



From sectoral systems of innovation to socio-technical systems Insights about dynamics and change from sociology and institutional theory

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Abstract

In the last decade ‘sectoral systems of innovation’ have emerged as a new approach in innovation studies. This article makes four contributions to the approach by addressing some open issues. The first contribution is to explicitly incorporate the user side in the analysis. Hence, the unit of analysis is widened from sectoral systems of innovation to socio-technical systems. The second contribution is to suggest an analytical distinction between systems, actors involved in them, and the institutions which guide actor’s perceptions and activities. Thirdly, the article opens up the black box of institutions, making them an integral part of the analysis. Institutions should not just be used to explain inertia and stability. They can also be used to conceptualise the dynamic interplay between actors and structures. The fourth contribution is to address issues of change from one system to another. The article provides a coherent conceptual multi-level perspective, using insights from sociology, institutional theory and innovation studies. The perspective is particularly useful to analyse long-term dynamics, shifts from one socio-technical system to another and the co-evolution of technology and society.

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1. Introduction

In the last decade ‘systems of innovation’ has emerged as a new topic on the research agenda of innovation studies. It has opened up a promising strand of study, in which the scope of analysis has been broadened from artefacts to systems, from individual organisations (often firms) to networks of organisations. Systems of innovation can be defined on several levels (e.g. national, sectoral, regional). This paper

makes a contribution to the level of sectoral systems. At this level there are several approaches, which describe the systemic nature of innovation, albeit with a slightly different focus, e.g. sectoral systems of innovation (Breschi and Malerba, 1997; Malerba, 2002), technological systems (Carlsson and Stankiewicz, 1991; Carlsson, 1997) and large technical systems (Hughes, 1983, 1987; Mayntz and Hughes, 1988; La Porte, 1991; Summerton, 1994; Coutard, 1999). I will briefly describe the thrust of these three approaches. A *sectoral system of innovation* can be defined as:

a system (group) of firms active in developing and making a sector’s products and in generat-

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ing and utilizing a sector's technologies; such a system of firms is related in two different ways: through processes of interaction and cooperation in artefact-technology development and through processes of competition and selection in innovative and market activities

(Breschi and Malerba, 1997, p. 131).

Although this definition includes the selection environment, it does not explicitly look at the user side. Furthermore, the definition mainly looks at firms, neglecting other kinds of organisations.

A *technological system* is defined as:

... networks of agents interacting in a specific technology area under a particular institutional infrastructure to generate, diffuse and utilize technology. Technological systems are defined in terms of knowledge or competence flows rather than flows of ordinary goods and services. They consist of dynamic knowledge and competence networks

(Carlsson and Stankiewicz, 1991, p. 111).

This definition highlights more explicitly the importance of not only understanding the *creation* of technology, but also its diffusion and *utilisation*. On the other hand, technological systems seem to be narrowed down to social systems ('networks of agents'). Although actors are important, the material aspects of systems could be better conceptualised.

The material aspect of systems is central in the *Large Technical Systems* (LTS) approach. LTS refer to a particular kind of technology involving infrastructures, e.g. electricity networks, railroad networks, telephone systems, videotex, internet. The LTS approach not only has a specific unit of analysis, but also developed a particular mode of analysis, looking at socio-technical 'seamless webs' and system builders (Hughes, 1983, 1986, 1987). Among the components of LTS are physical artifacts (such as turbo-generators, transformers, electric transmission lines), but also organisations (e.g. manufacturing firms, investment banks, research and development laboratories), natural resources, scientific elements (e.g. books, articles), legislative artifacts (e.g. laws) and university teaching programs (Hughes, 1987, p. 51). System builders travel between domains such as economics, politics, technology, applied scientific research and aspects of social change, weaving a seamless web into a functioning whole. New technologies and

the user environment are constructed in the same process.

These three approaches share an emphasis on interlinkages between elements, and they all see innovation as co-evolutionary process. But there are some differences regarding the kinds of elements involved in systems and their relationships. The aim of this paper is to contribute to the discussion about the kinds of elements and, especially, the dynamic interactions between them. These contributions focus on four points.

The first contribution is to include both the supply side (innovations) *and* the demand side (user environment) in the definition of systems. The sectoral systems of innovation approach has a strong focus on the *development of knowledge*, and pays less attention to the *diffusion and use of technology*, impacts and societal transformations. Sometimes, the user side is taken for granted or narrowed down to a 'selection environment'. Hence I propose a widening from sectoral systems of innovation to socio-technical systems. This means that the fulfilment of societal functions becomes central (e.g. transport, communication, materials supply, housing). This indicates that the focus is not just on innovations, but also on use and functionality. The need to pay more attention to innovation *and* users has, in fact, already been identified by a range of scholars in innovation studies and evolutionary economics. So the paper aims to link up with an identified 'open issue' in the field.

Second, with regard to the kinds of elements I will propose to make an analytic distinction between: systems (resources, material aspects), actors involved in maintaining and changing the system, and the rules and institutions which guide actor's perceptions and activities. I suggest such analytical distinctions are useful because some current literatures group together too many heterogeneous elements. For instance, Malerba (2002), pp. 250–251, wrote that "the basic elements of a sectoral system are: (a) products; (b) agents: firms and non-firm organisations (such as universities, financial institutions, central government, local authorities), as well as organisations at lower (R&D departments) or higher level of aggregation (e.g. firms, consortia); individuals; (c) knowledge and learning processes: the knowledge base of innovative and production activities differ across sectors and greatly affect the innovative activities, the organ-

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