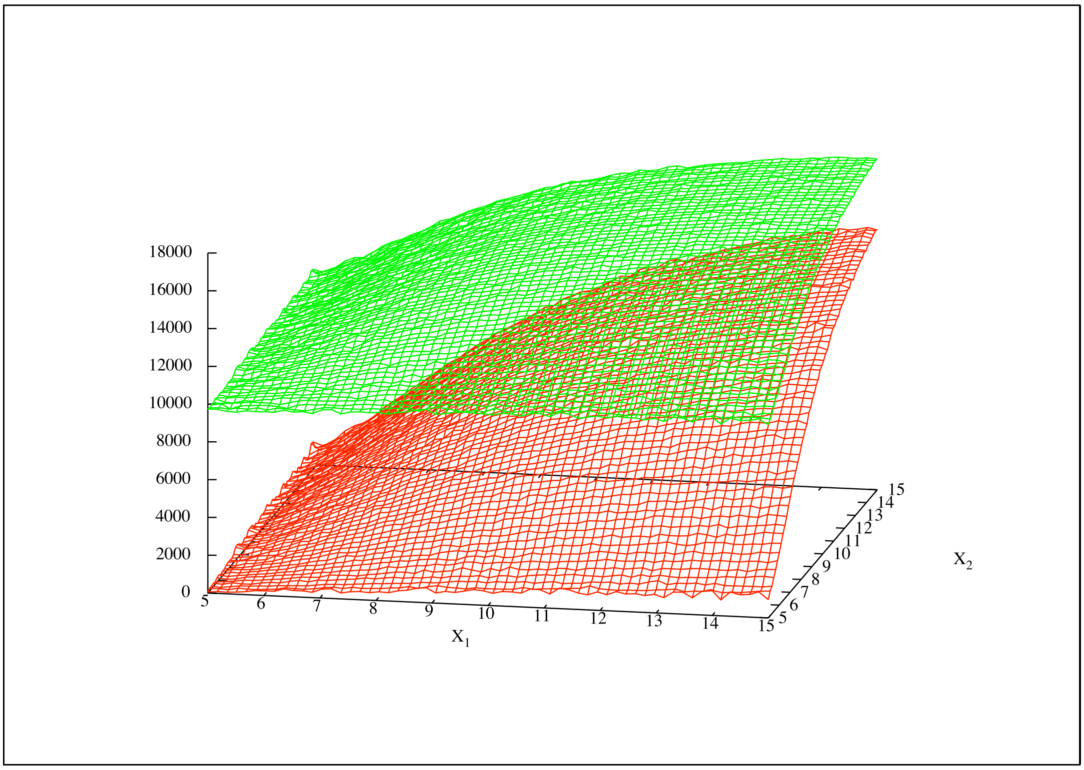


Figure 2: Sales of product X and total sales on the market in respect of different values for the characteristics of firm X.

To generate a demand function liable to be represented graphically we restrict the number of characteristic to two, and we consider the competition between two products only, X and Y. We consider product Y as constant, and evaluate the sales for the two products for different values of the two characteristics for X. We consider a market made of 20,000 consumers equally divided in two classes with the two available preferences $< 1, 2 >$ and $< 2, 1 >$. Product Y is configured to the values $\{10, 10\}$ while for product X we consider all values in the range $[5, 15]$ over the two characteristics. We set $\Delta = 0.4$ and $\tau = 0.1$, while the consumers fail to buy any product if none is perceived as having both characteristics with values above 8. The simulation generates 10,000 points in the bi-dimensional space $[5, 15]^2$ that are used as the values for the characteristics X_i, $i = 1, 2$. For each point the simulation computes the choice for each consumer, firstly by applying the pre-screening stage and, if passed, the modified TTB. Finally, for each point are recorded the total sales (number of consumers that made a purchase), products' sales and market shares[7].

Figure 2 shows the sales for product X and the total sales on the market measured on the vertical axis for each combination of the values of the characteristics X_1 and X_2. The total dimension of the market (obviously the upper surface) shows that only half of the consumers actually buy a product when product X is set to its minimal values, $[5, 5]$. This is because, at this low level, product X fails clearly to pass the pre-screening stage. However, because of the relatively high Δ, many consumers also perceive either Y_1 or Y_2 as below the threshold of 8 (actually, the "true" values are 10).

For increasing values of the characteristics of product X more and more consumers find that either Y or X pass the minimal requirement threshold, and consequently we observe that the total sales of the market increase, until reaching some 90% of total consumers with $X_i = 15$.

Concerning the distribution of consumers over the two products the graph clearly shows that product X gains market shares for increasing values of its characteristics[8]. Moreover, the aggregate demand shows that the aggregate effects of the model proposed enjoys the compensatory property, in that different combination of X_1 and X_2 can generate the same level of sales.

In conclusion, the exercise presented above shows that the proposed model for consumer is able to produce a market demand compatible with the requirements of economic theory. Only, this result is not generated by imposing on consumers theoretically unjustifiable and empirically unfunded assumptions of rationality. On the contrary, the proposed algorithm is based on empirically evidence of actual people behaviour. Moreover, the overall representation of the proposed consumer model is highly compatible with the implicit assumptions adopted in techniques widely used in applied consumers' research, such as the *conjoint analysis* (Green and Srinivasan, 1978; Marder, 1999). Consequently, the parameters determining the property of demand as represented above are likely to be either directly or indirectly available from surveys routinely performed by market research agencies.

To further explore the properties of the model it is necessary to extend the number of characteristics used, and therefore the dimension of the admissible set of preferences formed by all the permutations. Moreover, it is also necessary to extend the number of firms considered and to test the effects of the model's parameters. Even restricting the exploration to small sub-sets of these spaces, it would be impossible to represent the

[7] All the simulations in the paper have been developed with the simulation platform LSD (Valente, 1997; Valente, 2000; Valente, 2008). LSD can be downloaded from `www.labsimdev.org`, while the model's code and configurations of the models are available upon request.

[8] We do not report, for reason of space, market shares values nor sales for product Y. However, these latter values can be induced from the vertical difference between the total sales surface and that for the sales of X, which is clearly narrowing for increasing levels of X_i's.

properties obtained in terms of demand functions. Consequently, the next section presents results produced by using a setting resembling the dynamic evolution of a market, where the results are expressed in sales' time series, with the aim of showing both the flexibility of the instrument proposed and its capacity to provide robust theoretical explanations to a wide range of empirical phenomena.

3 Demand and markets' configurations

In this section we deploy the proposed model of consumers exploiting fully its potential, allowing for many products defined over a large set of characteristics. In order to present the results in a familiar context, we simulate the evolution of demand in a dynamic context, representing the development of a market for a new product, from its initial stage until the maturity stage. The goal of the exercise is to show the contribution of the demand to the definition of the emerging market configuration. For this purpose we assume an exogenously fixed supply side, made of a constant number of suppliers offering an unchanging set of products. This assumption, clearly unrealistic, allows to assess how different features of the demand side affect the resulting distribution of market shares, independently from changes in the supply side[9]. We will adopt the following methodological steps:

1. Show that the proposed model of demand is able to generate a large number of different market configurations (i.e. distributions of sales across suppliers) by modifying consumers' parameterizations and the (exogenous) state of the supply side, i.e. qualities of the products' available on the market.

2. Show the logical steps explaining the observed effects on the market configuration by means of the demand and supply assumed features.

3. Show that the explanations derived in the artificial settings are the same, or at least compatible, as those proposed to explain equivalent empirical phenomena.

Note that our goal is *not* to pursue realism in the sense of generating data series statistically equivalent to empirical ones. Indeed, this would be a hopeless endeavour, given the huge variety of markets, and, moreover, the assumption about the exogeneity of supply side would make the exercise useless. Instead, we aim at developing what yo may call a "partial" analysis of markets, referring to the identification of the influence of one element only (the demand side) to phenomena (market configurations) known to be, in fact, influenced by many factors.

As we will show that there are many real world phenomena that can be assimilated to those generated by the proposed models, that is, cases in which the role of demand is perfectly identifiable as separated from other factors. The "validation" of the proposed model will therefore be based not on the quantitative similarity between theoretical and empirical evidence, but on the compatibility of the explanations required to justify theoretical and empirical phenomena, limited to demand-only considerations. The constancy of supply side is therefore a necessary expedient to simplify the results and be able to explore the effects of demand on the results. You may consider this methodological approach as a preliminary step, complementary to the far more frequent case of modelling the supply sides of markets under unrealistically simplifying assumptions on demand. Both steps are

[9] In a sense this is the mirroring exercise, equally unrealistic, of models representing the evolution of firms assuming a constant demand side.

assumed to be later followed by the extension of the analysis by merging the two independently developed studies into a larger one, which will be able not only to inherit the knowledge developed at the first stage, but also study the interactions among supply and demand factors. See Valente (2000) for an example of such analysis.

3.1 General settings

We consider a simulation run as representing the development of a market for a novel product. At the beginning of the simulation only one single consumer exists on the market, representing the early consumers for a novel product. With time, more and more consumers become aware of the product and enter the market, regularly purchasing one of the products on offer. Since our model depends on the distribution of market shares, we need to impose a dynamics of consumers' entry, which is likely to affect the early stages of market.

One of the very few universal facts observed in many different markets is the s-shaped dynamics of the number of buyers in new markets. This phenomenon can reasonably be represented assuming that the entry of new consumers in a market is determined by a contagion diffusion model. That is, early consumers show their novel purchase to their friends, who mostly are not aware of it. Each of the new consumers brings, in turn, new consumers, giving rise to the initial increasingly steep growth. In later stages, most recently entered consumers have friends who already use the (no more so) novel product, so that we observe a diminishing growth of the market, until the saturation level is reached and no new consumers enter the market[10].

To simplify the interpretations of the simulation results we assume that consumers share identical tastes, income, and any other aspects not explicitly represented in the model. They decide on the preferences at time of the very first purchase, and then keep same preferences set for each subsequent purchase. This is obviously a quite unrealistic assumption, although we can invoke some sort of lock-in. For example, a new entrant in the early stage of the personal computer markets may "absorb" the preferences sponsored by Apple, and therefore choose one of their computers. Later, although the market shares of Apple have sensibly fallen, this consumer will apply again the same preferences, e.g. requiring fancy graphical interfaces (and likely choosing an Apple again, at least until IBM-compatible will offer a comparable windowing system). Another justification of this assumption is that preferences, even if changing, are modified quite slowly, and anyway slower than the time scale we consider in the model.

As in Smallwood and Conlisk (1979), a consumer in the market is supposed to make a purchase every few time steps, assuming the most general case of the product being a semi-durable[11]. This causes a differentiation between market shares measured on sales (determined by the consumers who make a purchase at a given time), and those measured on "installed bases", that is, consumers' ownership. For the determination of preferences seems obvious to make use of the installed bases distributions, more likely to be observed by new consumers than daily sales data.

[10] This buyers' entry mechanism opens the possibility, not exploited in the current version of the model, to construct cohorts and "family trees" of consumers, depending on when they entered the market and who introduce the novel product to them. Such information can be exploited to represent differentiated reactions for, say, consumers entered in the early stages of the market evolution in respect of later entrants.

[11] The model does not allow for supply dynamics, and therefore it is not possible to model a technological competition causing replacement of obsolete products (Richardson, 1996). In this case we would have a sales dynamics determined, besides the mere replacement, also by the timing of introduction of newer versions of products.

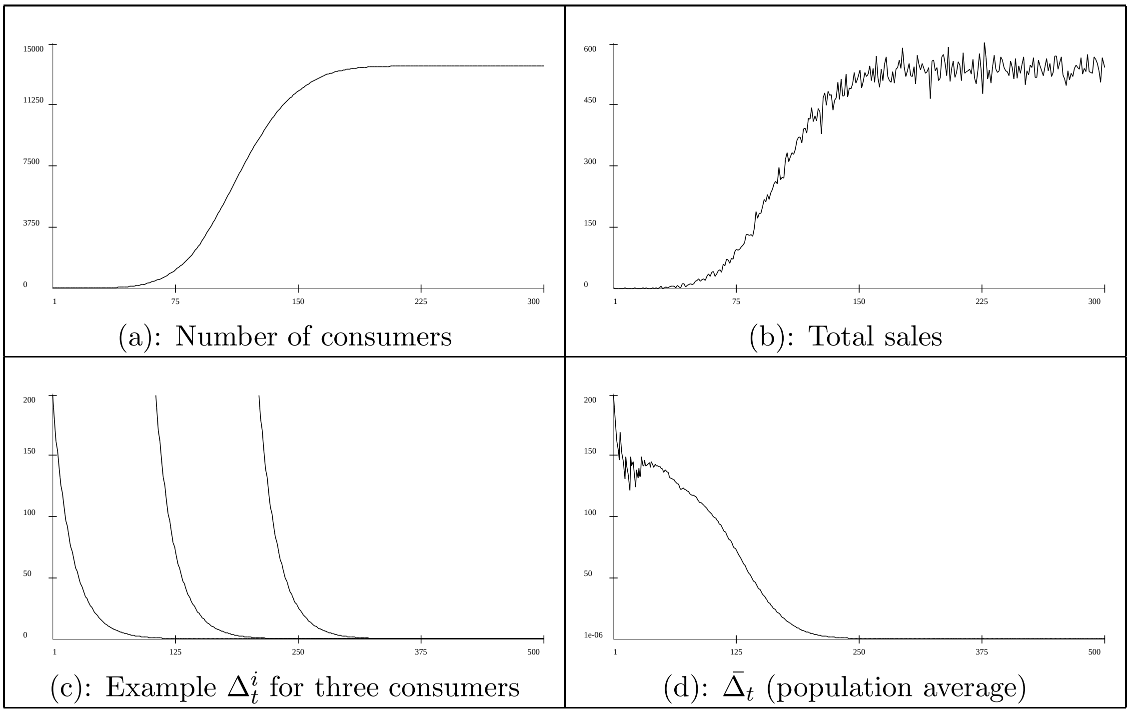


Figure 3: General settings. Each simulation run uses the same initialization producing the following dynamics: (a) the dynamics of consumers' entry; (b) the level of sales; (c) the level of Δ_t^i for single consumers (starting and limit values change for different exercises); (d) average Δ_t^i for the whole population of consumers.

Figure 3 summarises the overall settings adopted in all the simulations. We consider a market for a novel product, where the consumers enter following a contagion diffusion dynamics. At the beginning of a simulation run only one consumer is present in the market; this will introduce 7 new consumers in its lifetime, each of which will bring 6 new buyers, and so on. Eventually, the market dimension is made of 13700 consumers (see figure 3:(a)).

A consumer entering the market defines its preferences according to the algorithm define in paragraph 2.7, that is, depending on marketing strategies of firms and the market shares distribution at the time, and keep them throughout the simulation.

Each consumer makes a purchase at the first time step it is introduced in the market, and then replaces the product every few time steps[12], so that the level of sales at each period is a constant fraction of the total number of consumers present in the market (see figure 3:(b)).

Each consumer develops independently its own capacity to read products quality, represented by Δ_t^i. This consumer specific variable is represented as a constantly decreasing function reaching asymptotically the limit level Δ_∞^i, which will be a parameter of the model, indicating whether the consumers are allowed to make perfect decisions (Δ_∞^i=0) or will settle for a systematic, irreducible error ($\Delta_\infty^i > 0$). The same "error" variable is applied for all product characteristics (figure 3:(c)). Since consumers enter at different times, the average level of Δ_t^i's across all consumers reflects the population composition by age (figure 3(d)). As we noted, this parameter can be interpreted also as measure of the variety of demand, which can be expected to be high in the earlier purchases, decreasing

[12]The probability of making a new purchase is 0 for the first 20 periods after a purchase, and then increases linearly from the 21^{st} step reaching 1 after 40 steps.

with time while consumers develop a common system to evaluate products.

In the following we explore the model by varying a few parameters of the model and discussing the resulting market configurations. The parameters we will modify are the following:

1. Producers quality levels and marketing strategies. In all cases we will use a product space made of 10 characteristics, all supposedly "positive", that is consumers prefer higher values to lower ones.

2. Limit learning values (or limit variety) Δ^i_∞ determining whether, after an initial period, consumers are able to perfectly perceive the true products' quality levels ($\Delta^i_\infty = 0$) or, conversely, if even expert consumers continue to make (small) random errors.

3. Tolerance levels τ, determining whether (small) differences between the (perceived) quality of two products are considered irrelevant, evaluating the products as equivalent, or, conversely, if any difference in perceived quality is sufficient to discard the inferior product.

3.2 Simple Monopoly

As a first exercise we explore a very simple setting of the model, in order to both get accustomed to the model properties and test its basic features. We consider a configuration that we expect to generate a monopoly by considering 10 firms, 9 of which have all the quality levels set to 90 and the last one with superior qualities set to 100. Consumers are supposed to perfectly read the true quality levels $\Delta^i_\infty = 0$, after entering the market with a high "error" level. We also set $\tau = 0$, meaning that any small quality difference is sufficient to trigger the choice of the consumer, obviously in favor of the (apparently) highest quality product. Under these conditions preferences obviously do not matter, since every characteristic is dominated by one firm.

Figure 4 reports the series of consumers using each of the products through time, that is the level of installed bases for each product. In the final stages of the simulation consumers clearly opt for one product, the one with the highest qualities[13]. However, the dominated products can still make positive sales in the initial stages because of the poor capacities of buyers to assess products' values. At these times, when consumers have still high value of Δ^i_t's the distortion in the perceived values makes frequently appear dominated products as superior to the actual best one. At a later time, in the final stages of the simulation, the value of Δ^i_t falls to nearly zero for all the consumers, and therefore all of them consistently choose the best product, producing the expected monopoly.

Even though almost trivial, this exercise shows the typical properties of markets for novel products (see, e.g., Abernathy and Utterback, 1978): a confused initial stage, when many competing products enjoy positive and increasing sales, followed by the emergence of a dominant product. There are many explanations for this robust finding in the literature, related, e.g., to the exploration of different designs, uncertainty of possible uses, poor qualities of early products, etc. In this exercise, given the assumption of constant products' qualities, the only explanation is that the buyers' limited knowledge concerning the new product causes them to make comparison errors, which later can be avoided because of the increased capacity to correctly assess the true products' quality.

[13] For clarity of exposition we omit the indications of different series with colours or indexes. Obviously, the simulations' output allows for associations of each series to the related producer.

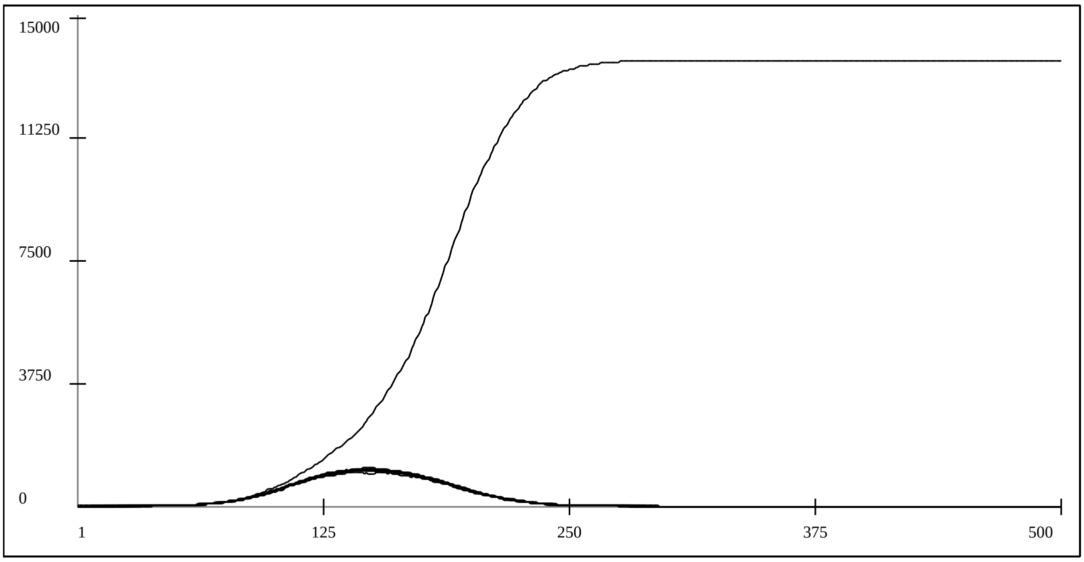


Figure 4: Installed bases dynamics for Standard Monopoly. All producers have identical quality and marketing values, but for one producer being superior than competitors. The superior product eventually dominates the market, after that buyers have reached perfect capacity to observe the true quality values ($\Delta_t^i \simeq 0$). However, in the early stages of the market the relatively high evaluation errors of consumers allow dominated products to enjoy positive sales.

Besides the implementation of the model, it is possible to use this result to extend past results. The robust evidence on a "shake out" of firms, where the number of producers suddenly falls (Klepper, 1996), can be interpreted from the perspective of demand-side. In the above results the sales of failing producers follows a relatively smooth pattern, due to the independent dynamics of Δ_t^i for each consumer. However, it may be possible that later entering consumers have specific "learning" patterns, or other features, making them to concentrate on only one, or a few producers, precipitating the shake out[14].

The proposed explanation for the sales pattern in a novel market dominated by one producer is obviously not alternative, but rather complementary to others, supply-centered ones. It shows that the same phenomenon on markets can be reproduced both by features on the supply and on the demand side of markets, though the relative importance can obviously differ in different cases. Even such a simple setting as the one used here we are reminded that in novel markets the necessity of consumers to learn how to evaluate products is sufficient to (contribute to) generate a well known and robust phenomenon.

3.3 Monopoly with errors

As a second exercise, let's consider an identical set up as in the previous example, but we limit the maximum level of expertise that consumers are able to reach, causing even expert consumers to make (small) errors in evaluating products' qualities, that is $\Delta_\infty^i = \lim_{t\to\infty} \Delta_t^i > 0$.

The results, reported in Figure 5, show that the "monopolist" is not able to reach 100% of the market, although enjoying a market share higher than competitors'. The obvious reason is that buyers continue to make errors in judging products' quality, although with lower probability than in the early stages of the market. This may be due to either an

[14]Another conjecture may suggest in a link between the timing of the shake out and the timing of the saturation of the market. However, available evidence (Klepper, personal communication) shows that after the shake out usually markets continue to grow at considerable rates.

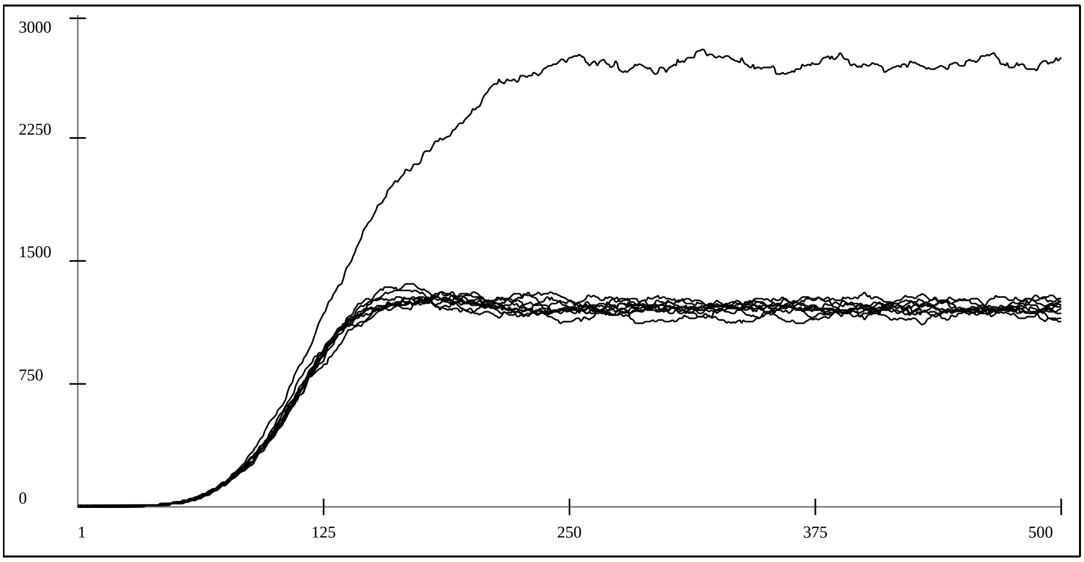


Figure 5: Installed bases dynamics for monopoly with limited learning. Consumers cannot reach perfect capacity to observe products' qualities, $\Delta^i_\infty > 0$.

objective difficulty in comparing products, or to scarce interest by consumers in spending time and attention to learn how to precisely assess products' relative quality.

Interpreting the "error" parameter as a measure of the variety of consumers', we may consider this result as produced by the distribution of consumers' tastes applied to the different products. In any case, this exercise, however trivial, shows that the model proposed is able to represent the evident and widespread empirical evidence of persistent positive market shares of several products, something that traditional demand models, based on the assumption of homogeneous products, have troubles to justifies: why should a consumer opt for a product when there are identical cheaper alternatives? As we will see, there are many and relevant considerations about market shares distribution across heterogeneous products. However, in this setting we are still close to the "classical" case of homogeneity, since we have one single product dominating all the others, but still we see consumers choosing the dominated products, that is, making objectively "errors" violating the utility maximization principle. Is this an aberration, that economists should rule out, or a real possibility?

In the economic literature it is frequent the case of referring to random errors producing dominated choices as "bounded rationality" , as opposed to the perfect rationality of agents who consistently maximise their utility function, although this distinction is technically incorrect[15]. Besides philosophical disputes, a more practical literature has long noticed the existence of (apparently) non-optimizing consumers. For example, the marketing literature has suggested that in many product categories seems to exist a "minimum market share" (Karnani, 1983), that is, a share of consumers who would buy practically any product, however poor in quality and highly priced, clearly due to a number of consumers with very little commitment in their purchases. Also, experimental economists are used to observe a small (but consistently positive) number of respondents opting for evidently dominated choices, usually dismissed as irrelevant and due to distraction or technical errors.

[15]Bounded rationality refers to the procedures used to reach a decision, independently from the features of the eventual choice. Conversely, perfect rationality is defined in terms the nature of the decision made, independently from the decisional process producing it. Therefore, the two concepts are disconnected, and potentially even compatible, as in the case where a computable routine brings about an optimal decision.

A mainstream economists may sustain that these observations do not necessarily imply a confutation of utility maximising behaviour, since the decision maker may include in the utility function as costs the time and attention required to avoid dominated choices. Consequently, buying a poor and expensive product can still be classified as optimal behaviour.

Concluding, besides interpretative issues, it seems that at least a fringe share of real-world decision makers fails systematically to abide to the optimizing principle. This exercise, although mainly motivated to introduce the reader to the interpretation of the model results, shows that the proposed model can generate a common and persistent phenomenon as reported in many contexts, and explain it by the same logic, confirming the capabilities of the model to properly represent the demand for a generalized market.

3.4 Monopoly with quality tolerance

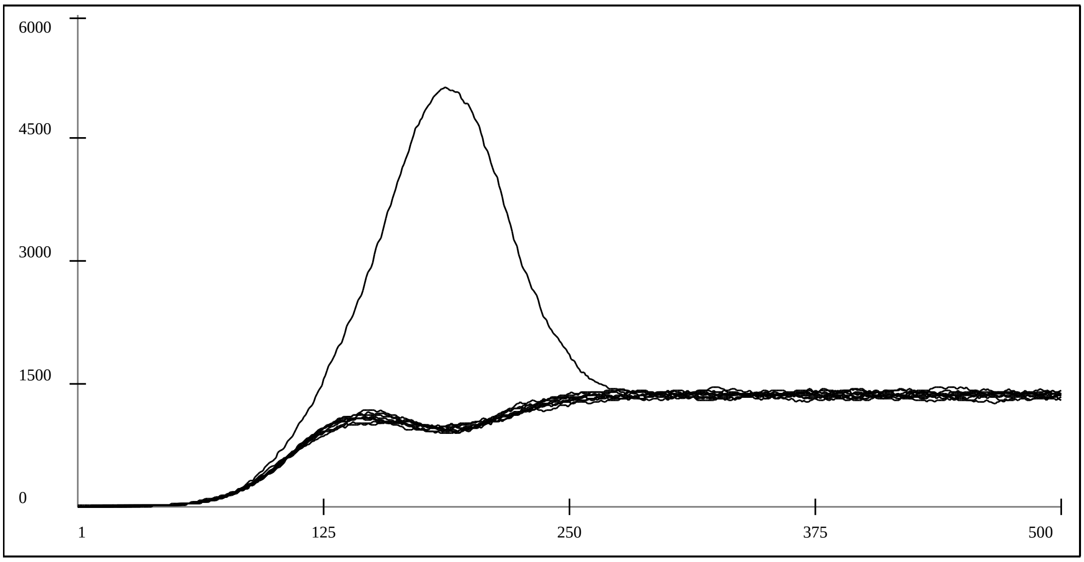


Figure 6: Installed bases for monopoly with perfect capacity to appreciate small quality differences ($\Delta^i_\infty = 0$) and positive tolerance, $\tau > 0$. Consumers consider the quality difference of the best product as not relevant, whence they are able to perfectly appreciate the true quality levels of products. However, in the medium term the positive level of Δ^i_t's produces high chances that (slightly) higher quality product appears as significantly better, consequently boosting its market shares.

In this exercise we consider the effect of parameter τ. We use the same set up as in the first exercise: all products identical, but for one superior to competitors', and buyers allowed to reach perfect capacity to judge products in the long term. However, the value for τ is set to 20%, consequently making irrelevant for consumers the difference in quality between the best products and the others.

As expected, the level of installed base series in the long term (the final steps of the simulation) is identical for all products (see Figure 6). In fact, at this point, all buyers are able to acknowledge that the higher level of quality of the best product is not relevant, and therefore choose randomly among all available products, generating practically identical shares for all products. However, this final configuration is reached after a period in which the share of the (slightly) superior product is systematically higher than competitors'. This phenomenon is due to the combined effect of the errors made by buyers and by the tolerance. Although the actual difference between the quality of the best product and the others is within the tolerance margin, when buyers are still making errors (relatively high Δ_t^i's) it is possible that the observed values of qualities have a larger difference than in reality, passing the tolerance level and appearing therefore as relevant for a decision. Although errors can be made in both direction, the probability that the difference between the two products is superior than the threshold τ is much higher.

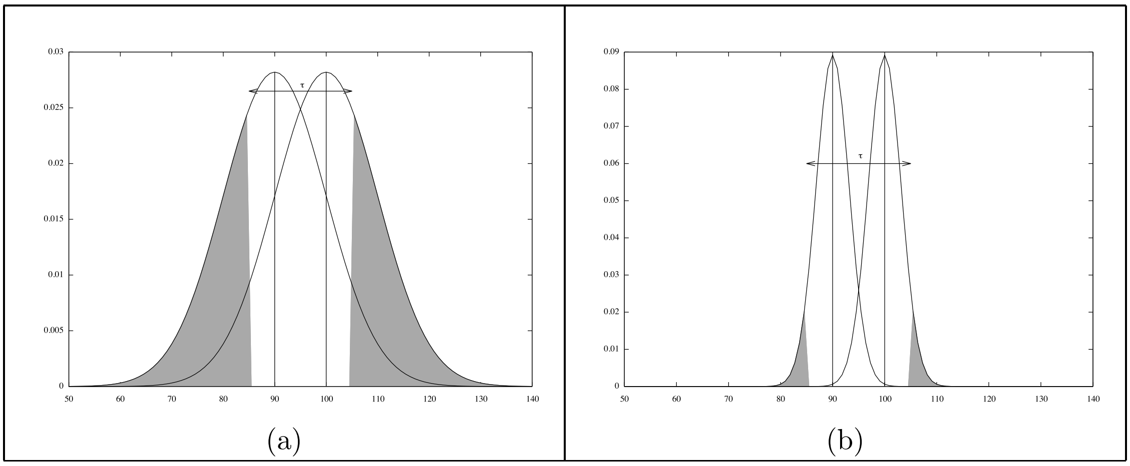


Figure 7: Example of areas producing the apparent significant superiority of actually equivalent products, in case of high (case *(a)*) and low (case *(b)*) Δ_t^i. The horizontal axis reports the quality of two products, one set to 90 and another to 100 (marked by the vertical lines). The vertical axis reports the probability distribution function of the perception of qualities, determined by the error Δ_t^i. The grey areas represent therefore the probabilities that the product with quality 100 appears as superior to the product scoring 90, even though the tolerance threshold τ is larger than the true quality difference.

Figure 7 provides an intuition of why this is the case. The two graphs report the probability distribution functions of the quality levels observed by a consumer, centered on their true values. The horizontal distance between the two grey areas represents the tolerance level τ, while the grey areas represent the probability that the quality difference between the two observations is larger than the tolerance, and therefore significant. When consumers are allowed to make large errors (high Δ_t^i, as in case (a)), then the the probability of mis-interpreting the distance as superior to the tolerance level is rather high. However, while consumers increase their expertise, and Δ_t^i decreases, the probability of interpreting the quality difference as significant decreases.

This effect has an obvious interpretation, and a quite counter-intuitive consequence. The interpretation is that when buyers are not perfectly able to judge products' qualities, they tend to favour higher quality ones, even when this superiority is, in fact, so small that it shouldn't make any difference. Empirical examples of such effect are plentiful, though indirect. Though it is hard to measure consumers' "errors", we can find indirect evidence in the commercial behaviour of competing firms promoting aspects of their product that, in fact, have no practical relevance. For example, in a recent past the two processors makers AMD and Intel engaged in the technological race to dominate the supply of processors for PC's. The two companies used to make grand statements about minimal clock speeds' superiorities of their processors, which no user would have ever been able to appreciate. The same applies to many commercials concerning hi-fi systems, where producers advertise distortion levels very far below the audible threshold.

It is worth to note the counter-intuitive consequence of this phenomenon. We may state that producers of superior products take advantage of not informing perfectly their customers, so that they have sufficient information to know that one product is better in some respect, but not sufficient knowledge to assess the relevance of such superiority. This is, in effect, what frequently happens: in their technological race, Intel and AMD claimed alternatively to sell the "world fastest processor", not that theirs chips offer 1000 MHz while the competitor's reaches only 999 MHz...

3.5 Natural oligopoly

Let's see now the effects of preferences formation, starting with a very simple model of market segmentation producing what we may call a "natural" oligopoly, that is, a market configuration defined by the exogenous features of the supply side.

Consider a market where products are differentiated, and each of the 10 competing products has the highest quality in respect of one of the 10 characteristics, and the producer adopts the consequent marketing strategy of giving high importance to its best quality. Consider for simplicity of exposition that firm i is specialized in producing products with the highest value on characteristic i.

The demand is formed by consumers who, as in the first exercise above, learn (with time) to perfectly observe the true products' values and discard a product for even minimal quality values differences, that is, $\Delta^i_\infty = 0$ and $\tau = 0$.

Because of the lack of tolerance, consumers in practice will make use of only the very first characteristic. In fact, since there is only one firm with the highest value on each characteristic, the modified TTB will be interrupted at the first cycle, returning the products appearing as superior on the characteristic topping the ranking of the consumer preferences. Therefore, when Δ^i_∞ approaches 0, product i will be systematically chosen by all the consumers having characteristic i at the top of their preferences.

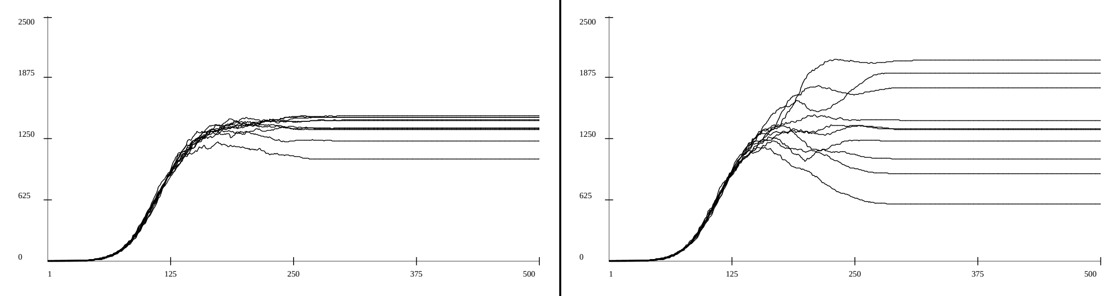
Reminding how preferences are constructed, the distribution of the top ranking characteristic of a consumer depends on the index $p_i = \sum_{j=1}^{n}(k^i_j s_j)^\delta$ at the time of entry of the consumer, i being the characteristic and j the index for all the n firms. By construction, the marketing strategies are identical for all firms, with k^i_j taking a low value when $i \neq j$ and high when $i = j$. Consequently, the market shares s_j and parameter δ determine the probability for a characteristic to be chosen as top characteristic in a consumer's preferences[16].

At the early stages of a simulation run, consumers, by definition, have high values of Δ^i_t, therefore, in practice, any product has the same chance of appearing as the best in respect of any characteristic. Consequently, we expect that the market shares of all firms will be roughly similar, generating consumers' preferences randomly distributed, as shown in figure 8.

In both figures we observe that at the end of the simulation the install bases for each firm remain constant, indicating that each consumer replacing a product will choose to buy from the same producer. This is because when a consumer reaches a level of expertise such to perfectly observe the true products' qualities, it will consistently choose the firm with the highest quality on the characteristic topping its preferences. Therefore, the market distribution we observe reflect the distribution of the characteristics across the top position of preferences among consumers.

The difference between the two figures highlights the role of the δ: exalting or reducing the impact of market shares differences on preferences' formation. In our model consumers tend to heed the marketing strategy pursued by the most popular firms, as measured by market shares. The parameter δ determines how strongly the combined effect of marketing

[16] We adopt the additional rule that when $s_j = 0$, as may happen at the early stages of the simulation when few consumers have entered the market, the value is replaced with a small, but positive, value s_{min} to allow for a positive chance of the firms' j marketing strategy to be considered.



(a): Low δ (b): High δ

Figure 8: Installed bases for specialised producers. Each product has one characteristic higher than competitors', and focuses its marketing on that characteristic. Low δ simulation (a) has lower concentration, while high δ has higher concentration

strategies and market shares affect a consumer decision on preferences. For example, when δ is close to zero consumers basically choose randomly the order in which to rank the characteristics for their preferences, paying no attention marketing pressure. Conversely, for high values of δ consumers adopt precisely the preferences promoted by the firm enjoying the highest market shares.

Since the model considers only the marketing effect on preferences formation, when δ is set to a low value we obtain very similar distribution of top ranking characteristics, and consequently high levels of dispersion, as in figure 8(a). Conversely, high levels of δ generate a self-reinforcing mechanism by which firms enjoying initially a slight advantage for random reasons manage to get a higher number of consumers adopting their favoured preferences, which further increases their market shares and consequently also the effectiveness of their marketing campaigns. The result, shown in figure 8(b) is to generate a more concentrated market, due to the higher homogeneity of consumers' preferences.

This phenomenon is similar to the effect produced by increasing returns to adoption (Arthur, 1994). That is, if products' quality is a function of the number of users, then the market will concentrate on a single product even if there is no objective reason for preferring it against competitors'. The same effect has been studied in Smallwood and Conlisk (1979) concerning the capacity of markets to identify the best product inducing this information (not available to single consumers) by the aggregate behaviour of markets. Such mechanisms are known to generate a widely diffused phenomenon of *path-dependency* (see, e.g. David, 1985). However, in our case the path-dependency generated does not concern directly the outcome of consumers' decisions, as in the cited cases, but rather the *criteria* applied to reach a decision, that is, the preferences. Such phenomena are likely to be more relevant for goods having a relevant social impact, such as fashion goods.

4 Market Segmentation

In the previous exercises we have built-in a market configuration (that is, the eventual distribution of market shares) by defining an *ad hoc* supply side, before as a monopoly and then as a "natural" oligopoly. In this section we move the general case where no specific effect is embedded in the supply. Anticipating the results, we will identify two different forms of market segmentation, that is, of persistence distribution of market shares. These two types of segmentation constitute two extreme cases with radically different properties, in particular in respect of the results one can expect by modifications on the supply side, as those resulting from innovations or price changes. Crucially, the two types of segmentation will be shown to be observationally identical, if one limits to collect only data on market shares distributions and suppliers features only. Yet, the same products will rank differently in the two cases, and the normative implications for a firm willing to increase its sales will also be different, proving that the analysis of the demand side, determining which of the two segmentation types actually occurs, is determinant to properly assess the market.

In the two exercises we use an identical supply side composed by 100 products. Each product is assigned random values, in a given range, to the characteristics' qualities of products and to the marketing strategies. As before, consumers enter the market following a contagion diffusion, forming their preferences at the time of entering the market. Concerning the formation of preferences we use a low value of δ that, coupled with the randomly determined marketing strategies, generates an evenly distributed ranking of characteristics in consumers' preferences.

4.1 Segmentation by approximation

For this exercise we assign consumers a null level of tolerance, $\tau = 0$, meaning that consumers discard all products that are even minimally inferior in respect to the characteristic used for evaluation. Since we are using real-valued random values, this implies that, in effect, consumers decide on the basis of one single characteristic, ignoring all other aspects of products. Therefore the number of characteristics used as product space, 10, equals the effective types of preferences, or, in other terms, the number of consumers' classes. Consequently, each consumer can be associated to the characteristic he or she uses to made purchasing decision, choosing the (apparently) best product on that characteristic and neglecting any further information.

The defining feature of the setting we consider here is the "error" parameter Δ^i_∞, which we set to a small but positive level $\Delta^T > 0$. This means that even expert consumers (in our model, those that have been using the product for a long time) continue to make small errors[17] when observing the qualities of products, therefore having the chance to select as "best" product in respect of a characteristic one that is, in effect, inferior. Figure 9 shows the series of install bases resulting from this setting.

Besides the usual initial confused period, the final configuration as emerging in the last stage of the simulation is both varied and relatively stable. It shows that most of the 100 firms enjoy a positive market share (more than 80 firms have at least a few customers at each period), and that the overall dimension of the firms' shares remains roughly constant, besides small random variations. This is surprising given that there are only 10 different "segments" of consumers, each choosing only on the base of one single characteristic. One may have expected that, as in the previous exercise, the 10 firms scoring highest in respect of each characteristic serve the bulk of consumers caring for that aspect of the product, with, possibly, small levels of sales for second-tier producers able to attract "outlier" consumers. Actually, this is what happens in case the limit error parameter Δ^T is set to a much smaller values. Instead, the results produced with small, but not infinitesimal, values of this parameter demand some further consideration.

Studying the distributions of consumers' choices we find that each firm is able to serve customers that opted for it because of different reasons, that is, consumers members of different classes, or having different preferences. Also, consumers' with the same preferences

[17] The quality levels for products are chosen randomly in the range [90:110] and $\Delta^T = 1$, implying that the perception error has a variance of about 1% of the average quality.

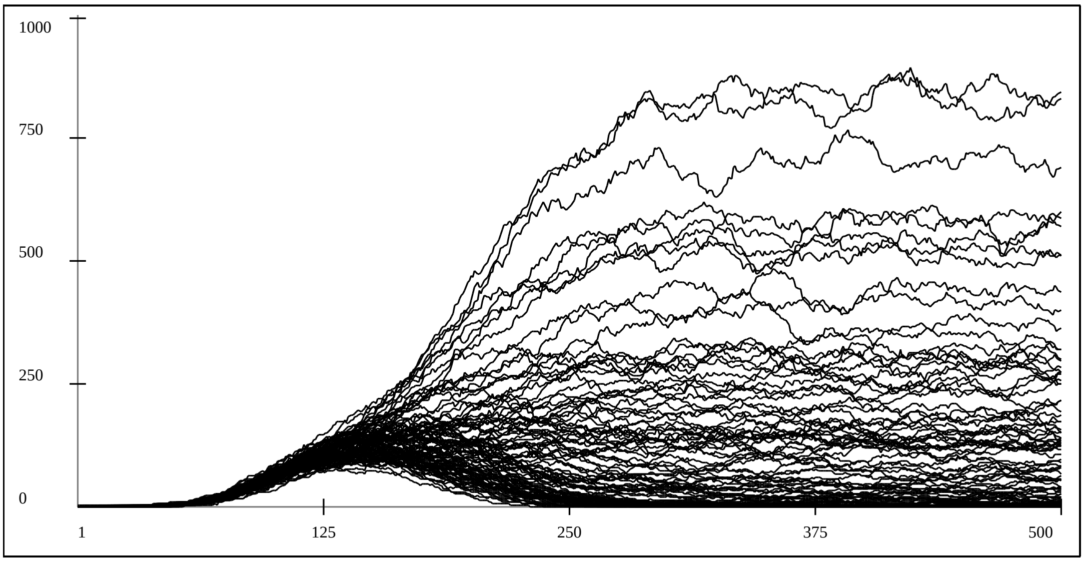


Figure 9: Market segmentation by approximation. 100 firms are assigned random values for quality and marketing strategies. Consumers are set with $\tau = 0$ and, even in the long term, a limited capacity to read product's values, $\Delta^i_\infty = \Delta^T > 0$.

are spread over a number of different firms, and at each purchase a consumer is likely to switch to different firms, with probabilities proportional to the relative values of products in respect of the characteristic used by the consumer. Consequently, the customers of any given firm will be both a varied (they chose the product for different reasons) and with low fidelity, because of the relatively high probability that they will switch to a new supplier at the next purchase.

This distribution of customers across producers is therefore a form of market segmentation, because an external observer, looking only at the levels of firms' shares of the market, would acknowledge the relative stability of the distribution. Looking at the detailed composition of each firm's demand, we see that it is made of "simplistic" consumers', each of which search for the best products in respect of one dimension only, and the relative dimension of each firm is due to the sum of different consumers considering its product as the best across many, if not all, characteristics. The segmentation of the market across the different products is therefore formed by slices of consumers that, by approximation, choose a product believing it as the best on a characteristic.

The above considerations on the type of customers in this market allow to derive relevant consequences. For example, in this settings it may be advantageous for a producer to pursue a generalist technological policy, aiming at scoring among the best in as many characteristics as possible, as opposed to a specialist policy aiming at offering the best product in one dimension, but scoring very poorly on most of the others. In the former case, a generalist is able to gain sales from many different classes of consumers. Conversely, a specialist would limit its appeal to only a single class of consumers, and, given the impossibility of consumers' to fully appreciate the true quality values, there is also the risk to not being able to capture all members of this class. Assuming a firm can decide which characteristic may be improved by investing R&D resources, the decision can be based on the analysis of the relative strength of the currently offered product in respect of competitors and on the dimensions of the classes of consumers adopting each characteristic as the sole decisional criterion.

4.2 Complex Market Segmentation

In this second experiment we set the "error" parameter Δ^i_∞ to zero, allowing consumers to perfectly observe the true products' qualities, after the usual initial period. Differently from the previous case, however, we impose a small, but positive, level of "tolerance", setting $\tau > 0$, assuming that consumers avoid discarding a product only for minor differences with the best value on a characteristic. According to the TTB algorithm, the likely cases of equivalence arising from the application of the top ranking characteristic are resolved using other aspects of the products, until a single product is selected. The result is that, differently from the previous exercise, consumers use more than one single characteristic to reach a decision; with the setting adopted on average consumers use 2.4 characteristics to identify the product to purchase at each round of application of the TTB algorithm.

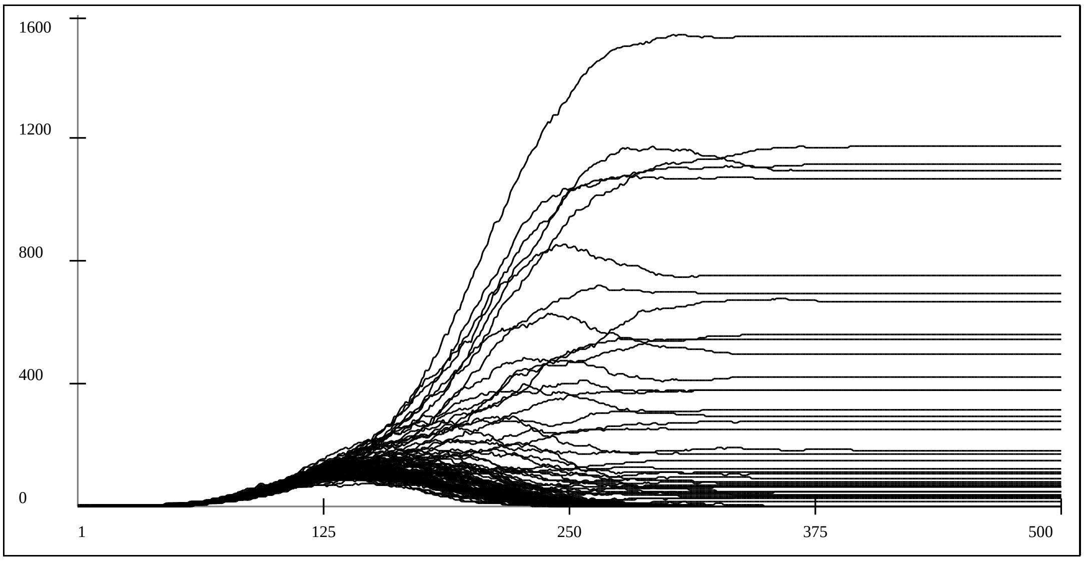


Figure 10: Complex segmentation. 100 firms are assigned random values for quality and marketing strategies. Consumers are set with $\tau = 0.02$ and with perfect capacity to read product's values, $\Delta^i_\infty = 0$

Comparing the results obtained with this settings (figure 10) with that from the previous exercise, we immediately observe one similitude and one difference. Both results report a similarly dispersed distribution, with many firms enjoying positive market shares. Moreover, both graphs show the stability of the distribution in the last stage of the simulation, with the only difference that in the second graph the series of installed bases for firms are perfectly stable, without the small random variation observed in the previous case.

The reason for the stability of firms share in this second exercise is that each consumer chooses deterministically the product to buy, after its Δ^i_t reaches 0. Consumers, at this stage, can perfectly read the true products' values, and therefore, applying a deterministic routine, choose consistently the same product at any purchase, causing producers to have a perfectly loyal set of customers.

Besides this technical and evident difference with the previous case, there is also another far more relevant, though less evident, difference: the composition of a firm's customer base.

The decisional mechanism represented by the modified TTB brings generally two different consumers to choose different products even though they are selecting upon the same product characteristic. To understand why this is the case it is necessary to analyse in detail the decisional mechanism adopted, the TTB modified with the concept of tolerance, or equivalence of high-value characteristic qualities with the highest values.

As described above, the decisional algorithm can be interpreted as a succession of rounds during each of which one characteristic is used to remove from the potential set of products those scoring less then optimally on that characteristics. At the very first round all products are included, and therefore the ones surviving are those that score optimally on a global scale, in respect of the characteristic used. Conversely, those surviving at the later rounds are the best ones among those that already survived the previous rounds. When a decision is made it is because one single product scores best in respect of the characteristic used for the current round. It is very likely that the chosen product will not be the absolute optimum, because the latter is likely to have been removed in previous rounds[18].

Consumers can be expected each to have different preferences, because of the sheer number of possible preferences using 10 characteristics[19]. Therefore, any two consumers reaching a decision by using the same characteristic are likely to have passed previous rounds using different characteristic. Therefore, their set of products on which they search for the optimum will differ, and will reach a different decision.

The overall result is that many firms manage to find a segment of the market that consistently choose their product, but each consumer choosing a product will likely provide a different motivation from other consumers choosing the same product. The number of firms with positive sales will be much larger than the number of characteristics used, even though each consumer can be claimed to have decided by selecting the best product by using one of the 10 characteristic. Only, each consumer is likely to have reached that stage after a different winnowing process.

Again, as above, many theoretical and practical consequences can be derived by the consideration on how the market configuration is generated by the setting used. From the theoretical perspective it is interesting to note that the crucial competition battle is fought on secondary aspects. In fact, suppose that, differently from our setting, all the consumers' share the same initial part of their preferences, that is, consider the same set of characteristics as of primary importance. Suppose also that all firms score similarly on these characteristics, because, say, a dominant design has been imposed by previous competition stages. This may be, for example, the case for the market for cars in a given segment, where type of engine, product design, etc. are well standardised. In these cases the model justifies the insistence of producers to battle on secondary aspects, such as electronic gadgets, aesthetics, "brand" attractiveness, etc., rather than minor improvements on core aspects.

The model also suggests that a firm willing to improve its competitiveness level, in our case limited to increase its sales, would need to study where best to introduce quality improvements on the basis of the competitors' own qualities and the type of demand they are facing. It may be possible that the firm's weakest aspect is responsible for consumer to discard it at the earlier rounds, and therefore this aspect would be worth to improve. But is is also possible that the weakest aspect is actually never used by most consumers', and therefore there is little reason to improving it. Only a detailed analysis of the firms' customers decisional processes can provide indications on how best to design an innovation policy. Crucially, such analysis requires a firm to consider not only consumers' preferences, but also to compare its own product with that of competitor, implying that

[18]Only a product scoring optimally (or equivalently) on *all* characteristics would be sure to be chosen by all consumers. But this is a quite unlikely case both in practice and in our settings, where 100 firms are initialized with random values.

[19]Being $n!$ the number of n elements permutations, the possible preferences are $10! = 3,628,800$.

different policies are required depending on the current states of competitors'.

4.3 Demand matters

The goal of the two experiments discussed above is obviously not to generate realistic data sets to be compared with real-world samples. Rather, they are meant to support the claim that limiting the analysis to the state of suppliers makes impossible to properly understand core aspects on the markets, such as expected effects of a given product modification and nature of the sellers' customer base. We showed this by using the same supply side facing two different groups of consumers'. Though the overall results where broadly similar, in terms of market shares distributions, the nature of their customer bases are shown to be very different.

Such comparison amounts to a sort of "dynamic" difference of the two settings, since we showed that the difference between the two markets concerns the likely reactions to a change, such as an innovation in one aspect of a product. However, the two results differ radically also on a more basic respect: the market distribution among firms and their relative ranking. In the following we are going to show that the two markets, though appearing similar in terms of distributional properties, actually reward different types of firms, so that the winners in one case are only secondary actors in the other case. This amount to a static difference that does not depend on the suppliers features, nor to the consumers' tastes and preferences, all identical in both cases, but exclusively to the procedures applied by consumers to reach a purchasing decision.

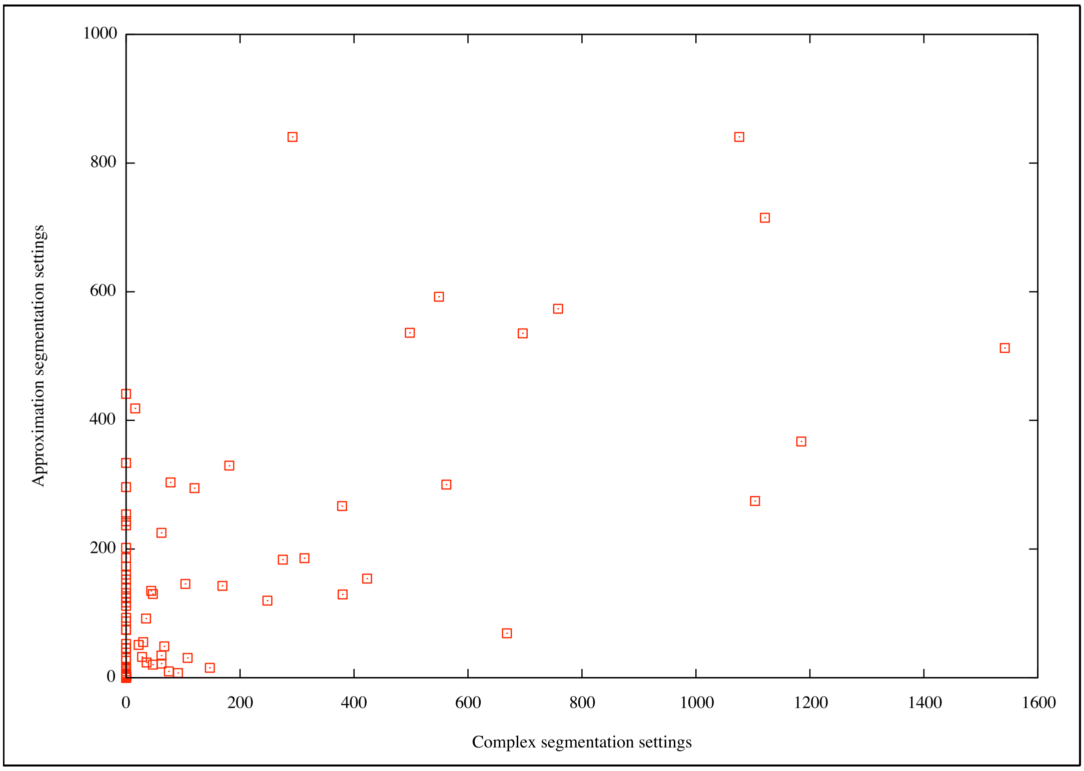


Figure 11: Demand-based differentiation. The figure compare the results produced with identical supplies, that is, set of firms and their products' qualities, but different setting for consumers. The graph plots a point for each firm in the model, where the co-ordinates report the average installed base values at the end of simulation runs as produced by the complex segmentation setting on the horizontal axis (data from figure 10) and segmentation by approximation setting on the vertical axis (figure 9).

Figure 11 reports the average installed base level for each firm obtained within the two experiments. Each point in the plot corresponds to a firm, with the horizontal axis measuring the firm's install base value for the setting "complex segmentation" (positive tolerance level), and the vertical axis measuring the same value in the "segmentation by approximation" setting, where the error parameter is positive. In both cases the last values of the simulations are used[20], in practice taking the final values from the two figures 10 and 9 respectively.

If products' features only were responsible for the configurations produced, and the different demand settings were only different means to reach the same eventual result, we would expect to find the points in the graph roughly aligned on the 45° diagonal. Conversely, the graph shows that, though a weak positive relation does exist, the points spread across a rather wide "cloud", with many points placed far away from the diagonal. For example, on the low-left side of the graph we see many firms enjoying positive, and even substantial, segments of the market in one case, but failing to conquer any customer at all in the other. Also, the best selling firm as measured on the horizontal axis is only a second-tier player when measured on the vertical axis, making half the sales of the best selling competitors.

By comparing the widely different results that many firms obtain in the two settings, it is clear that different profiles are required for a firm to succeed in the two cases. Moreover, we constructed the experiments by considering two extremely opposite cases, where tolerance only and "error" only affect consumers' decisions. Obviously, there is the full range of intermediate cases in between these two extremes, where both effects are relevant with different levels of intensity. As far as this work is concerned, however, it is sufficient to show that different demand features do matter for properly assessing the states of a market, and that not only tastes and preferences affects consumers' decisions, but also the actual purchasing procedures adopted.

5 Conclusions

The major goal of this work is to state that "demand matters", particularly to the studies of industrial dynamics preferred by much of the evolutionary economics literature. More precisely, demand matters not only because exogenous tastes and preferences ultimately determine success and failures of firms, but also because *how* consumers reach their purchasing decisions, given any exogenous factor, radically affects the overall properties of markets.

We propose a simple and general model for consumers' decision making. The model is aimed at representing consumers as boundedly rational agents, and is designed to deal with multi-dimensional products/services, as required to represent consumers in studies entailing heterogeneous products and product innovations. The model, reminiscent of lexicographic preferences, is a modification of a proposal originally developed in the experimental psychology literature, and it is based on the evidence of how people actually performs decisions under uncertainty. The proposed model is very simple, and its behaviour is governed by few and intuitive parameters. Moreover, the proposed model structure naturally leads to a clear definition of preferences, meant as decisional criteria, and distinguished from actual purchasing decisions.

The paper describes the properties of markets comprising demand sides made of consumers represented by such model. We have discussed three theoretical applications, meant

[20]For the segmentation by approximation setting the figure reports the average values for each firm over the last 100 steps, to smooth away the small random fluctuations.

to support the claim that the proposed model extends the insights of market properties.

Firstly, we showed how the proposed model for consumers correctly respects the basic tenets of a demand function, with the advantage that it applies to multi-dimensional product spaces. In such respect, the proposed model proves to be compatible with existing economic literature.

Secondly, we presented a set of experiments devised to highlight individual features of the demand represented with the proposed model. These examples clarify how markets are affected by the options available in the model. These results provide the opportunity to show how the explanations justifying the theoretical results match closely the analysis of a few empirical events, supporting the importance of demand's decision making in shaping markets and the capacity of the proposed model to properly represent consumers' behaviour.

Lastly, we deployed the demand model in a more challenging setting, considering a large number of firms initialized with random values to ensure a large degree of variety. Using the same supply side we described two experiments differing for the type of consumers composing the demand. These exercises allow to individuate two distinct mechanisms of "market segmentation", that is, of how consumers distribute across available products. The two resulting configurations would be indistinguishable, if one limits the analysis to the state of the supply side (identical in both cases) and to the distributional properties of observed market shares, whose aggregate properties are substantially identical. Conversely, we show that the two settings generate very different results, and would be a gross mistake to interpret the resulting markets as equivalent, both in terms of empirical and theoretical analysis.

We envisage two types of developments from this contribution. Firstly, the proposed model for consumers is an early proposal, and more research may lead to more elaborated versions, testing its validity in different contexts and for different purposes. Given the simplicity of the model it is quite easy to individuate the parameterisation required to adapt the modified TTB to any specific application. As an example of this kind of development, the model presented here has already been used in two works. One concerns the role of demand in hindering or promoting the development of green technologies (Bleda and Valente, 2009), allowing the analysis of how different policy initiatives may help to overcome technological and competitive obstacles to the diffusion of environmentally friendly technologies. The second concerns the relations between structural changes on the supply and demand side of macro-economic systems (Ciarli *et al.*, 2009), highlighting the links between growth, inequality, organizational and technological change.

The second development concerns the role of demand in theoretical and empirical analysis. Theoretical analysis, we suggested, has exceedingly focused on the role of producers, neglecting the contributions of demand even in cases where it should be as a central issue. For example, a long-standing debate concerns the remarkable phenomenon of the skewed distribution of firms' size commonly observed on many markets (Simon and Bonini, 1958). Most of the contributions focus on the properties firms' growth, discussing the functional forms generating results more closely related to empirical evidence. However, firms' size ultimately depends on customers' decisions, and therefore it is well possible that demand's features are a crucial, if not exclusive, justification of the observed distributions[21].

Concerning empirical analysis, the vast majority of works collect data by adopting

[21] For lack of space we did not discuss an intriguing result from the simulations in section 4. Both the experiments report a skewed firms' size distribution. Since there is no technological change, the only explanation resides in the distribution of firms' qualities and consumers' behaviour. We could therefore conjecture that the skewed size distribution is actually rooted in the distributional properties of demand.

supply-oriented criteria for statistical classifications, so that firms producing products in the same category are supposed to be direct competitors. However, when considering actual demand, in many cases we find firms member of the same class, though sharing the same technology, are very likely not being direct competitors, such as, for example, Ferrari and Fiat. Considering the data from firms in the same class as influenced by direct competition is not only wrong, but can also lead to statistically robust absurdities. For example, one may be able to show, with only a minimal level of econometric carelessness, the absurdity that more successful firms tend to decrease in size in respect of less successful ones. To show how this conclusion may be reached consider the very narrow category of "Motor Vehicles and Passenger Car Bodies", SIC code 3711. As a four-digit category this is very likely to be the finest classification any database may hope to permit. Yet, if this classification is used assuming all firms in the class to be competitors, then the results are very likely to be heavily biased. In fact, this class includes producers such as Rolls Royce and Ferrari, but also, say, Toyota and FIAT. Obviously, defining competitors as firms appealing to the same households' share of income, the first firms are definitely not competing with the second, and the results omitting this consideration may be absurd. A researcher may be tempted to interpret cross-section results as an indication of likely dynamic tendencies, as frequently done when available data concern short time periods. In this case, a regression between profitability (say unit profits) and unit sales is likely to show a clear, statistically significant negative relation, concluding that the most profitable firms will tend to decrease in size, and, viceversa, low profits leads to higher growth.

This last (admittedly extreme) example, as those presented throughout the paper, supports the central claim of this work: demand is a crucial, and too frequently neglected, element of economic analysis of markets. Ignoring the demand contributions to the explanation of observed phenomena is, at best, limiting the analytical power and, at worst, producing false and misleading results. We have proposed a consumers' model aiming at explicitly implementing a fully fledged demand side in markets for heterogenous, multi-characteristics products. We hope that more researchers in future will explicitly consider the demand-based aspects in their works.

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