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Design of innovation policy through diagnostic analysis: identification of systemic problems (or failures)

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"Activities" in innovation systems are the determinants of the development and diffusion of innovations. Examples are R&D, provision of organizations and institutions, financing of innovations, incubation, etc. These activities are partly performed by private organizations and partly by public organizations, the latter performing tasks that constitute innovation policy. As a basis for innovation policy, the problems (failures) in the systems must be identified. This article focuses upon the design of innovation policy through diagnostic analysis; it provides a framework for identification of systemic problems (or failures) in innovation systems.

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1. Introduction

This article deals with how systems of innovation may be analyzed for innovation policy purposes. Sometimes innovation policies are designed—and implemented—without any prior identification of a problem to be solved through the policy. Under these conditions, policies are often pursued without there being any need for them—which is devastating.[1] No policy at all is better than a policy that does not target an

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[1]An example is the large public program in the field of process innovation in the Swedish engineering industry in the 1990s, which was not based on any analysis indicating that process innovation was a problem in this sectoral system of innovation. As a matter of fact, the Swedish engineering industry performed better in this respect than that of any other country at that time. On the other hand, the Swedish engineering industry performed very badly with regard to product innovation. However, such innovation did not get any public attention or support. Hence, the lack of analysis identifying a policy problem led to a policy that was not needed and no policy where it was needed. (Edquist and Jacobsson 1987; Edquist 1991) Much more recently—in February 2007—The Danish

identified problem. Hence, it is necessary to identify problems to be solved before designing a policy; we call them "*systemic problems*," "*policy problems*" or just "*problems*."[2] To base a policy on such an analysis is very different from blindly copying policies that have been pursued in other systems. The mode of identifying systemic problems and their causes can be called "diagnostic analyses" that are strategic in all policy design. The problems in innovation systems that are to be solved or mitigated by means of innovation policy can only be identified by comparing existing innovation systems with each other—over time and space.[3] The things to be compared are the performance with regard to the intensity of different kinds of innovations in different systems—and the causal explanations for this performance.

Before going into the main issues of this article, we would like to mention here that current processes of *globalization* highly influence the design and implementation of innovation policies. All systems of innovation are embedded into a wider context and are influenced by this context to a larger or smaller extent, depending on the size and strength of the system in question. Globalization is not decreasing the need for innovation policy; on the contrary, it may be strengthening it. Firms are encountering rapidly changing and highly uncertain market and institutional conditions in the international context on top of the technological uncertainties associated with invention and innovation. For that reason, public action needs to focus on the adaptability of the innovation system with the overall objective of generating a national or regional framework that is conducive to firms' adaptability and efficient exploitation of the opportunities offered by globalization. This means that public action should focus on the different elements in systems and their real bottlenecks vis-à-vis globalizing dynamics, and, in particular, the deficient and/or missing aspects in the national institutional set-up to enhance firms' capabilities to operate in this

Council for Technology and Innovation published an Innovation Action Plan containing more than 70 very different initiatives. It has been argued that this shows a fundamental uncertainty with regard to what works and what does not. Critics argue that a more effective use of the allocated funds (€400 million), would have been to start out with a thorough analysis of the strengths and weaknesses of the Danish innovation system as a basis for stronger priority-setting. (Trend Chart Newsletter, European Commission, February 2007)

[2]We use the term "problem" instead of "failure" in order to avoid the connotations that the traditional economics notion of "market failure" has. This is conscious and intentional. A "market failure" implies a comparison between an existing system of innovation and an ideal or optimal system. Since it is not possible to specify an optimal innovation system, the notion of "market failure" loses its meaning and applicability. Not to lead thoughts in wrong directions, we therefore prefer to talk about "systemic problems" instead of "systemic failures." (Edquist 2001: 221; Chaminade and Edquist 2006: 144)

[3]An existing system can also be compared to a 'target system' which can be specified. See also Section 3.2.1.

globalized context.[4] Still, the focus of this article is on how innovation policies may be designed in national, regional, and sectoral innovation systems contexts—not primarily on how systems and policies are influenced by globalization.

This article focuses upon the identification of *policy problems* in innovation systems through *diagnostic analyses*, that is, how innovation systems should be *analyzed* with the design of innovation policy in mind. Hence, to be able to identify the problems in the system, the policy-maker needs to have a good understanding of the performance of the system and of how the system operates. Our approach is to concentrate primarily on the performance of systems of innovation in terms of *innovation intensities,* and on the *activities* in the system of innovation (rather than on the components of the systems) (Section 2). We also address the character of the *division of labor* between private and public organizations with regard to the performance of each of the activities (Section 3). On this basis, we outline how a diagnostic analysis may be strategically used for policy purposes (Section 4). In so doing, we stress the necessity of comparing existing systems with each other.

2. Activities in innovation systems

2.1 Introduction

As mentioned, our approach is to focus primarily on the activities in the system of innovation (rather than on the components of the systems).[5] The reasons why this is advantageous are presented below. First a few definitions.

Innovations are new creations of economic and/or societal significance, mainly carried out by firms (private or public). They may be new products or new processes. The firms produce (and sell) products that may be material goods or intangible services (new products are product innovations) by means of technological or organizational processes (new processes are process innovations).[6] For these reasons, nonfirm public organizations do not normally influence the innovation processes directly but influence (change, reinforce, improve) the context in which the innovating firms operate. What then is this context? A general, theoretical answer to this question is that the context is all those things that influence innovation processes, that is, all the determinants of innovation processes that can be specified as in subsection 2.2. The literature on systems of innovation shows that the systems of innovation approach are about the determinants of innovation processes—not about

[4]We have previously dealt with these issues in Borrás, Chaminade and Edquist (2008).

[5]As explained in subsection 2.2., the "components approach" and the "activities approach" overlap somewhat, although the activities approach includes more determinants of innovation processes and is much broader.

[6]We will return to a discussion of the importance of taxonomies of innovations in Section 3.

their consequences (Edquist 1997b).[7] *Innovation policy* is actions by public organizations that influence innovation processes.

2.2 Components and activities in systems of innovation

The traditional System of Innovation (SI) approaches, such as Lundvall (1992) and Nelson (1993), focused strongly upon the *components* within the systems, that is, organizations and institutions. Organizations are the players or actors, while institutions are the rules of the game, constituting constraints to the actions of the organizations.[8] More recently, some authors have focused more on what happens in the systems.

One way of addressing what happens in SIs is the following. At a general level, the main or "overall" purpose of SIs is to pursue innovation processes; that is, to develop and diffuse innovations. From now on, what we call "activities" in SIs (for a list of activities, see Box 1) are the determinants of the development and diffusion of innovations. Examples of activities are *R&D* as a means of developing economically relevant knowledge that can provide a basis for innovations, or the *financing* of the commercialization of such knowledge, that is, its transformation into innovations.

An alternative term for "activities" could be "functions." We have chosen "activities" in order to avoid the connotation of "functionalism" or "functional analysis" as practiced in sociology. Functionalism focuses on the consequences of a phenomenon rather than on its determinants. The fact that determinants of innovation processes are in focus in the systems of the innovation approach—see above—is a strong argument for not using the term "functions" in this context. (Edquist, 2005: 204, n. 16).[9] Hence, we use the term *activities* as equivalent to *determinants* of the innovation process.

The approach has also been used as the basis for a general definition of an SI, according to which a system of innovation includes "all important economic, social, political, organizational, institutional and other factors that influence the development, diffusion and use of innovations" (Edquist, 1997: 14, 2005: 183; Edquist and Hommen 2008: 6). If an SI definition does not include all the determinants of innovation processes, then which of the potential determinants to exclude, and

[7]This does not contradict the fact that the consequences of *innovations* are extremely important—for productivity growth, employment, the environment, social conditions, military strength, etc. But the system of innovation *approach* does not deal with these consequences. Neither does this article.

[8]In the early literature, the distinction between organizations and institutions was not that clear; players or actors were sometimes labeled institutions. I focus on "organizational actors" and "institutional rules," and I try to make a clear distinction between them (Edquist and Johnson, 1997).

[9]In order to avoid all connotations, the best would perhaps be to use the term "x" to denote the concept of activities—but this might seem too radical for some social scientists.

Box 1 Key activities in systems of innovation

(i) Provision of knowledge inputs to the innovation process

(1) Provision of R&D results and, thus, creation of new knowledge, primarily in engineering, medicine and natural sciences.

(2) Competence building, for example, through individual learning (educating and training the labor force for innovation and R&D activities) and organizational learning. This includes formal learning as well as informal learning.

(ii) Demand-side activities

(3) Formation of new product markets.

(4) Articulation of new product quality requirements emanating from the demand side.

(iii) Provision of constituents for SIs

(5) Creating and changing organizations needed for developing new fields of innovation. Examples include enhancing entrepreneurship to create new firms and intrapreneurship to diversify existing firms; and creating new research organizations, policy organizations, etc.

(6) Networking through markets and other mechanisms, including interactive learning among different organizations (potentially) involved in the innovation processes. This implies integrating new knowledge elements developed in different spheres of the SI and coming from outside with elements already available in the innovating firms.

(7) Creating and changing institutions—for example, patent laws, tax laws, environment and safety regulations, R&D investment routines, cultural norms, etc.—that influence innovating organizations and innovation processes by providing incentives for and removing obstacles to innovation.

(iv) Support services for innovating firms

(8) Incubation activities such as providing access to facilities and administrative support for innovating efforts.

(9) Financing of innovation processes and other activities that may facilitate commercialization of knowledge and its adoption.

(10) Provision of consultancy services relevant for innovation processes, for example, technology transfer, commercial information, and legal advice.

Source: adapted from Edquist (2005).

why, have to be justified. This is quite difficult since, in the present state of the art, we do not know the determinants of innovation processes systematically and in detail. Obviously, then, we could miss a great deal by excluding some determinants, since they might prove to be very important once the state of the art has advanced. For example, 25–30 years ago, it would have been natural not to regard the interactions of organizations as determinants of innovation processes. Now, we know that these interactions are important determinants of innovation processes. This definition, moreover, is fundamental to the "activity-based" approach to studying SIs (Edquist, 2005; Edquist and Chaminade, 2006).

The determinants (activities) influence the innovation processes; it is a matter of causality. A satisfactory causal explanation of innovation processes almost certainly will be multicausal, and therefore should specify the relative importance of various determinants. These determinants cannot be expected to be independent of one another, but must be seen to support and reinforce—or offset—one another. Hence, it is also important to study the relations among various determinants of innovation processes (i.e. between each of the activities). This simply indicates that causal explanations in the social sciences are extremely complex and very difficult to pursue.

Since the late 1990s, some authors have addressed issues related to the specification of activities influencing the overall purpose of SIs (Edquist 1997b, 2005; Galli and Teubal, 1997; Liu and White 2001; Johnson and Jacobsson, 2003; Bergek et al. 2008). Such a focus on "activities" within systems of innovation emphasizes strongly what *happens* in the systems—rather than their components. In this sense, the activities approach provides a more *dynamic* perspective, and can capture how various activities that influence specific innovation processes may change the performance with regard to these innovations—and thereby how the whole system changes. The activities approach also has a larger potential to point out why a certain system of innovation performs badly—or well—with regard to a certain kind of innovation. As we will argue in Section 3, this is of considerable importance for the design and implementation of innovation policies. The activities approach is simply more useful for policy purposes. As we have seen earlier, the activities approach can be used to define an innovation system and it also has the potential to be instrumental in the development of a theory about the determinants of innovation processes.

In this contribution, we place greater emphasis on activities than much of the early work on SIs. Nonetheless, this emphasis does not mean that we disregard or neglect the components of SIs (organizations and institutions) and the relations among them. Organizations or individuals perform the activities; institutions provide incentives and obstacles influencing these activities. This is accounted for by including "creating and changing organizations" and "creating and changing institutions" in the list of activities (see Box 1, subsections 2.3.3.1 and 2.3.3.3).[10] In this sense, the "component's approach" and the 'activities' approach" overlap.[11] However, the activities' approach includes many more determinants of innovation

[10]It should be mentioned that networking/interactive learning among organizations (activity 6 in Box 1 and subsection 2.3.3.2.) was also an important part of the early work on SIs that actually named the approach a "systems" one. In this context, we should also remember that the systems of innovation approach—also in early versions—is, as argued in subsection 2.1 about the determinants of innovation processes—not about their consequences.

[11]A difference is, however, that the component's approach emphasizes the accumulated stock of some capabilities while the activities' approach stresses flow (creation, change) phenomena to a larger extent.

processes and is hence much broader in this sense. We believe that understanding the dynamics of each of the activities and the division of labor between public and private organizations in performing them is important to understand, explain and influence innovation processes. It is a useful departure point for discussing the role of the state (public organizations) in stimulating innovation processes by means of innovation policies.

No consensus has yet emerged among innovation researchers as to which terminology to use and which specific activities to include. This is natural because innovation research has not yet been able to identify in a specific enough manner the determinants of the development and the diffusion of different kinds of innovations. This trajectory of research is still in an immature stage. The state of the art is simply not advanced enough, and this provides abundant opportunities for further research. Box 1 introduces a hypothetical list of 10 activities based on the literature and on our own knowledge of innovation processes and their determinants, as discussed in Edquist (2005) and Edquist and Chaminade (2006). The activities are not ranked in order of importance, but the list is structured into four thematic categories: (i) the provision of knowledge inputs to the innovation process; (ii) demand side activities; (iii) the provision of constituents of Sis; and (iv) support services for innovating firms. Each of the activities may be considered a partial determinant of the development and diffusion of innovations. The ten activities were first published in Edquist (2005). In Edquist and Hommen (2008) they were used in a systematic analysis of the national systems of innovation in ten small countries in Asia and Europe.

2.3 Activities Specified[12]

We now look at the 10 activities introduced in Box 1 in more detail from a *policy point of view* and point out the role of public organizations influencing or directly carrying out these activities. Some of the activities are performed by private organizations while others are performed by public organizations, that is, through policy. We focus on this division of labor between private and public organizations with regard to each of the activities. [13]

2.3.1 Provision of knowledge inputs to the innovation process

2.3.1.1 Provision of research and development

"Research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man culture and society, and the use of this stock of knowledge to devise new applications" (Frascati Manual, 2002: 30). According to the Frascati Manual, the

[12]This section is directly based on Edquist and Chaminade (2006) and Chaminade and Edquist (2006).

[13]Of course, public and private organizations can collaborate.

term R&D covers three activities: basic research, applied research, and experimental development. *Basic research* is experimental or theoretical work undertaken primarily to acquire new knowledge without any particular application or use in view. *Applied research* is also original investigation in order to acquire new knowledge, but is directed mainly toward a specific practical aim or objective. *Experimental development* is systematic work, drawing on existing knowledge gained from research and/or practical experience, which is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced and installed (Frascati Manual, 2002: 30).

Here, we want to distinguish, to the largest possible extent, between determinants of innovation processes and innovation processes as such. Obviously, "Experimental development," according to the Frascati definition, highly overlaps with innovation activities. Therefore, we exclude experimental development from the concept of R&D.

R&D results are an important basis for some innovations, particularly radical ones in engineering, medicine, and the natural sciences. R&D resulting in radical innovations has traditionally been an activity partly financed and carried out by public organizations. This applies to basic research, as well as to applied research in some countries, conducted in universities and other public research organizations. NSIs can differ significantly with regard to the balance between these two kinds of organizations in the provision of R&D. In Sweden, <5% of all R&D is carried out in public research organizations. In Norway, this figure is >20%. In 1999, the proportion of all R&D financed by firms in the OECD countries ranged from 21% in Portugal to 72% in Japan (OECD, 2002b); privately funded R&D is much more important in advanced countries than in other countries.

Such data may be a way of distinguishing between different types of NSIs. In most NSIs in the world today, little R&D is carried out and the bulk of this is performed in public organizations. The majority of these countries are poor and medium income countries. Few countries that spend a lot on R&D are rich, and much of their R&D is carried out by private organizations. This includes not only some large countries such as the United States and Japan, but also some small and medium-sized countries such as Sweden, Switzerland, and South Korea.

Because innovation processes are evolutionary and path dependent, there is the danger of negative lock-ins, that is, trajectories of innovation that lead to inferior technologies resulting in low growth and decreasing employment. Potentially, superior innovation trajectories may not materialize and the generation of diversity may be reduced or blocked. In such situations, the state should favor experimentation and use R&D subsidies and public procurement for innovation, for instance, to support possible alternatives to the winning technologies (Edquist *et al.*, 2004).

In sum, public organizations may influence the R&D activity in different ways ranging from allocating funds for specific research activities in public universities and research centers to stimulating alternative technologies via R&D subsidies. However, much research is needed to understand the inter-relationships of R&D, innovation, productivity growth, the role of R&D in innovation in different sectors, and the impact of different instruments on the propensity of firms to invest in R&D.

2.3.1.2 Competence building

Here, we use the definition of Lundvall *et al.* (2002: 224) of *competence building* that includes: "...formal education and training, the labor market dynamics and the organization of knowledge creation and learning within firms and in networks." Knowledge is a "stock" category and learning is a "flow" category adding more knowledge to the existing "stock." Competence building includes processes and activities related to the capacity to create, absorb, and exploit knowledge for individuals and organizations. Obviously, this includes formal learning as well as informal learning.[14] The latter being vital for innovation processes and, therefore, an important part of (the activity of competence building in) innovation systems.

In most countries, the education and training that are important for innovation processes (and R&D) are primarily provided by public organizations—schools, universities, training institutes, and so on. However, some competence building is done in firms through learning-by-doing, learning-by-using, and learning-by-interacting—that are informal activities. Competence building may increase the human capital of individuals; that is, it is a matter of individual learning, the result of which is controlled by individuals.[15]

The organizational and institutional contexts of competence building vary considerably among NSIs. There are, for example, significant differences between the systems in the English-speaking countries and continental Europe. However, scholars and policy makers lack good comparative measures of the scope and structure of such differences. There is little systematic knowledge about the ways in which the organization of education and training influences the development and diffusion of innovations. Since labor, including skilled labor, is the least mobile production factor, domestic systems for competence building remain among the most enduringly national of elements of NSIs.

Nonetheless, competence building should not be limited to human capital. Organizations may have competences that exceed the sum of the competencies

[14]Formal learning is planned learning resulting from activities within a structured learning setting; it often takes place within a teacher–student relationship, such as in a school system. Informal learning occurs outside formal learning and teaching settings, often through the experience of day-to-day situations. It is a part of "lifelong learning" extending for decades after formal schooling. Formal learning is often a foundation for informal or ongoing learning.

[15]There is also organizational learning, the result of which is controlled or owned by firms and other organizations. Organizational learning leads to the accumulation of "structural capital," a knowledge-related asset controlled by firms (as distinguished from "human capital"). An example of such an asset maybe a patent, based on learning pursued by individuals but often owned by firms. Organizations have an interest in transforming individual knowledge into organizational knowledge, for example, through codification of individual knowledge into operation manuals.

held by their employees.[16] Human capital is hired by the company but is always owned by individuals. However, there are ways in which the firm can capture individual knowledge and transform it into organizational knowledge. There is also learning at the social level, that is, neither individual nor organizational learning, but involving society outside these spheres. Organizing the processes of learning within the firm and in networks is part of the competence-building activity. Many individuals belong to many networks, both formal and informal, where learning takes place. Moreover, individuals may have attachments other than employment to organizations, such as labor unions, technical societies, and Rotary Clubs. Scholars have only very recently started to analyze such processes, and many questions remain unanswered (Edvinsson and Malone, 1997; Guthrie and Petty, 2000; Sanchez *et al.*, 2000; Chaminade, 2003; Nooteboom, 2004).

2.3.2 Demand-side activities

2.3.2.1 Formation of new product markets

The state might need to intervene in the market on the demand side for two main reasons: a market for certain goods and services might not exist, or the users of goods and services might not be sophisticated enough to provide the required feedback to the producers with regard to new needs.

There is often uncertainty about whether a market demand exists in the very early stages of the development of new fields of innovation. A telling example was the belief that the total computer market amounted to four or six computers in the 1950s. Eventually markets develop spontaneously—or not at all.

One example of market creation is in the area of inventions. The creation of intellectual property rights through patents gives a temporary monopoly to the patent owner, intended to enhance commercialization and facilitate the selling and buying of technical knowledge.[17] Policy makers may also enhance the creation of markets by supporting legal security or the formation of trust.

Another example of public support to market creation is the creation and introduction of standards. For example, the NMT 450 mobile telecom standard created by the Nordic telecommunication offices in the 1970s and 1980s—when they were state-owned monopolies—was crucial for the development of mobile telephony in the Nordic countries. This made it possible for the private firms to develop mobile systems (Edquist, 2003).

[16]Of course, the competence of an organization may also amount to less than the sum of the individual competencies, the organization thereby being dysfunctional.

[17]Paradoxically, then, a monopoly is created by law in order to create a market for knowledge: that is, to make it possible to trade in knowledge.

In some cases, the instrument of public procurement for innovation has been important for market formation.[18] In other words, a market emerged because the public sector demanded products and systems that did not exist before the public procurement for innovation. This has been—and still is—an important instrument in the defense sector in all countries. It has also been important in infrastructure development (telecoms, trains, etc.) in many countries. Public policy may also influence demand—and thereby diffusion of innovations—when public organizations require a certain product mix, such as a minimum share of electricity based on renewable resources or cars powered by fuel cells.

2.3.2.2 Articulation of quality requirements

The provision of new markets is often linked to the articulation of product quality requirements, which may be regarded as another activity of the SI. Articulation of quality requirements emanating from the demand side with regard to the characteristics of new products is important for product development in most SIs, enhancing innovation and steering processes of innovation in certain directions.[19] Much of this activity is performed spontaneously by demanding customers in Sis, as a result of interactive learning between innovating firms and their customers. However, product quality requirements may also be a consequence of public action, for example, regulation in the fields of health, safety, and the environment, or the development of technical standards. Public procurement for innovation normally includes a functional specification of the product or system wanted, and this certainly means demand articulation that influences product development significantly.

Still, we know very little about the formation of new markets and the articulation of quality requirements. Instruments such as public procurement for innovation, regulation, or subsidies may influence these activities, but further discussion is needed on the adequate division of labor between public and private organizations in this field.

2.3.3 Provision of constituents for SIs

2.3.3.1 Creation and change of organizations

As pointed out above, organizations are considered key components in systems of innovation. Entry and exit of organizations, as well as change of incumbent organizations, are therefore important activities contributing to the change of systems of innovation as such. Organizations include not only firms, but also universities, research institutes, financing bodies, and so on. But since firms are ultimately

[18] Edquist *et al.* (2000) analyze public procurement for innovation in more detail.

[19] The meaning of the term "direction" is discussed in subsection 3.2.

responsible for commercializing new products, and as there is only so much one can say in one paper, we will choose to focus mainly on the creation and change of firms.

The creation and change of organizations for the development and diffusion of innovations is partly a matter of spontaneous firm creation (through entrepreneurship) and diversification of existing firms (through intrapreneurship). However, public action can facilitate such private activities by simplifying the rules of the game and by creating appropriate tax laws. Mergers between firms are also organizational changes. New R&D organizations (research organizations, universities) and innovation policy organizations can also be created through political decisions.

One important role of policy is to enhance the entry and survival of new firms by facilitating and supporting entrepreneurship. Compared to incumbents, new entrants are characterized by different capabilities, and they may be the socio-economic carriers of innovations. They bring new ideas, products, and processes. Hence, the state should create an environment favorable to the entry of new firms and the growth of successful small and medium-sized firms. Survival and growth of firms often require continuous (or at least multiple) innovation, particularly in high-tech sectors of production.

Enhancing entrepreneurship and intrapreneurship may be a way of supporting changes in the production structure in the direction of producing new products to a larger extent. There are three mechanisms by which the production structure may change through the addition of new products: existing firms might diversify into new products (as has happened often in Japan and South Korea, for example); new firms in innovative product areas might grow rapidly (as many have in the United States, for example); foreign firms might invest in new product areas in a country (Ireland, for example).

Adding new products to an existing bundle of products is important, since the demand for new products often grows more rapidly than for old ones—with accompanying job creation and economic growth. New products are also often characterized by high-productivity growth. The state could therefore create opportunities and incentives for changes in the production structure. Policy issues in this context concern how policy makers may help develop alternative patterns of learning and innovation, and nurture emerging sectoral systems of innovation.

In any system of innovation, it is important to ascertain whether the existing organizations are appropriate for promoting innovation. How should organizations be changed or engineered to induce innovation? This dynamic perspective on organizations is crucial in the SI approach, both in theory and in practice. Creation, destruction, and change of organizations were very important in the development strategies of the successful Asian economies and they are crucial in the on-going transformation of Central and Eastern Europe. Hence, organizational changes seem to be particularly important in situations of rapid structural change which, in turn, is linked to building the capacity to deal with changes.

2.3.3.2 Interactive learning, networking, and knowledge integration

As we have pointed out, relations among SI components (i.e. organizations such as firms, universities, and public organizations, and institutions such as established practices, rules, and laws) are a basic constituent of systems of innovation. Relations facilitate interactive learning which, in turn, is a basis for innovation. The SI approach, emphasizing interdependence and nonlinearity, is based on the understanding that firms normally do not innovate in isolation, but interact with other organizations through complex relations that are often characterized by reciprocity and feedback mechanisms in several loops. Innovation processes are not only influenced by the components of the systems, but also by the relations among them. This captures the nonlinear features of innovation processes and is one of the most important characteristics of the SI approach.

The interactive nature of much learning and innovation implies that this interaction could be targeted much more directly than is normally the case in innovation policy today.[20] Innovation policy should not only focus on the organizations of the systems, but also—and perhaps primarily—on the relations among them. Relations between organizations might occur through markets and other mechanisms, which implies integrating new knowledge developed in different spheres of the SI and coming from outside with knowledge already available in the innovating firms. It is a matter of "learning linkages" across the boundaries of organizations.

Most of the interaction of organizations involved in innovation processes occurs spontaneously when there is a need. The activity of (re)combining knowledge—from any source—into product and process innovations is largely carried out by private firms. They often collaborate with other firms, but sometimes universities and public research organizations are also involved. The long-term innovative performance of firms in science-based industries strongly depends on the interactions of firms, universities, and research facilities. If they are not spontaneously operating smoothly enough, these interactions should be facilitated by means of policy. Here institutions are important, as we will see in the next subsection.

The relations between universities and public research institutes, on the one hand, and firms on the other are coordinated only to a limited degree by markets. Policies help coordinate relations in different ways and to different degrees, reflecting differences across NSIs—but sometimes they are not coordinated at all. Incubators, technology parks, and public venture capital funds (discussed in subsection 2.3.4) might also help in similar ways. This means that the public sector might create organizations to facilitate innovation. At the same time, however, it might create the rules and

[20]Interactive learning has been studied empirically by Lundvall (1992) and Meeus and Oerlemans (2001).

laws that govern these organizations and their relations to private ones—that is, create institutions (Edquist *et al.*, 2004).[21]

2.3.3.3 Creation and change of institutions

Institutions are normally considered the second main component (organizations are the first) in SIs. Creating, demolishing, and changing institutions are crucial to the maintenance of SIs' dynamism. Important institutions in systems of innovation are intellectual property rights (IPR) laws, technical standards, tax laws, environment and safety regulations, R&D investment routines, firm-specific rules and norms, and many more. They influence innovating organizations and innovation processes by providing incentives for or obstacles to organizations and individuals to innovate. Many institutions (such as laws and regulations) are publicly created and therefore easy to modify by the state. However, others are created by private organizations, such as firm routines, and are much more difficult to influence by state intervention.

IPR laws are considered important as a means of creating incentives to invest in knowledge creation and innovation (and, as argued above, they create markets). Tax laws are also often regarded as influencing innovation processes. An important question here is what kinds (and levels) of taxes hinder or facilitate innovation and entrepreneurship.

We have already mentioned the important role of institutions in facilitating the interaction of organizations in the previous subsection. The state may, for example, support collaborative centers and programs, remove barriers to cooperation, and facilitate the mobility of skilled personnel among different organizations. This might include the creation or change of institutional rules that govern the relations between universities and firms, such as the one in Sweden stating that university professors shall perform a "third task" in addition to teaching and doing research: that is, interact with the society surrounding the university, including firms (Edquist *et al.*, 2004). There are institutions that influence firms and there are institutions that operate inside firms (for taxonomies of institutions see Edquist and Johnson, 1997).

Some institutions are created by public organizations. They are often codified and constitute policy instruments (such as the aforementioned IPR laws). Public innovation policy is partly a matter of formulating the rules of the game to facilitate innovation processes. These rules might have nothing to do with markets, or they might be intended to create markets or make the operation of markets more efficient. But not all institutions are created by public organizations. Other institutions, such as culture, norms, routines, etc. develop spontaneously over history without public involvement.

[21]Of course, public innovation policy can also be pursued with regard to the remaining eight activities, that is, outside the realm of organizational and institutional change.

As in the case of organizations, it is important to ascertain whether the existing institutions are appropriate for promoting innovation and to ask the same question of how institutions should be changed or engineered to induce innovations of certain kinds. Here too, the evolution and design of new institutions were very important in the development strategies of the successful Asian economies and in the ongoing transformation of Central and Eastern Europe. Hence, institutional (as well as organizational) changes are particularly important in situations of rapid structural change.

2.3.4 Support services for innovating firms

2.3.4.1 Incubation

Incubating activities include the provision of access to facilities and administrative support for new innovating efforts. In recent decades, incubating activities have been carried out in science parks to facilitate commercialization of knowledge. That this activity has become partly public has to do with the uncertainty characterizing early stages of product development, which means that markets do not operate well in this respect. Also, very recently, universities have started their own incubating activities to commercialize the results of their research activities.

However, innovations are also emerging in existing firms through incremental innovation and when they diversify into new product areas. In those cases, the innovating firms normally provide incubation themselves. There is a need to better understand the conditions under which incubation needs to be a public activity and when it should be left to private initiative.

2.3.4.2 Financing

Financing of innovation processes is absolutely crucial for turning knowledge into commercially successful innovations and to facilitate their diffusion. The significance of financing of innovation processes is certainly not reflected in the space it receives here—and the heading "support services" is not intended to downgrade its importance. Finance comes primarily from private actors within innovating firms (internal capital markets), stock exchanges, venture capital funds and firms, banks or individuals ("business angels"). However, in many countries—including the United States—public organizations provide finance, in the form of seed capital for instance, in support of innovation activities.

As with public intervention in general, public funds (financial subsidies) should only be made available when firms and markets do not spontaneously perform this activity well enough (e.g. when uncertainty is too large). But the question is not just when the public sector should finance innovation activities but also how: that is, what should be the instruments and what should be the appropriate balance between public and private funding in a particular SI.

2.3.4.3 Consultancy services

We finally arrive at the tenth SI activity included in Box 1, that is, the provision of consultancy services for innovation processes. Worth mentioning here are consultancy services related to the transfer of technology, commercial information, and legal questions. They are primarily offered by private organizations (such as specialized consultancy firms or entrepreneurial associations), and they may be instrumental when innovations result from diversification processes and when new firms are established around innovations.

But there are cases (e.g. certain SMEs and mature sectors) where public authorities also provide consultancy services, either directly or by acting as broker between firms and service providers. As an example one may mention regional public organizations, which provide, among other things, information to the local SMEs on market opportunities, new technology developments, and partnership opportunities.

3. Innovation policy as division of labor between private and public organizations in performing the activities

3.1 Introduction

As discussed in Section 2, our approach is to focus on the *activities* in the system of innovation (rather than on the components in the systems). As a complement to this, we focus systematically on the character of the *division of labor* between private and public organizations with regard to who performs each of the activities.[22]

As a basis for the design of innovation policy, the *problems* in the systems must be *identified*. The question is then how this can be done. There are two subquestions here:

1. what is a “policy problem”? and
2. how can we identify the problems?

A quick glance at the activities specified in subsection 2.3 (Box 1) reveals that each of them is performed partly by private organizations and partly by public organizations.[23] Since innovation policy is actions by public organizations that influence innovation processes, policy is a part of all of the ten activities This is the reason why innovation policy is not included as a separate activity in Section 2. There is a

[22]This division of labor is important since innovation policy is defined as actions carried out by public organizations that influence innovation processes. Private–public partnerships can also be addressed in these terms.

[23]However, it is seldom that an activity is performed by private or by public organizations exclusively. It is a continuum: both private and public organizations are normally involved in the performance of each activity.

division of labor between private and public organizations with regard to each of the activities. This division of labor varies between countries and over time.[24] When public organizations carry out part of the activities, this is the way they can influence the *context* in which the innovating organizations operate, that is, the determinants of innovation processes. To determine this division of labor is a matter of strategic choices in innovation policy making.[25]

3.2 *What is a "Policy Problem"—and how can it be identified*

Systems of innovation may be national, regional, or sectoral. These three perspectives may be clustered as variants of a single generic "systems of innovation" approach (Edquist, 1997a: 3, 11–12). Much of the discussion here is based on the premise that the different variants of the systems of innovation coexist and complement each other. Whether the most appropriate conception of the system of innovation, in a certain context, should be national, sectoral, or regional depends, to a large extent, on the questions one wants to ask (Edquist, 2005).

The reasons for public policy intervention in a market economy, that is, the rationales for public policy intervention, may be specified as follows. Two conditions must be fulfilled for there to be reasons for public intervention in a market economy:

1. private organizations must prove to be unwilling or unsuccessful in achieving the objectives[26] formulated; a *problem* must exist; and
2. the state (national, regional, local) and its public organizations must also have the *ability* to solve or mitigate the problem (Edquist 2001).

A *problem*, in our sense, that is, from a policy point of view has to do with (a low) *performance* of the innovation system (see subsection 3.2.1). As we shall see, the *explanations* of that (low) performance are also crucial for the design of innovation policy (see subsection 3.2.2). These issues are discussed in two subsections below.

3.2.1 Policy problems as performance: innovation intensities

The *performance* of an innovation system is the same as the output of the system, that is, what "comes out" of it. That output is—simply—*innovations*. To simplify, we are here assuming that the innovation policy objectives are formulated in terms of innovation intensities for certain kinds of innovations. Of course, this is not often the case. Instead, innovation policy objectives are normally formulated in much looser terms; for example, in terms of achieving increased economic growth, a better environmental balance, or more military strength—objectives that are only partly

[24]Examples were provided in subsection 2.3.

[25]These strategic choices are closely related to the rationales for public action—see subsection 3.2.

[26]Policy objectives are formulated in a political process, normally not—or only to a very limited extent—by analysts. Objectives are further addressed below.

achieved through innovations, and partly through other means. Hence, most national or regional innovation policies are *not* based upon the relative performance—in terms of the innovation intensities of different categories of innovations, of the country or region in question. However, in order to achieve more precision in innovation policy making, the objectives *should* be formulated in terms of intensities of various kinds of innovations. Until then the policy-makers act in the dark—or at least in the mist. Only pure luck can make them successful in achieving their—quite unspecific—objectives. The performance of an innovation system should not be measured as economic growth or military strength. These are different things, partly outside the innovation system, but very important.[27]

The innovations in terms of which the objectives should be formulated may be of different categories:

1. it may be a question of the development of innovations ("new to the world") or the diffusion or absorption of innovations (that are "new to the firm," "new to the country" or "new to the region");
2. radical or incremental innovations;
3. high-tech products or low-tech products;
4. product innovations or process innovations;
5. innovations related to specific sectors of production (material goods in general, specific goods-producing sectors; intangible services in general, specific service-producing sectors, etc.); and
6. innovations related to certain—general—objectives of innovation policy: economic, social, environmental, military, etc.

[27]The main reason for this is that it does not make sense to consider the innovation system to be the same as the whole economy or the whole society. It is much more sensible to limit the notion of innovation system to innovations of various kinds and the activities that influence their development and diffusion. This requires, of course, that the innovation output of innovation systems can be measured; it is very difficult to improve what cannot be measured. Much remains to be done with regard to measurement of innovations, and we return to that issue below. Of course, we also need to know the approximate consequences of innovations for economic growth, environmental balance, and military strength, since this is what innovation policy makers want to achieve in the end. However, the consequences of innovations are different from innovations as such or the determinants of innovations, and it is important to distinguish these three categories. In the literature on innovation systems, it is clear that consequences of innovations are normally not included in the definitions of systems of innovation. The consequences of (different kinds of) innovations are, as is generally accepted, extremely important for productivity growth, environmental balance and military strength. However, the study of consequences of innovations is a very complicated issue in itself. It is not addressed in this article. Growth is not an output measure of the innovation system, but innovations are very important for economic growth. Hence, innovation policy is an important part of growth policy, but they are not the same.

Hence, a policy problem may be low innovation intensity for a certain category of innovations. Talking about different categories of innovations is the same as discussing in terms of certain directions of innovation processes—to be discussed below.

From a policy point of view, it is very important, in the way hinted at above, to divide innovations into different categories. Hence, *taxonomies* of innovations are important, as are *indicators* of the intensity of different kinds of innovations in a system of innovation. *Taxonomies and indicators are crucial as a basis for the design and implementation of innovation policy.*

Let me say a few words about innovation indicators. The performance of a system of innovation can be measured by means of the propensity to innovate (or innovation intensity). Ideally, propensities should be known for many specific categories of innovations (see above), which is why the Community Innovation Surveys (CIS) (in Europe) and similar surveys carried out in non-European countries are so important. They measure (describe), among other things, the propensity to innovate for specific categories of innovations in various innovation systems (national, sectoral, and regional). If we do not know these propensities we cannot identify problems to be solved by innovation policy. Hence, the measurement of propensities to innovate with regard to specific categories of innovations is of utmost importance for policy purposes. It is important to develop the CISs to measure innovations of different kinds in an even more fine-tuned way, for example using a refined version of the list of indicators above. Countries that have not yet carried out an innovation survey should do so.[28]

To be useful for policy purposes, these measurements and descriptions must be *comparative* and *comparable* between systems. The reason is that it is not possible to say whether innovation intensity is high or low in a certain system if there is no comparison with innovation intensities in other systems. This has to do with the fact that we cannot identify "optimal or ideal" innovation intensities (just as we can not specify an optimal innovation system).

This means that problems cannot be identified through theoretical analysis alone.[29] The problems cannot be identified through a comparison between an empirically existing system of innovation and an optimal one, since we are unable to specify an optimal system of innovation. What remains is then to compare existing systems of innovation with each other. Such comparisons can be made between the same systems over time, or between different existing systems.[30]

[28]Patents are often considered to be innovation indicators, but they are not, in the proper sense of the word. A patent is rather an indicator of invention, indicating that something is new, but not necessarily that it is economically useful. (Keep in mind that most patents are never used.)

[29]However, we have stressed the importance of taxonomies of innovations. The creation of such taxonomies has a conceptual and theoretical basis or dimension.

[30]It is also possible to compare an existing system with a "target system." Such a system can be specified, but we can never argue that it is an optimal or ideal one.

Only in this way, we can identify the "policy problems" or "systemic problems." In other words, "*systemic problems*" can be identified only by comparing existing innovation systems with each other—over time and space.

The rationale of innovation policy is to solve or mitigate policy problems. If the system is performing very well, thanks to its spontaneous operation (based on the actions performed by private organizations), then no problem exists and policy intervention is not needed. Such intervention is only called for when the system is performing badly—in a relative sense. In other words, a "problem" exists only if the (politically formulated) objectives in terms of innovation intensities are not achieved by private organizations.

Let us now return to the discussion of innovation intensities in more general terms.

If a policy problem is a low innovation intensity (of a certain category of innovation), it might seem that "more innovation is always better." However, this is not the case. We cannot take for granted that innovation is always good and that more is better. At the same time, we cannot determine how much innovation is "optimal." This is certainly a dilemma that is not solvable and we have to live with it, and deal with it. Let me discuss this briefly.

First, we have argued that we can only determine if innovation intensity is high or low in one system of innovation by comparing it with innovation intensities in other systems. This begs the question of how the innovation intensities in "other systems" are determined. Can the innovation intensity for a certain category of innovations be too high? The answer to this question is related to the fact that we talk about innovation intensities for different categories of innovations. Hence, we enter into a discussion about the *direction* of innovation processes—not only the *number* of innovations.

In a system with limited resources, a very high innovation intensity for one category of innovations probably means a low innovation intensity for other categories. This might be unwanted. Some kind of balance among different categories of innovations may be preferred.

We briefly mentioned some taxonomies of innovations above. Some balance of the categories in those taxonomies may be motivated:

- between "new to the world" and "new to the firm innovations;"
- between radical and incremental innovations;
- between high- and low-tech products;
- between product and process innovations;
- between innovations in specific sectors of production; and
- between innovations related to certain objectives of innovation policy: economic, social, environmental, military, etc.

Innovation policy objectives should be formulated in these terms, that is, in terms of intensities of various kinds of innovations. When doing so, it is important to know the consequences of various categories of innovations for productivity growth, employment, environmental balance, and military strength. This is because there is a difference between innovations as such and the consequences of innovations for economic growth, the environment, military strength, etc. Also things other than innovations influence these wider phenomena. For example, economic growth is also influenced by employment intensity, education level, etc. Certain kinds of innovations do not necessarily translate into high impact on these wider phenomena. These are reasons why the two should be distinguished. One could think about this stepwise. First, it is a matter of being able to measure innovations (which we are not very good at). Second, it is a matter of measuring the consequences of innovations for economic growth, the environment, military strength, etc. (which may be even more complicated). Similarly, innovation policy should be formulated in two steps. Innovation policy can directly only influence innovation processes—not economic growth, etc. (although innovation is a major determinant of economic growth). However, as mentioned before, the analysis of consequences of innovations is outside the scope of this article.

There are certainly "dual use" innovations, for example, innovations that fulfill both military and economic objectives. In addition, these taxonomies—and others—may be combined with each other, and hence there are a very large number of categories of innovations that may be "balanced" with each other. There are certainly no generally accepted criteria for achieving these kinds of "balances"; they will have to be discussed in a pragmatic way from case to case. What this argumentation does indicate, however, is that the *direction* of innovation processes is as important an issue as the *number* of innovations. They both have to be in focus when policy objectives are formulated and policy problems are identified. For example, innovations intended to solve environmental problems may be important to balance innovations that have been pursued for economic reasons, and may in fact have caused the environmental problems in the first place.

In addition to the number of innovations and the direction of innovation processes, the *significance* of the innovations is, of course, crucial—for the formulation of innovation policy objectives and for the analysis of whether they have been achieved or not. A new horseshoe is less significant than the first integrated circuit. In general, innovations that have a wide use are more important than others, that is, generic and general purpose innovations are the more important. And turnover due to new products is more important than the number of new product innovations.

3.2.2. Causal explanations of policy problems

Still, an *identification of a "problem"* by means of empirical-comparative analysis is not sufficient as a basis for designing innovation policies; it is only a first step. First of all, the existence of a problem is only a necessary condition for pursuing an innovation policy. Public organizations must also have the ability to solve or mitigate the problem. A detailed *analysis of the causes* of the problems might be necessary and new organizations and institutions might have to be created in order to develop this ability. To know *that* there is reason to consider public intervention is not enough. An identification of a problem only indicates *where* and *when* intervention is called for. It says nothing about *how* it should be pursued. In order to be able to design appropriate innovation policy instruments, it is necessary to also know the causes behind the problem identified—at least the most important ones (Edquist, 2001: 234–235).[31]

A (low) propensity to innovate with regard to a certain category of innovations is actually what should be explained. This is where the activities in innovation systems enter the stage. In the conventional terms of the scientific method, the propensity to innovate is *explanandum* and the determinants are the *explanans*.[32] These determinants are referred to as "activities" in Section 2, where we hypothetically list 10 such activities, clustered into four main categories. In the recent book on the national systems of innovations in 10 small countries in Asia and Europe (Edquist and Hommen, 2008), these 10 activities are discussed in depth for each of the 10 countries.[33] The research question asked there was: "What were the national characteristics of the activities that influenced innovation processes in the ten national systems of innovation." We wanted to discuss the explanations of the propensity to innovate.[34]

Systematic identification of such determinants of innovation processes is a surprisingly under-researched area in innovation studies. Partly for this reason, but also because of the very complex nature of innovation processes, as well as the difficulty of developing causal explanations in the social sciences, it is very difficult to arrive at a "complete" causal explanation of the propensity to innovate in an SI. We might have to accept being able to point out only the main activities behind a low propensity to innovate.

The combination of a problem identifying analysis and a causal explanation may be called a "diagnostic analysis" (Edquist, 1994, 2001). Such an analysis may provide a basis for an efficient therapy or treatment—namely, an innovation policy. Without a diagnosis it is impossible to know what prescription is required, and without timely

[31]A causal analysis might also reveal that public intervention is unlikely to solve the problem identified, due to the lack of ability.

[32]Such analyses are always pursued within a theoretical framework—unconsciously or consciously, implicitly or explicitly. As mentioned, our framework is based on the activities in systems of innovation.

[33]The countries were Denmark, Finland, Hong Kong, Ireland, South Korea, The Netherlands, Norway, Singapore, Sweden, and Taiwan.

[34]Hence, the data on Sweden presented in Box 2 above are discussed from this perspective in the rest of the chapter on Sweden (Edquist and Hommen, 2008: Ch. 7).

Box 2 The case of Sweden: input and output innovation indicators

To illustrate, I am inserting a box on Sweden, taken from various parts of Edquist and Hommen (2008), in the midst of this discussion. The context is a discussion of the so-called Swedish paradox, which refers to a mismatch between very high values of indicators of inputs into innovation and low values of output indicators. The notion of a "Swedish paradox" has been central to recent innovation policy discussions in Sweden. When first formulated, it was as a reflection of a *high research and development (R&D) intensity* in Sweden coupled with a *low share of high-tech (R&D intensive) products* in manufacturing as compared to the OECD (Organization for Economic Co-operation and Development) countries. It was seen as a paradox between a high input and a low output measured by these specific indicators (Edquist and McKelvey, 1998).[a] We present comparative data for six small countries (Denmark, Finland, Ireland, Netherlands, Norway, and Sweden) in the statistical appendix. Data, taken from the Community Innovation Surveys (CIS), include R&D intensities and innovation intensities on the input side, which measures all expenditures made in order to carry out R&D or to innovate, divided by firms' turnover. The Swedish figure for R&D was 38% higher than the figure for the country ranked second (Denmark). Also for innovation intensity, Sweden ranked first. We conclude that these input intensities of Swedish firms are very high compared to the other countries (Edquist and Hommen, 2008: 240–241, 517–530).

On the output side, we revisit the paradox by analyzing the proportion of innovating firms, the share of all firms that have introduced new processes, and the share of firms having introduced product innovations.[b]

First, the proportion of innovating firms measures the share of firms that have introduced either a *product or a process innovation*. For this indicator, Sweden (all Swedish firms) ranked only fourth for both periods, that is, 1994–1996 and 1998–2000 with a performance only slightly above average. Sweden was followed by Norway and Finland for the 1994–1996 period, and by Norway only in the 1998–2000 period. However, when the data are disaggregated into manufacturing, KIBS, finance, and trade, Swedish firms perform much better in the service sectors of finance and trade than in manufacturing.

Second, focusing on the share of all firms that have introduced *new processes* during a three year period, Sweden's performance was 14% below the average, and ranked fourth (out of six) for the first period, and fifth (out of five) in the second period.[c] Hence, Sweden was at the bottom in comparison, even though differences among the five countries were rather small. Worryingly, the Swedish position deteriorated over time between the two periods. Swedish firms performed somewhat better in services than in manufacturing. It is interesting that previous studies have shown that in the past Sweden—at least Swedish engineering industry—was very advanced with regard to the introduction of new process innovations (Edquist and Jacobsson, 1988).[d] However, judging from the CIS data, this no longer seems to be true.

Third, we have analyzed four indicators related to *product innovations*. The indicator *introduction of new to the firm products* measures the share of firms that introduced products that were new to them (but not to the "world") during a 3-year period. Here, Sweden ranked fourth (out of six) for 1994–1996 and fourth (out of five) for 1998–2000.

As a contrast, the indicator *introduction of new to the market products* measures the share of firms that introduced products that were new to the market (i.e., new to the "world") during a

(continued)

Box 2 Continued

3-year period. Sweden ranked fourth (out of five), with only Norway behind. Interestingly, for both indicators Swedish firms performed better in services, but poorly in manufacturing, in comparison to other countries.

The indicator *turnover due to new to the firm products* is the turnover due to new-to- the-firm products introduced during a certain period, divided by total turnover at the end of the period. Here, Sweden performed very well, ranking first among the five countries compared. Hence, the performance was much better in this respect than with regard to the proportion of all firms that innovated new-to-the-firm products.

The indicator *turnover due to new to the market products* is the ratio of turnover due to new products or significantly improved products (goods or services) introduced during the period 1998–2000, divided by the total turnover in 2000. Here, Sweden was somewhat below the average, ranking third (out of four). Thus, Swedish firms performed relatively worse with regard to creation than to imitation.

It is also interesting that the performance in respect of this indicator was much better for small firms than for large ones, that is, small firms were much more creative than large ones, as compared to the other countries. Hence, the overall performance of all firms—which was, on average, worse with regard to creation than to imitation—may be explained by the domination of large firms in the Swedish NSI.

Comparatively speaking, the input indicators for Swedish firms are very high. On the output side all indicators are quite low compared to the other countries—with only one exception: *turnover due to new to the firm products*.[e]

The comparison made here has been with 4 and 5 small industrialized countries in Europe and the result should be tested through further comparisons with more countries. Even so, we have reformulated the paradox in more specific terms than previously discussed in the research and policy literature. Our overall conclusion is that the Swedish NSI is not as capable, as some other small industrialized countries, of transforming the very large resources invested in R&D and innovation activities on the input side into correspondingly large outputs of product and process innovations on the output side. The productivity (or efficiency) of the Swedish NSI, in this sense, is simply not high. Hence, the existence of the Swedish paradox is *confirmed* on the basis of the different, broader and more detailed indicators based on CIS2 and CIS3.[f] More specifically, the results suggest that the underlying problem may reside with the large firms that dominate the NSI and their under-performance in innovation outputs. The data in this box emanates from two Community Innovation Surveys; CIS II which covers the period 1994–1996 and CIS III which covers the period 1998–2000. Supplementary work on more recent Community Innovation Surveys is currently carried out by Charles Edquist and Jon Mikel Zabala at CIRCLE. It includes analyses of CIS IV (2002–2004), CIS 2006 (2004–2006) and the recently published CIS 2008 (2006–2008). The results will be published in due course. They will show that the ranking of Sweden among the countries above has changed considerably with regard to several of the indicators during the first decade of the 21st century. For example, in 2006–2008 Sweden had the highest share of innovating companies as well as the highest share of firms that had introduced new to the

(continued)

Box 2 Continued

market products. For many of the indicators there were, however, no clear trends over the 15-year period.

[a]This publication of 1998 was written in 1994, was internally published in 1996 and was based on a publication from 1992—which, in its turn, was a translation of a chapter in an appendix to the final study of the Swedish Productivity Delegation of 1991 (Edquist and McKelvey, 1991).

[b]This discussion is taken directly from Edquist and Hommen 2008: 241–243 and that analysis is based on data from Edquist and Hommen (2008: 517–530).

[c]Our data measured mainly technological process innovations and did not include organisational process innovations.

[d]It was shown that Swedish manufacturing firms were among the world leaders in the 1970s and 1980s with regard to the diffusion of computer-controlled process technologies (numerically controlled machine tools, industrial robots and flexible manufacturing systems) in the engineering industry.

[e]This could indicate that the new (to the firm) products innovated, on average, account for large volumes of sales, which is certainly a great strength of the Swedish NSI. And this is probably related to the dominance of large firms in Sweden—selling "new to the firm" products in large quantities.

[f]In addition, the input component of the Swedish paradox can be *extended* to all innovation expenditures, which do not only include R&D expenditures. Further, the difference between Sweden and the other countries with regard to this indicator was even *larger* for innovation intensity than for R&D intensity. In other words, the paradox can be reformulated along these lines: on the input side we could use innovation intensity instead of R&D intensity—or both.

prescriptions there is a risk that we might become pathologists—that is, try to find the diagnosis after the patient has passed away. However, satisfactory causal explanations in the social sciences are rare phenomena. Therefore, an inability to explain in detail might not be a reason to abstain completely from intervention in the process of innovation. Because, problems identified may sometimes be very severe—for the economy, for the environment, or for the social conditions—trial-and-error intervention may be necessary. However, it is still necessary to have some clues about which are the most important causes of a problem.

4. Strategic use of diagnostic analysis for policy purposes

Let me summarize in telegraphic form what has been argued in this article with regard to the design of innovation policy.

(I) A diagnostic analysis is firstly related to the performance of an innovation system. We must be able to point out the kinds of innovations with which the system is performing badly. This is defined as a *problem*. What is also required is that the objectives of the innovation policy are specified in terms of the kinds of innovations that should be influenced, that is, the policy objectives should be expressed in terms of innovation intensities. We discussed this problem identification in subsection 3.2.1.

(II) However, a diagnostic analysis also includes an identification of the causes of the problems identified. We proposed—in Section 2 and subsection 3.2.2—that such an analysis may be carried out in terms of the 10 activities in systems of innovation.

In carrying out a causal analysis to provide a basis for innovation policy, there are two important analytical questions (questions 1 and 3 below), and two policy questions (questions 2 and 4), one policy question related to each analytical question:

1. what *is* the division of labor in activities influencing (a low) performance with regard to a certain category of innovations? (Where is the border line between the respective parts of a certain activity performed by private and public organizations?);
2. what *should* the division of labor be? Should there be *more/less* public intervention, that is, should the border line between the respective parts of each activity performed by the private and public organizations be moved?;
3. what *are* the characteristics of the part of the activities performed by public organizations (i.e. what are the characteristics or features of the public intervention)?; and
4. how *should* the characteristics of the public intervention be changed?

These four questions should be asked with regard to each of the ten activities. In addition, they should be asked for each of the relevant categories of innovations.[35] To *determine* the—existing and/or wanted—*division of labor* is a matter of *strategic choices* in innovation policy-making.

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[35]Therefore, taxonomies of innovations are very important.

References

Bergek, A., S. Jacobsson, B. Carlsson and S. Lindmark (2008), 'Analyzing the functional dynamics of technological innovation systems: a scheme of analysis,' *Research Policy*, **37**, 407–429.

Borrás, S., C. Chaminade and C. Edquist (2008), 'The challenges of globalisation: strategic choices for innovation policy,' in G. Marklund, N. Vonortas and C Wessner (eds), *The Innovation Imperative: Globalisation and National Competitiveness*. Edward Elgar Publishers: London.

Chaminade, C. (2003), 'How IC management can make your company more innovative,' *How to Develop and Monitor your Company's Intellectual Capital*. Nordic Industrial Fund: Oslo, Norway.

Chaminade, C. and C. Edquist (2006), 'From theory to practice: the use of the systems of innovation approach in innovation policy,' in J. Hage and M. Meeus (eds), *Innovation, Science and Institutional Change. A Research Handbook*. Oxford University Press: Oxford.

Edquist, C. (1991), *Utvärdering av Statligt Stöd till Verkstadsindustriell Teknik* ('Evaluation of Public Support to Technical Change in the Engineering Industry' in Swedish). Report on State Support to R&D and Technological Development, Swedish Ministry of Industry, September.

Edquist, C. (1994), 'Technology policy: the interaction between governments and markets,' in G. Aichholzer and G. Schienstock (eds), *Technology Policy: Towards an Integration of Social and Ecological Concerns*. Walter de Gruiter: New York, pp. 67–91.

Edquist, C. (1997a), *Systems of Innovation: Technologies, Institutions and Organizations*. Pinter Publishers/Cassell Academic: London, UK.

Edquist, C. (1997b), 'Systems of innovation approaches: their emergence and characteristics,' in C. Edquist (ed.), *Systems of Innovation: Technologies, Institutions and Organizations*. Pinter/Cassell Academic: London, UK. (The book is out of print, but this chapter has been republished in Edquist, C. and McKelvey, M. (eds.) *Systems of Innovation: Growth, competitiveness and Employment, An Elgar Reference Collection*. Edward Elgar Publishing: Cheltenham, UK, 2000).

Edquist, C. (2001), 'Innovation policy: a systemic approach,' in B.-Å. Lundvall and D. Archibugi (eds), *Major Socio-economic Trends and European Innovation Policy*. Oxford University Press: Oxford, UK.

Edquist, C. (2003), 'The fixed internet and mobile telecommunications sectoral system of innovation: Equipment, access and content,' in C. Edquist (ed.), *The Internet and Mobile Telecommunications System of Innovation: Developments in Equipment, Access and Content*. Edward Elgar: Cheltenham, UK.

Edquist, C. (2005), 'Systems of innovation: perspectives and challenges'. The Oxford Handbook of Innovation, *Chapter 7*. Oxford University Press: Oxford, pp. 181–208.

Edquist, C. and C. Chaminade (2006), 'Industrial policy from a systems-of -innovation perspective,' *European Investment Bank (EIB) Papers*, **11**(1–2), 14–46.

Edquist, C., L. Hommen and L. Tsipouri (eds) (2000), *Public Technology Procurement and Innovation*. Kluwer Academic Publishers: Boston/Dordrecht/London, 2000.

Edquist, C. and L. Hommen (2008), 'Comparing national systems of innovation in Asia and Europe: theory and comparative framework,' in C. Edquist and L. Hommen (eds), '*Small Country Innovation Systems: Globalisation, Change and Policy in Asia and Europe*. Edward Elgar: London.

Edquist, C. and L. Hommen (eds) (2008), *Small Country Innovation Systems: Globalisation, Change and Policy in Asia and Europe*. Edward Elgar: London.

Edquist, C. and S. Jacobsson (1987), *Flexible Automation: The Global Diffusion of New Technology in the Engineering Industry*. Basil Blackwell: Oxford, 1988.

Edquist, C. and B. Johnson (1997), 'Institutions and organizations in systems of Innovation,' in C. Edquist (ed.), *Systems of Innovation: Technologies, Institutions and Organizations*. Pinter/Cassell Academic: London and Washington. (The book is out of print, but this chapter has been republished in Edquist, C. and McKelvey, M. 2000.).

Edquist, C., F. Malerba, J.S. Metcalfe, F. Montobbio and E. Steinmueller (2004), 'Sectoral systems: implications for European innovation policy,' in F. Malerba (ed.), *Sectoral Systems of Innovation: Concepts, Issues and Analysis of Six Major Sectors in Europe*. Cambridge University Press: Cambridge, UK.

Edquist, C. and M. McKelvey (1991), 'The diffusion of new product technologies and productivity growth in Swedish industry,' *Consortium on Competitiveness &Cooperation (CCC) Working Paper, No 91-15, 1992, Center for Research in Management*. University of California: Berkeley.

Edquist, C. and M. McKelvey (1998), 'High R&D intensity without high tech products: a Swedish paradox?,' in K. Nielsen and B. Johnson (eds), *Institutions and Economic Change: New Perspectives on Markets Firms and Technology*. Edward Elgar: Cheltenham, UK, pp. 131–149.

Edvinsson, L. and M. Malone (1997), *Intellectual Capital; Realizing your Company's True Value by Finding its Hidden Brainpower*. Harper Collins: New York, USA.

European Commission (2003), 'Study on the measurement of intangible assets and associated accounting practices', DG Enterprise.

European Commission (2007), 'TrendChart newsletter', February.

Frascati Manual (2002), *Proposed Standard Practice for Surveys on Research and Experimental Development*. OECD: Paris, France.

Galli, R. and M. Teubal (1997), 'Paradigmatic shifts in national innovation systems,' in C. Edquist (ed.), *Systems of Innovation: Technologies, Institutions and Organizations*. Pinter/Cassell Academic: London, UK.

Guthrie, J. and R. Petty (2000), 'Intellectual capital literature review,' *Journal of Intellectual Capital*, **1**(2), 155–176.

Johnson, A. and S. Jacobsson (2003), 'The emergence of a growth industry: a comparative analysis of the German, Dutch, and Swedish wind turbine industries,' in S. Metcalfe and U. Cantner (eds), *Transformation and Development: Schumpeterian Perspectives*. Heidelberg, Germany: Physica/Springer.

Liu, X. and S. White (2001), 'Comparing innovation systems: a framework and application to China's transitional context,' *Research Policy*, **30**, 1091–1114.

Lundvall, B-Å. (1992), *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. Pinter: London, UK.

Lundvall, B-Å., B. Johnson, E.S. Andersen and B. Dalum (2002), 'National systems of production, innovation and competence building,' *Research Policy*, **31**(2), 213–231.

Meeus, M., L. Oerlemans and J. Hage (2001), 'Patterns of interactive learning in a high tech region: an empirical exploration of complementary and competing perspectives,' *Organization Studies*, **22**(1), 145–172.

Nooteboom, B. (2004), *Inter-firm Collaboration, Learning and Networks: An Integrated Approach*. Routledge: London/New York.

Nelson, R.R. (1993), *National Systems of Innovation: A Comparative Study*. Oxford University Press: Oxford, UK.

OECD (1999a), *Managing National Innovation Systems*. OECD: Paris, France.

OECD (1999b), 'Measuring and reporting intellectual capital: Experience, issues and Prospect', International Symposium, Royal Academy of Arts and Sciences. Amsterdam: Netherlands, pp. 9–11. June.

OECD (2002b), *Main Science and Technology Indicators*. Vol. 2002/2, OECD: Paris, France.

Sánchez, P. C., C. Chaminade and M. Olea (2000), 'Management of intangibles: an attempt to build a theory,' *Journal of Intellectual Capital*, **1**(4), 312–327.