1. Introduction: the meso-foundations of national innovation systems

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1.1

Today, a high level of consensus exists regarding the importance of scientific progress and technological innovation for the growth and competitiveness of firms and for the improvement of national economic performance. Indeed, since the early 1970s the economics and management literature has paid special attention to two essential aspects of this phenomenon. The first concerns the *formulation and revision of synchronic and diachronic models*¹ in an effort to identify and explain the constitutive elements as well as the dynamics of technological change. The second concerns the *identification and analysis of the macro- and micro-level factors* influencing and conditioning the innovative performance of firms. Among these, the systemic approach to innovation has emerged during the 1990s as a particularly useful conceptual framework to understand the determinants and consequences of innovation in a useful way (Edquist 1997).

The research works presented in this book deal with the analysis of various patterns of developing and using technology capabilities – encompassing the process of innovation in different national and sectoral contexts in Latin America and Europe. The first distinctive feature is that they explore the relationship between micro- and macro-level processes on a comparative basis, through the analysis of fairly heterogeneous cases. The commonalities lie in the level of observation. At the micro level, technology transfer, implementation and diffusion are considered as organizationally complex processes of knowledge flows and transformations, which pose crucial challenges in terms of the management of expertise (Fleck 1983) and *sociotechnical alignment* (Molina 1990, 1997). At the macro level, the main concern is usually the influence of structural conditions, such as national, regional and sectoral, social and technological contexts and the trends regarding these processes. Here the concepts of *national innovation systems* (NIS) and *industrial*

clusters (Porter 1990) are extensively used in the analysis of several of the contributors. The second distinctive feature is that the *meso level*, that is, the linkage between the micro and the macro levels is here conceptualized in terms of the setting up of *sociotechnical constituencies* (STC) (Molina 1990, 1997). It is argued that strategies and policies to improve innovative performance at regional and national levels should pay special attention to this level and consequently to the constituency building process.

This synthesizing micro–macro approach is considered a coherent and significant contribution to the insights offered by the separate frameworks of NIS, industrial clusters and STC. In this book, sociotechnical constituencies play a fundamental role in innovation-based economic development at regional and national level. More precisely, constituencies are considered as a way of understanding the processes of accumulating capabilities and intensifying interactions between different types of institutional actors in countries and regions. Furthermore, knowledge flows and partnering are seen as usefully integrating and deepening even further the understanding of constituency building and sociotechnical alignment.

1.2

Among the diverse perspectives presently adopted to analyse innovation, the economic approach represents perhaps the most comprehensive one and allows further conceptualization and an ample view of its effects on other fields of activity. In fact, from this point of view, innovation is a techno-economic process by means of which firms increase their knowledge base to improve their operations, processes, products or services. This new knowledge determines diverse types of benefits for the firms, the users of products and technologies, and the whole set of agents which participate in the process of innovation, and are reflected in economic terms in the last instance. Due to its complexity and transdisciplinary character, the following categories are suggested to better understand innovation in its different perspectives: its *nature*, *taxonomy*, *outcomes* and *sources*.

The first category, *nature*, allows the definition of innovation as a transdisciplinary process that involves, among others, scientific, technical, administrative, social behavioral and economic aspects. It involves at least three non-linear subprocesses: creation, production and diffusion, though the temporal relationship between these is vague and debated. There are many issues related to the nature of innovation, from the role of individuals such as entrepreneurs and champions, to technology transfer and the diverse types of collaboration between agents and organizations to complement their capacities as well as the alignment of the diverse elements involved in the process.

A major contribution to the understanding of the nature of innovation is the evolutionary approach to technical change, which has been developed since the early 1980s to explain at a detailed microeconomic level the process of innovation (Nelson and Winter 1982). This approach is based on the assumption that firms and products compete for survival and evolve within a selection environment, namely the market. From this perspective innovation consists in solving diverse (technical) problems that firms find in the course of their activity, and thus enhancing their competitiveness. These technological solutions, related to products' or processes' performance attributes, occur within corridors, or trajectories determined by 'normal technology' constituting technological paradigms (Dosi 1982). Innovating activities that generate a new inertia or trajectory culminate in dominant configurations (Metcalf 1993; Utterback 1994), which usually take the form of a new product with a set of specifications synthesized from the accumulation of previous solutions. Dominant designs generate a trend towards standardization that reduces the variety of possible products to a few 'species'.

Related to the second category, several *taxonomies* have been proposed about the types and scopes of innovation, many of them related to the dynamics of industrial innovation² and the measurement of technical change.³ They can be well synthesized in a three-dimensional space with the following axes: (a) type of innovation (product or process); (b) scope (from radical to incremental); (c) architecture (from component to system).

From a techno-economic perspective, innovative processes may have two possible extreme *outcomes*, with an infinite variety in between: success and failure. In practice, it is difficult to categorize outcome in a once-and-for-all static fashion. Often, perceived failures may return as key steps to success in the learning process of particular innovations; and successes may prove more short-lived in their impact than initial results may have indicated. However, success and failure will always depend on both the partial results obtained in the different stages of the innovation process and the competitive market environment within which the firm is launching the innovation.

Sources of innovation relate to the driving forces of innovative processes. This aspect has gained increasing importance especially for policymaking. Initially, the fundamental debate focused on the science-push and market-pull models and choice of one or the other would influence both policy initiatives aimed at fostering innovation at a national level and firms' technology strategies at micro level. Towards the end of the 1970s, however, interactive models of innovation were proposed, suggesting a two-way linkage between scientific and technological supply and market demand, with strong reciprocal influences.⁴ The recent literature on systems of innovation seems to have superseded this debate, though it could be stated that the empirical studies on innovation have not yet been able to integrate concrete problems to this framework.

1.3

Associated with the evolutionary theory of technical change the national innovation systems (NIS) approach has been attracting attention since the beginning of the 1990s. Lundvall (1992) defines a NIS as a set of elements and relations that interact, within national boundaries, in the production, diffusion and use of economically useful new knowledge. Nelson (1993) considers a NIS as a set of institutions whose interactions determine the innovative performance of firms. They define innovation in a broad sense as the process by means of which firms master and put into practice product designs and new parallel manufacturing processes.

While definitions are relatively similar, the debate is very lively and thorough regarding the meaning, scope and use of the concept (Alcorta and Peres 1998). First, the concept of innovation itself varies widely from 'hard' scientific and technical conceptualizations, to 'soft' institutional or organizational conceptualizations. Second, the concept of system varies from the 'aggregation of institutions or sectors' to the 'synergies originating from their joint operation'. Similarly, there are differences concerning whether the emphasis should be put on the elements, in their relationships, or on both. Third, some internal limits of the NIS approach are still evident; for example, there is no clear delimitation of the characteristics of institutions and organizations the NIS should encompass. Finally, there is the issue of whether and to what extent there are national limits to the system.

Other authors conceptualize NIS in terms of policies that affect innovative performance. Among them, Wijnberg (1994) defines the system as the sum of interactions between a specific public authority and the industries that include the firms whose behavior is most influenced by the former. Similarly, Metcalfe (1995) defines a NIS as a set of agents, which contribute to the development and diffusion of new technology, providing the framework within which governments form and implement policies to influence the innovation process.

From our perspective, the NIS approach helps to stress the importance of the supranational, national, regional and sectoral dimensions (see Lundvall 1992; Edquist 1997) in determining the innovative behavior of firms. This environment, in turn, influences the structure and interactions of industries, firms, the research subsystems and networks, the institutional framework and the diverse governments' policies. Policymaking aimed at improving innovative performance should then take into account some particular characteristics of systems, such as the 'constitutive unity'⁵ between element and relation. This implies that maintaining the NIS operation depends on stimulating the creativity of the agents through, simultaneously, improving the depth and quality of the connections. The different elements that constitute the system

make complementary contributions to the innovation process by informal and formal relationships that facilitate knowledge flows. It has been suggested through the observation of various experiences, that networking – that is, the establishment of semi-permanent relations between agents – seems to be the most adequate mechanism to allow such flows.

1.4

The NIS approach helps to identify the range of structural elements whose strength allows the successful competitive performance of national industries. However, research work about national innovation systems takes place on a fairly high level of aggregation and there remains a gap between the structural assessment and the detailed process involved in the unfolding and possible formation of competitive networks and industrial clusters. Additionally, NIS literature focuses mainly on dyadic relations; there are few empirical studies that address and describe regional or sectoral patterns of interaction between a broad variety of actors (Meeus et al. 1999). Thus, the setting up and implementation of policies by countries that wish to develop competitive strengths are expected to benefit from the conceptualization of the detailed grounding process of building industrial clusters within a NIS.

The sociotechnical constituencies approach, which puts technological processes at the center of its analytical focus, sheds some light on conceptualizing the social and technical elements and relations involved in building sustainable networks and industrial clusters from intra- and inter-organizational levels. According to this approach, innovation and diffusion become a single, but dynamic process of interaction between technical, socioeconomic, political and cultural factors, stressing the point that no single element can explain by itself the shape of technological processes. This interpenetration can take place at national and/or international level, and can involve competitive or collaborative interactions as well as a combination of both. Thus, STC can only exist through their rooting in the sociotechnical fabric of specific countries and regions (Molina 1990).

The ‘management of expertise’ then arises as an essential ability of firms to access and combine the range of knowledge required to succeed in technology transfer and subsequently in innovation. This capability resides within firms, but also in the networks linking them to their sources of knowledge and their markets. Organizationally, it is reflected in the constituency-building imperative to integrate the different functional skills which are internally involved, and to network them effectively with a diverse set of actors. However, the process of technology transfer and innovation involves more than outsourcing knowledge flows. In fact, new knowledge must be transformed

or 'translated' before innovation is developed to a point that it can be launched on the market. The sociotechnical alignment process involves the acquisition, synthesis and transformation of diverse types of knowledge obtained from diverse sources, internal and external to the firm, in order to arrive at product solutions that effectively meet the needs of the users.

There is an apparent paradox in the management of expertise, since firms' ability to identify, access and utilize external knowledge is dependent on their internal capability in the specific area of knowledge. This is now seen as an essential assumption to succeed in technology processes that involve the outsourcing of knowledge. Thus, while firms generally license a technology which they do not possess themselves, their ability to be effective in exploiting this new knowledge will depend on their own related expertise, that is, on their ability to use their external networks to rapidly acquire whatever expertise they need. Consequently, there is a wide spectrum of relationships between the sociotechnical constituents of a system of innovation, from market transactions to the constitution of self-dimensioning knowledge networks, capable of reacting and transforming themselves when changes in the environment occur. Many of these interactions consist in knowledge flows that are able to stimulate innovative performance, but not all the constituents are capable of assimilating and transforming this knowledge to generate sustainable economic activity.

Thus, the STC/NIS approaches seem to form a powerful policy-oriented conceptual apparatus, capable of identifying and correcting what can be called 'system failures', according to one of the most important ways of interpreting policy design. Again, these failures correspond to the constitutive unity of the system and threaten the operation and existence of the system itself. The main policy task seems to be to increase the systems' capacity to evenly distribute knowledge among its constituents. This involves the setting up of mechanisms to increase the quantity and quality of the relations, as well as mechanisms to increase the capacity of the diverse agents involved to accumulate, transform and generate knowledge.

1.5

This volume collects the work carried out within a European ALFA research program about National Innovation Systems in Europe and Latin America, with a special focus on Great Britain, Italy, Spain, Cuba, Mexico, Argentina and Peru. As mentioned earlier, the particular studies, in general, attempt to internalize a new conceptual framework, namely the *sociotechnical constituencies approach*, as a means of performing regional studies within the NIS general framework. These studies, which range from broad theoretical

contributions to specific regional studies or the combination of both, were carried out in 1998 and 1999 and discussed during two scientific meetings which were organized in Mexico City and Pisa.

Chapter 2 by *Alfonso Molina* and *Tony Kinder* is concerned with the development of sustainable industrial capabilities, understood as a country's ability to shape significantly the content, direction and dynamism of the long-term evolution of target industrial clusters. It aims in the first place to advance the existing theoretical apparatus used to deal with the understanding and practice of processes of industrial clusters and innovative capabilities. In addition, this conceptual framework is implemented to describe and discuss the experience of electronics-cluster fostering in Scotland. The theoretical work focuses on the integration of fundamental insights from the literature on industrial clusters and national systems of innovation and concepts that characterize the sociotechnical constituencies approach. The empirical work concentrates on the analysis of the depth and sustainability of Scotland's electronics clustering experience, with particular emphasis on the governance dominating its evolution.

In Chapter 3 *Mario Cimoli* and *Roberto Constantino* examine the concepts of a knowledge-based economy, networks and innovation to put into the Latin American perspective their proposal that within globalization, the benefits derived from innovation networks are not equally distributed. Moreover, they point out that the specialization of production and knowledge generates a system of networks where the demand for knowledge and innovation is continuously addressed towards advanced economies, increasing their capabilities of capturing those benefits and advantages. They conclude, through the analysis of the Mexican automotive industry, that the building of technological capabilities in a context of liberalization might create some dysfunctional linkages inside the domestic network structure of the economy. From their point of view, these seem to generate in the case of the most advanced Latin American economies a dual economic structure characterized, on the one hand, by a few modern firms controlled by multinational enterprises and large domestic firms; and on the other, by the majority of producers poorly linked to the industrial cores and with a low rate of exchange of information and knowledge.

Alfonso Molina and *Mirta Michilli* examine in Chapter 4 the process of constituency building in the generation of the City of Rome's telematics strategy. They start by providing a general economic and IT industry background of the city of Rome, with reference to a national systems of innovation approach, as far as the data allow. They then describe the most important actions and projects undertaken by relevant companies and other public and private organizations, as well as the status of current research and the relationships of the university with industry and local government. This provides

the broad context for the second major empirical part that uses the constituency-building approach to analyse the emergence and development of the Municipality's telematics strategy-making process. This discussion uses the diamond of sociotechnical alignment to map the evolution of the major aspects of this process. It includes a description of the rationale and operation of Eurolaboratorio, a policy instrument set out to promote a simultaneous process of telematics strategy-making and mobilization of key players in Rome. The success of this organization in taking the Municipality into many European collaborative research and technology projects is analysed, as well as the approach implemented for the unified strategy-making/clustering process in Rome and the present state of this process and the political-human factors influencing its development.

In Chapter 5 *Nicola Bellini* and *Andrea Piccaluga* first explore the emergence of the knowledge-based economy as the result of both the activity of a specific separate sector in charge of producing new knowledge, and of many other routine activities in economic life, which take the diverse forms of learning analysed in the literature. From this point of view, the approach they support is that of other scholars who have started to explore an explicitly co-evolutionary view, according to which the accumulation of technological knowledge is shaped and constrained by the nature of the organizations and institutions where this knowledge is embedded, and, conversely, new forms of knowledge demand and opportunity trigger changes in corporate organizations and broader institutions. In their work, a synthetic analysis of evolutionary paths, which characterize university institutions in advanced countries in general and in Italy in particular, is presented. These issues are also compared with the concrete case of an experimental project: 'Project Link' launched at national level by Scuola Superiore Sant'Anna. This case is analysed using the STC approach.

Carlos Correa examines the relative importance of different sources of information for innovation in Chapter 6. In particular, he discusses the intensity, nature and impact of knowledge flows, from public R&D institutions to firms working in the biotechnology field. The chapter is based on a survey conducted in Argentina, Brazil, Chile, Colombia and Uruguay, based on the approach developed by Faulkner and colleagues at the University of Edinburgh. The study describes the types of knowledge generally transferred (protected by intellectual property rights or freely available), the channels used (formal or informal), the impact of the transfers as perceived by the recipients and other elements that characterize the academia-industry linkages in the countries considered. On the basis of the information gathered, he concludes that there are objective factors, that affect the intensity and content of such linkages, which are beyond the subjective considerations often cited in the literature as main obstacles to expand academia-industry relations.

In Chapter 7 *Leonardo de la Rosa* and *Blanca Esther Martín* describe the development of two high-tech clusters – biotechnology and pharmaceutical – within the Cuban national innovation systems. The case of Cuba is particularly interesting for scholars involved in innovation-based economic development; the country has invested in education, training and research, and focused efforts towards some specific sectors where good scientific performances have been achieved. The authors argue that contacts between scientific research and manufacturing have, in general, increased and that important results have been obtained in the two science-based industrial clusters which have been analysed. What is now needed is the involvement of third parties in order to enrich the system of incentives and the interaction between science and industry.

From a policy-oriented view, in Chapter 8 *Alma Rocha-Lackiz* and *Roberto López-Martínez* argue that the absence of a continuous and coherent science and technology policy (STP) in Mexico, as well as measurements based on allowing public intervention only to correct ‘market failures’ has limited the possibilities for Mexican firms and research organizations to increase industrial competitiveness. Within a general framework provided by the economics of technical change, the sociotechnical constituencies approach and the proposals on national innovation systems, they analyse the most important characteristics and instruments of the current Mexican STPs. They conclude with the proposal of an untried framework for policymaking in Mexico and explore diverse corrective measurements to improve current policies. In general terms, they suggest the need to abandon the ‘market failure’ paradigm. This implies in turn, the government’s commitment to adopt the necessary instruments to make possible the integrated and co-ordinated participation of the various actors involved in technological change. Additionally, a shift is proposed from ‘organization-centred’ policy instruments to ‘technology-centred’ ones. This is considered as the starting point for the construction of sustainable knowledge networks and industrial clusters needed to guarantee variety and competition within a national innovation system.

The point of departure for *Pere Escorsa* and *Jaime Alberto Camacho* in Chapter 9 is the current decentralization process under way in Spain. Spanish regions – which are called Autonomous Communities – enjoy vast autonomy for the design of their industrial, scientific and technological policies. These adopt policies which complement those that are proposed at national or European level. Among the Spanish Communities, the Basque Country seems to be a region that has set up a very good industrial policy, designed around specific clusters, which are considered regional priorities: machine tools, electric appliances, aircraft industry and others. They function in a bottom-up way, starting with the detection of the technological needs of each cluster. Thereafter, all the agents of the science, technology and industrial system are

mobilized, such as the technological centres, which are very strong in this region, or the university. The chapter attempts to describe and analyse the policies included in the Basque Country Technology Plan I and Science and Technology Plan II, examining their recent evolution.

Mercedes Inés Carazo, Isaías Flit and Angel Hurtado examine innovation, science and technology in Peru, within a national innovation system approach, to provide a framework that determines the vision, objectives and values to guide the promotion of innovation at the national, regional and sectoral levels. Activities currently taking place, involving in a concerted way public, private and academic institutions, are described. The specific roles of the institutions are portrayed as well as the main instruments and organizational set-ups such as: sectoral inter-institutional networks, interrelated technical and managerial service centres, highly specialized innovation and quality centres, and technological information systems. The importance of learning how to strengthen innovative capabilities and entrepreneurial attitudes is highlighted, as well as the need to set up financial arrangements to promote the supply and demand of innovation-related services. Finally, the authors outline the oncoming challenges developing countries face in their endeavour to participate in a proactive way in a global economy marked by technological change.

NOTES

1. Or *static* and *dynamic models*; the former emphasize the constitutive elements, while the latter focus on the behavior of those elements during time.
2. Since the work by Abernathy and Utterback (1978).
3. See, for example, Saviotti and Metcalfe (1984); Sahal (1985) and Grupp (1994). The OECD manuals for scientific and technical activities and innovation provide standard practices for surveys of research and experimental development.
4. For a complete discussion of these models see Rothwell (1992).
5. Within a system, there are no elements without relational connections or relations without elements. See Luhmann (1995).

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