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# Technological clusters with a knowledge-based principle: evidence from a Delphi investigation in the French case of the life sciences

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**Abstract**

Recent works in the theory of technical change show the effect of irreversibility and lock-in on the diffusion and creation of innovation processes, which are able to stop the development of a generic technology. Therefore, industrial policies play a major role in selecting and supporting the innovative process. The purpose of this paper is to prove the possibility to derive a typology of future innovations in terms of generic technology from a Delphi type technology survey. Thus, it is possible to get a better understanding of the industrial dynamics and to design an interesting tool for industrial policies or for firm strategies, as far as they aim at developing stable technological trajectories. This is applied to the French case of the life sciences. The paper suggests interesting explanatory trajectories in order to fight against diseases such as cancer, Alzheimer or Schizophrenia. 

*Keywords:* Generic technology; Technological trajectory; Clustering analysis; Competencies; Foresight process

## 1. Introduction

In industrial economics and especially in knowledge-based economics, many studies refer to irreversibility and path-dependency in connection with the post-Schumpeterian developments of the evolutionary thought. We thus have a better understanding of the evolution of technical change with the introduction in the economic theory of the concept of generic technology and of technological trajectories. In such dynamical and complex social systems, an important point is to understand the role of determinism. The question is to know what kind of small events in today's decisions may have great importance for tomorrow's actions and determine an irreversible evolution of the system, and what kind of events have no impact. In fact, to be able to forecast the development of knowledge and technological change in some well-known trajectories could be one of the major tasks of industrial policies in order to support innovative processes. The purpose of this paper is precisely to propose a taxonomy of future technologies, providing a better understanding of industrial dynamics. Therefore, we suggest a statistical analysis of a Delphi investigation, based on science and technological knowledge complementarities, in order to design coherent clusters, which may be considered as a theoretical tool for political decision-making. The ultimate goal is to define generic technologies and to determine some possible trajectories in order to propose some guidelines for an industrial policy, so as to

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avoid bottlenecks, to choose the best possible future as well as the path to arrive there.

The paper is organised in the following way. Section 2 develops the theoretical and conceptual settings, while Section 3 presents the data and our methodology of technological clustering. In Section 4 our results are examined and Section 5 gives some conclusions in terms of public policy.

## 2. Theoretical aspects

One of the starting points of our work is the assumption that agents are facing a limited number of technological opportunities. The first problem for each economic agent is to identify and successfully exploit a small sub-set of opportunities, one of the main constraints being the boundedness of the agents' own economic competences, defined as the ability to identify, expand and exploit business opportunities (Carlsson and Eliasson, 1994). As a matter of fact, in the evolutionary tradition, because of the hypothesis of bounded rationality (Simon, 1982) and complex environment of selection, each agent cannot decode the whole available information. Agents face then an additional dimension of uncertainty because of the gap between their competence in the use of information and the difficulty of their decisional problem (Heiner, 1983). In other developments of his initial work, (Heiner, 1985, 1988) the author shows that there is no interest to use an information source too distant from the agent's local experience and that the same principle applies to decision rules. Thus agents and/or firms search for new things close to the things they know and do well. Therefore, there is a tendency for a firm to stay on a technological trajectory that was successfully exploited in the past (Dosi, 1982). Similar concerns emerge in the process of innovation in the sense that an innovative firm is constrained by its current set of competencies: this sustains the notion of technological cumulativeness, i.e. the idea that technical change is gradual and incremental, since it builds on accumulated competencies in the firm's technical domain. Thus, a specific innovation generates a stream of subsequent innovation (a technological cluster), which improves gradually upon the original one. In this perspective, the development of a technological trajectory is the outcome of the intrinsically cumulative nature of learning processes (Rosenberg, 1976; Nelson and Winter, 1982). The generation of new knowledge builds upon what was learned in the past, not only in the sense that knowledge constrains current research, but also in the sense that knowledge generates questions, which in turn generate new research (Malerba et al., 1997). Moreover, research is typically characterised by dynamic increasing returns in the form of learning by doing, learning to learn and the fact that today's research generates tomorrow's new opportunities (Cohen and Levinthal, 1989; Klevorick et al., 1995).

Nevertheless, technological cumulativeness and localised learning generate irreversibility, which is expressed by the property of path-dependency in the evolution of the systems (Foray, 1997). As it is well-known, there is a variety of phenomena that can be classified under the heading irreversibility such as switching costs, all classes of sunk costs, etc.[1] All those interactions between irreversibility and learning processes sustain endogenous processes of localised technological change along technological trajectories by generating localised competencies (Antonelli, 1997). Moreover, the path-dependency feature of the system is reinforced by the combination of dynamic forces (Antonelli, 1997) such as learning, network externalities, economies of scale, the simple process of reduction of uncertainty, technological complementarities and inter-relatedness which impliy increasing returns to adoption and shape the dynamics of diffusion processes along the trajectories. Such systems are path-dependent in the sense that the long run equilibrium can be affected by historical events along the path (David, 1992). Thus, the mode of development of a technology (including many potential trajectories) is strongly influenced by initial decisions[2]. Initial (or transitory) actions put the system on a path that cannot be left without costs. Three problems can appear at this stage, which can block industrial development.

1. The first one concerns the context of these initial decisions made under great uncertainty and ignorance of the respective qualities and

[1] For a complete analysis of irreversibility and path-dependency in industrial organisation, see Antonelli, (1997).

[2] See for example, the work on economic standard which shows that technologies selected first have greater chances to diffuse faster (Katz and Shapiro, 1986; Farell and Saloner, 1985; Foray, 1987).