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THE DESIGN QUALITY OF PRODUCTS: A METHOD OF PURSUING INNOVATION

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I. Introduction

Innovation is nowadays an imperative; this idea is repeated by economists and business experts. The reason for this can be easily explained both at the macro-economic and the micro-economic level.

At the macro-economic level it was clearly shown for the first time by the famous Middle European economist Joseph Schumpeter in his fundamental work on the theory of development,[1] and after him in a host of scientific works. We mention here two of these which give particular insights into the field.[2]

If we follow Schumpeter's thinking we can define as innovation every change in products or in production which gives an advantage to producers in the form of a profit, putting them apart from other producers in the same field, i.e., in a *monopoly* position in which they alone are able (for a period of time) to exploit the change. We need, however, to specify some of the terms of this conceptual setting. Innovation in the Schumpeterian way of thought does not need to be *technological* in a strict sense. Schumpeter himself lists several possible forms of change: it may be the product itself, or only the quality of the product, or its marketing presentation, or even its market, or its channels of distribution; it may be the production process, or the input materials and factors, or even the delivery channels, or the geographical localization of production; it may be one of these elements or some combination of them; in other words, it may be anything in between the beginning of production and the consumer. From a strictly economic viewpoint it is not as important to know what the change precisely consists of; what is important is that there is a change of some kind, some difference as compared to the traditional procedure, a difference which involves some economic advantage in the form of a price increase, a cost decrease, or both, for the entrepreneur who had the courage to put the new idea into practice.

The monopoly advantage is only temporary, because the innovation profit attracts other economic actors who try to obtain the innovative knowledge in order to obtain a share of the potential profit available from the innovation.

On the basis of this definition one may therefore ask: what is the real connection between technology and innovation, in the sense that people usually speak about "technological innovation"? The answer is simple: from an economic point of view innovation is only a differentiation which introduces a utility without technological implications. It is clear, however, that the great majority of differentiating ideas can be drawn from the immense pool of technology and science. But this is not exclusive, and it is a mistake to consider innovation only from the technological point of view. Great mistakes in corporate strategy can be made if this is done. In order to differentiate between the two concepts, two different terms may be used, *invention* for strictly technological phenomena, and *innovation* when the economic aspect is in the forefront.

II. The Utility of Innovation as a Classificatory Criterion

The advantage accruing from an innovation is offered either by temporary price and cost values, which are set by the strategy employed by the entrepreneur, or by the innovation

itself and by the time lag which leaves competitors behind the innovator. Hence, if **R** is the revenue for a given period (e.g., one year), **C** the total cost in the same period, and **L** the time lag, then the total profit U_T of the innovation can be expressed as follows:

$$U_T = (R - C) L \qquad (1)$$

which holds true if the profit for the unitary period **(R - C)** does not change over time. It is however interesting to note that the total utility U_T depends on price and costs for the unitary period and on the time lag of advantage in respect to the competition. I consider that this second aspect is possibly more important than the first, since it depends mostly on technological circumstances, whereas prices depend also on corporate strategies.[3]

The total utility of an innovation may give us a key for classifying different types of innovation. For this purpose, I consider it useful to follow the original Schumpeterian classification:

(1) The first-ranked innovation is **product innovation**. An entirely new product opens up a completely new market and requires an entirely new technology, distribution and delivery channels. Everything is new and has to be found out—almost like the discovery of a new continent. In this case the time lag for the innovator may be a substantial one, and he may also be protected by patent.

(2) Second is **process innovation**, i.e., a new way of combining production factors in order to obtain the same product as before. This result can be achieved by a different sequence of operations, as also by the use of new and more effective machinery. Process innovation is often difficult for competitors to duplicate, because it has no external manifestation and is kept secret internally to the innovator's company for a certain period. It may produce a substantial time lag. Process innovation directly affects costs and indirectly affects prices.

(3) The third rank position may be given to all **minor product modifications**, i.e., those that are not of a substantial nature: quality level, formal aspects, commercial presentation, and the like. Here we may consider all the technical variations that improve product performance without changing its main classification pattern. For example, a better kind of wine is still a wine and has not changed to another type of beverage. In the case of formal modifications only we may deal with better esthetics, new fashions, or other commercial aspects.

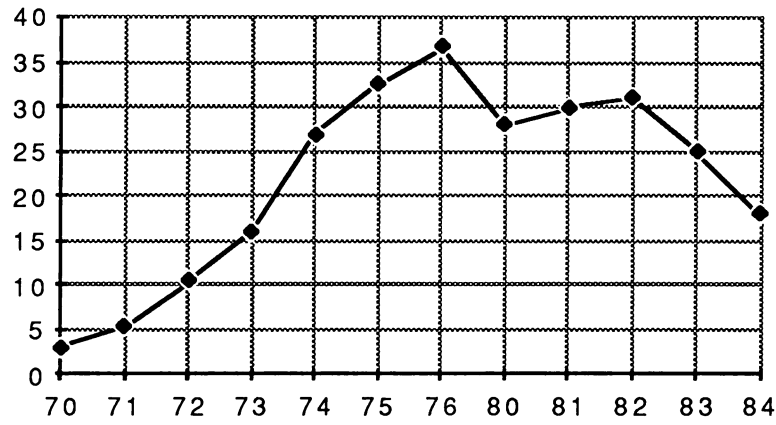
There are countries—a typical example being Italy—which exhibit a very lively activity in this kind of innovation, with important macro and micro results. Differentiations in this instance are very open and apparent to everybody outside. A new fashion is immediately perceived not only by consumers, but by the competition, which is then able to quickly reproduce or even improve on it. Hence, we may assume that the time-lag between innovator and imitators is here a very short one, with a non-positive effect on expected profit.

This kind of innovation manifests itself in waves of quick changes which follow each other periodically—for example, seasonally, like changes in fashion. The skill of the entrepreneur then consists (as happens in the Italian fashion industry)[4] of being always in the forefront of the phenomenon.

But sometimes also fashion innovation can last for longer periods. For example, analyzing the life cycle of blue jeans,[5] we find the following data with respect to consumption versus time:

The figure shows that the fashion in blue jeans in Italy was not short-lived. This item of

I. Consumption of blue jeans in Italy, 1970-1984, (in millions of pairs)



clothing had a longer-lasting importance which may perhaps be explained by the needs of consumers in the relevant period.

We may therefore conclude that it is not easy to arrive at a judgment about the various types of innovation, with respect to the effects that they produce. Our classification must be interpreted as only approximately indicative; yet, it may be important for assessing different types of innovative policies.

(4) Fourth are **organizational innovations**, i.e., new ways of organizing personnel, methods, or production factors. Such innovations may have beneficial effects with respect to the time lag of competitors, especially because they are often unique and depend not so much on general rules as on particular circumstances. To take some examples: outside of Japan it is very difficult to organize work in the Japanese way; it was difficult if not impossible to imitate the idiosyncratic internal organization of the economically very successful *People Express* airline company; and nobody, even in Italy, was able to reproduce the peculiar organizational network of the Prato industrial district.[6] In these cases, in my view, the real problem lies rather in the extent of the effective cost saving brought about by organizational innovations. I suspect that very often the differential is not substantial, and the incremental profit obtainable may not be worth the incremental effort. In any case, even here general judgments are dangerous, and are perhaps better avoided.

(5) The fifth and last kind is **geographical innovation**, e.g., a change in the supply or the distribution channels, or a change in the location of production. Here we can give a historical example.

The medieval prosperity of the Italian republics, particularly the Venetian Republic, relied heavily on certain delivery channels for commodities of Levantine origin or mediation, such as pepper. The trade route was very long, beginning in the East Indies and continuing through the Indian Ocean and the Red Sea or Persian Gulf, then through the Middle East to the Mediterranean, where Venetian traders loaded the merchandise onto their ships for transport to Europe. These routes were populated by large numbers of

independent merchants, each one burdened by substantial costs and rising prices. Calculations based on prices of the period show a source:consumer price ratio of 1:1000, i.e., an increment of 100,000%.[7] When Portuguese sailors circumnavigated the Cape of Good Hope Europeans were able to reach the Moluccas directly for the first time, tapping the valuable commodity at the source and thus greatly shortening the supply channel; this brought an enormous revolution to world economy, if for no other reason than it meant the end to the medieval prosperity of the Italian peninsula.

Another kind of geographical innovation is when new markets for known products are opened; or, as is happening nowadays, when standard technology production (i.e., production with low innovative potential, very often labor- and/or material-intensive, where the level of knowledge required for the operation is not high) migrates to developing countries where labor and material costs are low.

Geographical (locational) innovations do not, in my opinion, have very long-lasting effects. They have the defect of being externally visible and therefore readily attracting competition. The Portuguese monopoly of the Indian Ocean route lasted only briefly: within a few decades the Portuguese were replaced by other Europeans—the Dutch, French, and British. If today a multinational enterprise discovers an attractive location for its production in the developing world, competitors will follow quickly; and, presumably, the same holds true for the discovery of new markets.

III. Innovation Risk

A critical aspect of innovation risk is managing failures **before they take place**. From this point of view the most important point to consider is that innovation is almost always a high-risk procedure; only a fraction of the tentative attempts actually produce results. It is difficult to obtain good statistics on this subject, for enterprises—like people—tend to quickly forget their failures. Urban & Hauser, however, cite failure rates ranging from one-third to two-thirds, with the differences being due to variations in technology and in products. In the field of consumer goods, failure rates are substantially higher.[8]

There are two kinds of risk connected to innovation: technological, and commercial.[9] The so-called technological risk is the probability that the venture or idea cannot be realized from a technical point of view. Again, we can use a historical example: before Columbus' crossing of the Atlantic, nobody could be sure that the project was feasible. A chance was taken. In fact, if Columbus own ideas had been correct, given his technological means and knowledge, the realization of his innovative project (to reach Asia by a direct westward sea route) would not have been possible. The fact that the unknown American continent was interposed between the West and the East of the Eurasian continent was a fortunate circumstance. In my opinion, there is no innovation without much uncertainty, and it is always a matter of chance—great or small—of overcoming it.

In many modern technological fields this kind of risk may be small, even very small; the world of technology is nowadays so vast that we can almost always find some specialized knowledge to overcome a problem. But some risk may always be present: when someone initiates a new project he may be confident of completing it, but never fully certain. The word *invention* contains the root *inven-* "find" and finding may require searching or exploration; and the word *innovation* has the root *nov-*, a new thing or concept which has to be explored. Nobody can fully anticipate the results of an exploration.

As already stated, it is useful to distinguish between the terms *invention* and *innovation*: the former being only technological in nature, the latter being both technological and economic, i.e., it must also entail market success—consumers have to be induced to buy

and pay for the new product or service. We can thus summarize the first of the two risks as the probability of invention.

The second type of risk is commercial in nature and depends on the probability that the new product will be accepted by the market. It is, indeed, the probability of proceeding from invention to innovation, viz., actually conquering a share of the consumer market. To stick to our historical example: the risk that Columbus would not obtain any valuable commodity from his discoveries—and, indeed, he was for a number of years the object of this kind of accusation.

This kind of risk is not present in those types of innovation where there is not total or partial change of the product. If only the organization, the process, or the location is changed, the product and the markets are not directly involved; they remain the same, as do the chances of selling the product. Hence, we have the certainty of market existence, even if there may be uncertainty as to its extent. For example, in process innovation (Type 2) costs can be lowered and hence prices also may be lowered; but with lower prices a larger market share can be gained.

We may therefore conclude that product innovations (Type 1) are the most risky, since two kinds of risk have to be taken into consideration—the technological and the commercial. Indicating[10] the probability of technological success as $\mathbf{P_t}$ and the probability of commercial success as $\mathbf{P_c}$ the average of expected utility of an innovation $\mathbf{M(U_T)}$ may be expressed as

$$M(U_T) = P_t \times P_c \times (R - C) \times L - (1 - P_t) \times (1 - P_c) \times K \qquad (2)$$

where **K** is the cost of innovation failure. When either $\mathbf{P_t}$ or $\mathbf{P_c}$, or both, are zero, the average utility of the innovation is negative, i.e., it is no more than a cost for the innovating entrepreneur, without his obtaining any benefit.

It is not easy to find good data about the extent of these risks. Urban & Hauser[11] provide some data on the percentage of success of product innovation resulting from technological opportunities. They are distinguished as follows: the first have, in practice, an assured market, since their inspiration originates in a consumer need; the probability of success varies from 60% to 90%; the probability of overall success in the second case, however, varies from 10% to 34% only, since the risk originates in science and technology and no market is assured.

We may therefore conclude, in the case of product innovation (Type 1), that commercial risk is substantial: it is almost impossible to predict with certainty what will be the market fate of a new product, even if the original concept seems very attractive. It is clear, therefore, why scholars in the field deal mostly with the problem of envisaging methods and procedures oriented towards risk reduction, and particularly the reduction of commercial risks: for it significantly increments the average utility of an innovation. If the probabilities of success $\mathbf{P_t}$ and $\mathbf{P_c}$ are bigger, the same happens (proportionally) to $\mathbf{M_{(UT)}}$, as can be seen at a glance from expression (2) above.

Techniques of risk reduction are the main subject of most texts which treat R & D management.[12]

IV. Project Quality as an Innovation Risk Reduction Procedure

A new procedure oriented toward the goal of innovation risk reduction may be envisaged in the vast field of quality control techniques.[13] In a very general sense quality control may be defined as a control activity within a company that is directed at checking the product

delivered against predetermined qualitative design standards.

To conceptualize this activity two conformations of quality are defined: quality of conformance (i.e., the avoidance of deviations from design standards) and quality of design. The latter is more difficult to determine, since it represents the deviation between the given design of the product, established by the company's engineering department, and the actual needs of the consumer market. For this purpose we may speak of a model of the product,[14] i.e., an optimal design that is able to fully satisfy the desires of the consumer in the given field of consumption.

The problem lies with the fact that the model of consumer desires is very difficult to establish until there is a real product to satisfy them. For example, humans during their history have always desired rapid transportation, but this was not clearly determined until the automobile, the airplane and other means of transport were invented. Before their invention humans had thought up fantastic ways of satisfying their desires—chariots of fire, winged horses, seven-league boots, and so on.

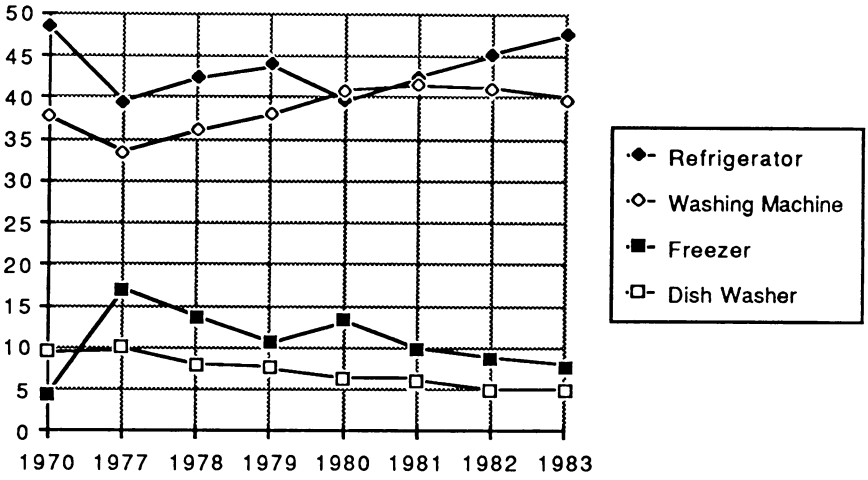
The improvement of design quality is therefore an innovative procedure, for something new has to be invented in order to close the gap between the unclear ideas but precise needs of the consumer on the one hand, and on the other the possibilities offered by the technological culture of the epoch. Improving design quality is valuable for reducing innovation risks, as it is oriented toward the adaptation of design models to market needs, i.e., it does not operate in a world that is at a distance from real markets. A general method for determining design quality problems may therefore be of great value for tracing promising innovative areas and potential.

But how can such aspects be determined? To date we have no definitive methodology in this area. Nevertheless, one may state that wherever a design quality defect exists it will certainly also have a market consequence. It is necessary to establish what kind of consequence may ensue from a design quality problem. One aspect that emerges easily may be the following: the design defect causes a certain dissatisfaction in the buyers. Initially they can be convinced to purchase a new product, but if design defects are apparent they will not repeat the purchase.

In a research project carried out at the University of Ancona[15] the market behavior of the most important household appliances on the Italian market was studied. Figure II shows the market shares for refrigerators, washing machines, freezers and dishwashers over a fifteen year period. It is striking to note that two of these (refrigerators and washing machines) cover 80% of the market, while the other two take up the remainder. Of these two, the dishwasher is clearly the weaker product, showing a low and decreasing trend in its share of the market over time. If these data are compared with the functional needs of consumers we observe that such a pattern does not seem justified, for washing dishes is still an important and time-consuming problem in Italian homes. If anything, we would expect the freezer to exhibit a weak market trend, for every refrigerator already has a small freezer incorporated in it, and the average family size has been decreasing.

More research is needed to definitely answer this question; but we think that the low market-penetrating force of the dishwasher has something to do with its low design quality. These machines, as conceived today, do not successfully fulfil the consumers' needs of rapid and effective dishwashing. In Italy, at least, those who have bought dishwashers do not use them very often and they stand idle for long periods. There is therefore no need for repeated purchases. A more definite judgment would require the monitoring of markets other than the Italian one; but, on the basis of the data at our disposal, a working hypothesis may be formulated, to the effect that a new type of design, innovative in character, would

II. Market share of household appliances in Italy, 1970-1983



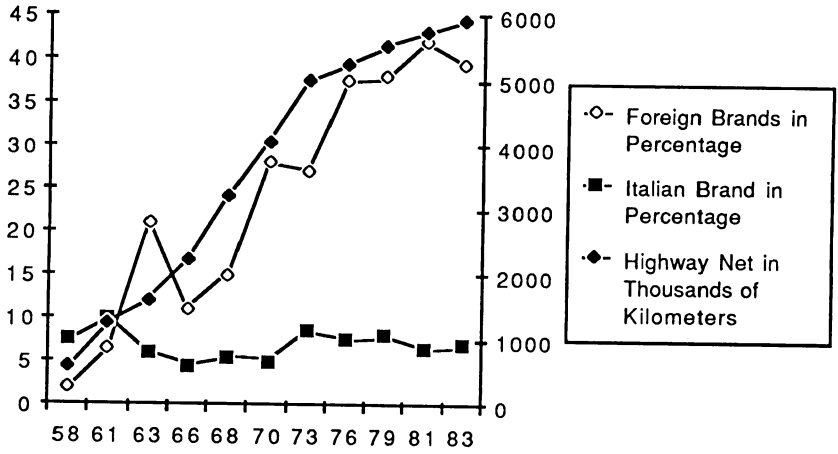
be better suited to consumer needs. Other data point in the same direction, too: there are many kinds of design, brought out by various producers,[16] but with little standardization and uniformity.

Similar examples may be cited for other sectors of production. In an investigation carried out at the University of Urbino[17] we compared the Italian market share of a well-known Italian automobile brand, the market share of foreign automobile producers, and the extension of the Italian freeway net. The results are striking: the expansion of the market share taken by foreign firms closely parallels the expansion of the freeways, an opportunity which the Italian brand was not able to exploit during the same period, cf. Figure III. There may be numerous explanations for this phenomenon, but a design quality problem cannot be excluded: viz., that the Italian cars had some less appealing characteristic which was not present, or present to a lesser degree, in the foreign cars. This hypothesis is confirmed by data with respect to internal quality troubles within the company concerned;[18] these show a pressure for design quality changes during the same period, i.e., the period during which the Italian highway system was modernized. In my view, the engineering department of this company pursued a type of design that suited the older type of narrow, overcrowded highway, where rapid acceleration and deceleration (for passing purposes) was required; multi-lane freeways require a different kind of philosophy, based on high average velocity, reliability, and product durability—characteristics exhibited better by foreign brands during the period concerned.

The examples cited here may provide us with a clue in our search for a method of design-quality investigation:

1. The market results of a product should be studied, particularly the pattern of repeated purchases. A product that is well adapted to consumer needs will certainly be bought more than once by consumers; and the reverse is true for

III. Market share of automobile brands and length of highway network in Italy, 1958-1983



a product with design quality problems. The reason why purchase-repetition is not realized may provide important hints with respect to an innovative initiative, i.e., a method of using past errors to produce positive results.

2. The standardization of product design should be investigated. A product with multiple and highly different design variants is suspect with respect to low design quality; such a product has, therefore, high innovative potential. If we study various models and the changes introduced into them by engineers much can be learned to help in the pursuit of innovation recommendations and indications.

These two points are based on limited investigative material; we hope, however, that more extensive research can be undertaken to obtain more data and to elaborate a more complete method of design-quality investigation, a field offering interesting perspectives for innovative policies and methods.

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NOTES

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2. Robert U. Ayres, *The Next Industrial Revolution: Revising Industry through Innovation* (Cambridge: Ballinger, 1984); Bellisario Merolle et alii, *L'incentivazione ed il finanziamento dell'innovazione* (Angeli: FAST, 1984).
3. See, e.g., Brian C. Twiss, *Managing Technological Innovation* (London & New York NY: Longman, 1980) 19, and Glen L. Urban & John R. Hauser, *Design and Marketing of New Products* (Englewood Cliffs NJ: Prentice-Hall, 1980), 2, 29.
4. Cf. William J. Stanton & Riccardo Varaldo, *Marketing* (Bologna: Il Mulino, 1986) 152, 158. The Italian fashion industry was analyzed in this respect by Graziana Gattoni, *Studio dei problemi della qualità in una piccola azienda: il caso di un maglificio*, Doctoral dissertation, Università degli Studi di Ancona, 1985/86.
5. Data from Daniele Paoloni, *Ciclo di vita e programmazione della produzione del jeans: il caso di un'azienda della valle del Matauro*, research paper, Università degli studi di Urbino, 1984/85.
6. Giovanni Lorenzoni, *Una politica innovativa nelle piccole e medie imprese* (Milano: ETAS Libri, 1979).
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8. Glen L. Urban & John R. Hauser, *Design and Marketing of New Products* (Englewood Cliffs NJ: Prentice-Hall, 1980) 2, 29.
9. Brian C. Twiss, *Managing Technological Innovation* (London & New York NY: Longman, 1980) 131, 132.
10. Twiss 131, 132.
11. Urban & Hauser 26, 28.
12. For a thorough examination of these problems, see Twiss and Urban & Hauser.
13. A limited reference list on quality control: A.V. Feigenbaum, *Total Quality Control* (3rd. ed., New York NY: McGraw Hill, 1983); J.M. Juran, *Quality Control Handbook* (3rd. ed., New York NY: McGraw Hill, 1979); Alessio Lokar & Francesco Marchesi, *La programmazione della qualità merceologica nell'azienda industriale moderna* (Ancona: Camera di commercio di Ancona, 1978).
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15. Francesco Ranaldi, *Qualità di progetto ed innovazione nell'industria degli elettrodomestici: il caso delle lavastoviglie*, Doctoral dissertation, Università degli Studi di Ancona, 1984/85.
16. Ranaldi, *Qualità di progetto*. In this thesis eleven different washing systems that existed on the market were identified.
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18. Agostini, *La qualità*.

POVZETEK

NAČRTNA KAKOVOST PROIZVODOV KOT METODA ZA RAZVOJ INOVACIJE

Avtor razlikuje med iznajditeljstvom in inovacijami. Prva dejavnost je predvsem tehnološkega značaja, druga pa gospodarskega. Razlikovanje je zelo važno pri podjetniški strategiji. V ta namen je prav tako pomembno razlikovati razne vrste inovacij na podlagi njihove srednje koristnosti. Avtor uporablja ta kriterij za določanje petih vrst inovacij: proizvodno, procesno, zadevajočo zunanje spremembe na proizvodu, organizacijsko, lokalizacijsko ali zemljepisno. Iz opisanega izhaja velik pomen, ki ga je treba posvetiti inovacijskemu tveganju, glede katerega nudi avtor podatke in zgodovinske primere. Na koncu opiše avtor novo metodo zmanjševanja inovacijskega tveganja, ki izhaja iz tehnik kakovostnega nadzora.