

## Chapter 2

# The Economics of Variety

In this chapter, I review the theoretical basis for the economic analysis of variety. The goal of this chapter is twofold: I want to position critically my work and developed few useful concepts. In particular, I will describe two approaches to the issue of variety and point out their different conclusions on the nature of variety generation and its limits.

### 2.1 Variety Generation in the Product Life Cycle

A first approach stems from Abernathy and Utterback (1975, 1978) who tried to explain some stylised facts about the industrial and technological dynamics in the automobile sector.

In the early days of an industry there is a wave of new entrants whose aim is to take advantages of opportunities to sell various versions of the new artefact: few of them succeed and grow rapidly and many die and are replaced by new entrants. In this first phase, opportunities and turbulence are high, concentration low. Thereafter, the market stabilizes, entry slows, the number of firms reaches its peak and a slow and continuous shake out occurs reducing drastically over time the number of extant firms. Together with this process there is a shift from product innovation to process innovation (Klepper 1996).

Several theoretical reasons have been given for this story. Abernathy and Utterback (1978), provided the first and the most influential explanation. They suggested the idea of a dominant design linked with a technology life cycle underlying the development of the industry.

When a new technology emerges, the environment is characterised by high uncertainty about how the technology can satisfy users' requirements and users themselves are not well aware of their needs. In this phase, there is lot of experimentation and learning, and product innovations are frequent (Burns and Stalker 1966). Moreover, uncertainty about the future development of the industry restrains firms from investing in process technology, which is not easy to redeploy. In this fluid phase in the automobile industry, there were attempts to produce

petrol, electric, and steam engines. It was uncertain whether the internal combustion engine would become the standard in the end (Abernathy 1978).

The interplay between depletion of technological opportunities on the firms' side and determination of preferences on the demand side serve to select a standard version of the product, the dominant design in the jargon of Abernathy and Utterback. Dominant design is *a specific path (...), which establishes dominance among competing design paths* (Suarez and Utterback 1995, p. 416).

As described in the model developed by Abernathy and Utterback, when a radical innovation emerges, before the industry finds a satisfactory compromise between form and context, there is a period where different designs are competing (Abernathy and Utterback 1975). Competing on design means to find product attributes that best fit with demand requirements. The Model T Ford did not emerge as dominant design because it was cheaper and more robust than the other cars *ceteris paribus*, but because Henry Ford decided that the product design had to focus on cheapness and robustness, rather than, for instance, aesthetics, comfort, and originality.<sup>1</sup>

Once a dominant design has emerged, only the firms able to produce it efficiently will survive, there are fewer entrants because entry barriers became higher and, therefore a shake out occurs. From the technology side, there is progressive shift from radical to incremental innovation and from product to process innovations. The last phase of the industry is the maturity: only few marginal changes are made on the product, competition is based on price and, therefore, on cost-cutting technologies improvement. The few firms left are those big companies with a large market that allows them to exploit economies of scale. It has been later acknowledged that the distinction between radical and incremental innovation was incomplete in the mature phase of a cycle and the dichotomy between architectural and component innovation was introduced (Henderson Clark 1990). A component innovation involves modification of a part of a sub system, that leaves the existing structure unchanged. On the other hand, *the essence of an architectural innovation is the reconfiguration of an established system to link together existing components in a new way* (Henderson and Clark 1990, p. 11).

The success of the Product Life Cycle (PLC) theory is due to its powerful simplicity in accounting for many stylised facts of industrial dynamics. It can be used by consultants to assess the strategic position of firms<sup>2</sup> and by evolutionary economists who coupled the idea of dominant design with that of technological trajectory (Dosi 1982). Dosi talks about *reciprocal consistency* between Abernathy and Utterback and his own thesis as common.

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<sup>1</sup> Consumers perceived the car as an strange horseless carriage for rich people. Therefore, competition was based upon comfort as in the most luxuries market segment of carriage industry. On the contrary, Ford offered a new concept of the product (Clark 1985).

<sup>2</sup> For instance the PLC is the underlying concept of the Boston Consulting Group (BCG) Matrix. Stern and Stalk (1998) contains the original contribution by Bruce Henderson on the BCG matrix.

painstaking attempt to construct a non neoclassical theory of technical change capable of giving a satisfactory account of (1) the relationship between economic forces and the relatively autonomous momentum that technical progress appears to maintain, (2) the role of supply side factor... (Dosi 1982, p. 159).

The conceptual proximity of technological trajectory and dominant design is strengthened because PLC theory is intrinsically a theory of lock-in. Clark explained this characteristic by recalling two properties of design. First, the concept of design, as introduced by Simon (1962) and Alexander (1964) can be defined as solution to a given problem. Alexander calls “form” the solution and “context” the problem. Then, he explained,

design is not only a matter of form that should be adequate to the user, but every design begins with an effort to achieve fitness between two entities: the form and its context. [...] In other words, when we speak of design, the real object of the discussion is not the form alone, but the ensemble comprising the form and the context (Alexander 1964 quoted in Clark 1985, p. 236).

The context is defined by consumer needs, whilst the form consists of the attributes embedded in the product. Secondly, Clark explains that the process of searching for a design involves the analysis and the identification of the components of the form and how they may be organised into architecture. These components have different significance in the product and some proceed logically and temporally before others. This process shapes a system that has hierarchical structure where the form of some subcomponents depends upon decisions taken for others at a higher level: major changes cannot occur without alterations to the global architecture. For instance the design of the combustion chamber followed and depended on previous choices about energy transformation, the adoption of internal combustion and the design for power delivery involving the use of pistons (Clark 1985, p. 241).

In the first phase the interplay between form and context is crucial for the process of design, but, after a dominant design has emerged, the form became rigid as consequences of its hierarchical structure. Changes are likely to be incremental within the last level of the hierarchy. Moreover, as time goes by, the hierarchical structure became more branched and incremental change results to be more and more marginal. This is exactly the case of the car that in the beginning it was even possible to convert into a tractor. As put forward by Cebon et al. (2001), this evidence is explained by PLC theory by considering the increasing synergetic specificity both among product's components and between demand and technology. In the case of the car the synergies among components increased and it has been more and more difficult to add parts not designed to fit exactly a car or, even, a specific model. The synergies between demand and technology increased as well: in the early days of the automobile industry, different groups of consumers, like the farmers could benefit from the new product. Thereafter, the design developed specifically to fit the context of car as a passenger vehicle.

Only when architectural innovation occurs, are modifications to the core component of the artefact possible. Always Cebon et al. (2001) suggested that the introduction of modularity could be considered as an architectural innovation that

decrease the synergetic specificity among components and reduces the lock-in effect of the dominant design. If, as seen in the previous chapter, different modules can be added on platform, the range of variety increases. A modification of the single module is easier because it does not involve modification of the core components in the platform.

Though powerful, the PLC theory has some weaknesses. In particular the basic version of the PLC underestimates the role of demand. Nelson (1994) and Porter (1990) doubt that a dominant design can emerge in markets with a heterogeneous demand. Teubal as well as Foray and Gruebler suggest that bifurcation in design trajectories can occur if firms face segmented demand (Teubal 1979; Foray and Gruebler 1990). However the case of automobile has been taken as paradigmatic for PLC theories, which manages to explain the evolution of this industry.

The implications for the generation of variety in PLC theories are straightforward. Variety, in term of different variants of competing products, reaches the peak in the first fluid phase before the dominant design emerges. Thereafter variety is generated by incremental improvements and refinements in the product that follow a relatively technological trajectory. Secondly, these improvements and refinements generate variety only to a certain extent since they involve only components at the lower lever of the design hierarchy. More variety can emerge only if there are architectural innovations that change the structure of the design (Abernathy and Clark 1990). This means that limits in the expansion of variety are endogenous to the product:

Proposition 1: There exist limits in the expansion of variety endogenous to the product.

## 2.2 The Equilibrium Approach to Variety Generation

A theory of generation of variety, *strictu sensu*, in the PLC theory was only an implication of basic considerations about product and technological evolution. Other non-PLC approaches attempt to construct a theory of optimal variety generation. The term product variety is used in this approach to refer to the number of variants within a specific product group, corresponding broadly to the number of “brands” as the term is used in marketing literature or the number of “models” in consumer durable markets (Lancaster 1991, p. 189).

Two bodies of literature are reviewed: models with representative agent and address models. In economics, the theory of variety began as a by-product of the analysis of the deviation from the competitive model (Polo 1993, p. 29). As capitalism evolved, shortcomings in the model of perfect competition became more apparent. A theoretical attack to the Marshallian<sup>3</sup> framework first took place

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<sup>3</sup> Marshallian framework refers to market economies in which every relevant good is traded in a market at publicly known prices and all agents act as price takers (Mas-Colell et al. 1995, p. 307).

in Cambridge during the 1930s, where Piero Sraffa, dissatisfied with the partial equilibrium analysis, in his article “The law of returns under competitive conditions” (Sraffa 1926), decided to shift its research interests away from perfect competition. Similarly, Edward Chamberlain and Joan Robinson analysed oligopolistic industries under the assumption of firms as price-setting entities (Chamberlain 1933; Robinson 1933). In particular, Chamberlain addresses the issue of product differentiation in oligopolistic industries. In his basic work, he describes a model where preferences are referred to the set of all goods. The classical assumption of quasi-concave utility function attributes to the consumer a taste for variety, in the sense that all goods are purchased by each consumer and her utility is higher, the higher is number of products.<sup>4</sup> Demand is homogenous and can be summarised by a representative agent. From the supply side, each firm is a monopolist producer of a distinct good facing a downward sloping aggregate demand curve. However, it is not monopolistic at industry level; an industry is defined as a group of firms with similar cost structure and whose products have a degree of substitutability. The presence of positive profits in the industry, in the absence of entry barriers, pulls new firms to enter the industry with a variant of the product. This event decreases the residual demands for incumbent firms. When the demand is tangent with the average cost curve, price is equal to marginal cost and marginal revenue is equal to marginal cost: the profit for firms and thus for industry is zero, thus entry stops and there is equilibrium. The outcome of this model is that generation of variety is lowered by reduction in the degree of product substitutability, by increased in the fixed cost of production, and by decrease in the market size. Many criticisms can be made about these approaches, including the inappropriate adoption of the concept of the representative agent (Kirman 1989). However one result is important to retain for the following analysis. The generation of variety requires two necessary conditions that agents show a taste for variety and that firms make profit in producing more variety.

Address models, on the other hand, date back to the seminal paper by Hotelling (1929), “Stability in Competition”. The assumptions are rather different from the representative agent model: they assume preferences on the different variants of the good. Consumers can rank them and will buy only the one they perceive as the best. They have heterogeneous preferences and, therefore, rank different varieties of products differently. In order to depict these assumptions, Hotelling describes a model where firms compete on more than one characteristic: for instance, in his paper, they compete on location and price. The model introduced a single dimensional space, a street for instance, where firms can locate to sell their products. The products, although homogenous, differ for the consumer in terms of

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<sup>4</sup> Quasi-concavity in the utility functions implies that a preference relation on a consumption set is convex. That means that, if the commodity bundle  $x$  is indifferent to  $y$ , any linear combination of  $x$  and  $y$ , cannot be worse than either one or the other alone, i.e. a mixture (more variety) is almost preferred. A classic reference is Mas-Colell et al. (1995), [Chap. 3](#). In this body of literature, the most popular contributions are Dixit and Stiglitz (1977), Hart (1985) and Perloff and Salop (1985).

location. Consumers are uniformly distributed along the street and they have to bear transport cost to reach the location of a firm. Under this framework Hotelling state the principle of minimal differentiation, that is that two symmetric firms locate in the centre. It was shown after decades (D'Aspremont et al. 1979) that Hotelling's result was wrong and that the minimal differentiation can be the outcome of a location process only under certain assumptions. However, the importance in Hotelling's contribution was the suggestion of a new way of addressing the problem of product differentiation. Lancaster was the first to develop the idea of Hotelling that the spatial approach can be extended to product differentiation along other dimensions. Lancaster (1966, 1971) developed models where a good can be considered as a "bundle of characteristics" and these characteristics became the unit of the analysis. Consumers express their preference on characteristics, not on the good.

Qualitatively these models have the same outcome as the monopolistic competitions' models: variety depends negatively by substitutability and fixed cost. However, they add an important feature. If in Chamberlain's model a larger market predicts an increase in variety, this outcome is ambiguous in address models. In these models there is a distinction between the width of the market, that is the dispersion of consumers' preferences, and the depth of the market, or the density of consumers at each location (Lancaster 1990, p. 200): therefore a market could be larger but if it is homogenous with consumers concentrated in a certain location, that leads to clustering of firms in this location rather than an increase in variety.

A comparison between these models and PLC models makes little sense because they originate in different economic traditions, aim to answer different questions, and use different methodological tools. However, the reason why I compare them is that they reach a different conclusion on the nature and on the constraints in variety generation.

As seen before, the variety in PLC is mainly considered as improvement in the design and its limits are established by boundaries in the hierarchical structure of the product. The generation of variety is incremental and continuous only to the extent it involves the lower levels of hierarchy and along autonomous technological trajectories. Further improvements can take place only with important and discrete change in the architecture. On the contrary, in the Lancastrian approach, the product does not show any limit in the variety it can achieve. Its form is continuous and flexible; the main street of Hotelling's model is a line infinitely divisible. Only the size and composition of demand, by dictating incentives, and opportunities for development of process technology and thereby production costs, set boundaries to expansion of variety.

Proposition 2: Only the size and composition of demand, by dictating incentives, and opportunities for development of process technology and thereby production costs, set boundaries to expansion of variety.

Since this book is an empirical study of the variety in an industry, it is closer in the epistemological foundation and in the tools it is using to the PLC tradition. However, as explained in the next chapter, both because the methodology roots in

the characteristic's approach and because it observes variety at a specific point in time there is also a flavour of Lancasterian models. Nevertheless, since the book aims to increase the understanding on the generation of variety, no assumptions should be made a priori on its nature and on the nature of these limits. On the contrary this dichotomy will drive the empirically analysis and the validation of one of the two theory will be an outcome of the analysis.

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