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Identification of Policy Problems in Systems of Innovation through Diagnostic Analysis

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Abstract:

'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 ones. Those performed by public organizations constitute innovation policy. As a basis for innovation policy, the problems in the systems must be identified. These 'systemic problems' or 'policy problems' can be identified only by means of comparing existing innovation systems with each other – over time and space. On this basis the division of labor between public and private organizations must be analyzed. This division of labor varies between countries and over time. To determine this division of labor is a matter of strategic choices in innovation policy-making. This paper will be focused upon the identification of systemic problems through diagnostic analysis.

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1. Introduction

This paper deals with how systems of innovation can be analyzed for innovation policy purposes.[2] 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.[3] It is better with no policy at all than a policy that is not targeting an identified problem. Hence, it is necessary to identify problems to be solved before creating a policy; we call them **'systemic problems' or 'policy problems' or just 'problems'**. 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'. Such diagnostic analyses 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. 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 behind this performance.

Before going into the main issues of this paper, we here want to mention 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 – although to a larger or smaller extent, depending on the size and the 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 the top of the technological uncertainties associated with inventive and innovative activities. For that reason, public action needs to focus on the adaptability of the innovation system with the overall objective to generate 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 shall focus on the different elements in the systems and their real bottlenecks vis-à-vis globalizing dynamics, and in particular, the deficient and/or missing aspects in the national

[2] This paper was written during my stay as guest professor at the Centre for Advanced Studies, Oslo, Norway in April and June 2008.

[3] An example is the large public program in the field of process innovation in the Swedish engineering industry in the 1990's. It was not based on any analysis that indicated 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 in 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 get no 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 1991; Edquist and Jacobsson 1987) Much more recently – in February 2007 – The Danish Council for Technology and Innovation published an Innovation Action Plan. It contains 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 (EUR 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. (TrendChart Newletter, European Commission, February 2007)

institutional set-up that enhances the firms' capabilities to operate in this globalized context.[4] The focus in this paper is, however, on how innovation policies can be designed in national, regional and sectoral innovation systems contexts – not primarily on how systems and policies are influenced by globalization.

This paper will be focused upon the identification of **policy problems** in innovation systems through **diagnostic analyses**, i.e. how innovation systems should be **analyzed** with the design of innovation policy in mind. 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 focus primarily on the **activities** in the system of innovation (instead of on the components of the systems) (section 2) and on 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 will outline how a diagnostic analysis can be strategically used for policy purposes (section 4). In doing this, we will stress the necessity of comparing existing systems with each other.

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

2. Activities in Innovation Systems

2.1. Introduction

As mentioned, our approach is to focus primarily on the **activities** in the system of innovation (instead of on **components** of the systems). The reasons why this is advantageous are presented below.

Innovations are new creations of economic significance primarily carried out by firms (private or public ones). The firms produce (and sell) products that may be material goods or intangible services. (New products are product innovations.) The firms produce the products by means of technological or organisational processes. (New processes are process innovations.) [5] For these reasons, non-firm public organisations do not normally influence the innovation processes directly. Instead they influence (change, reinforce, improve) the **context** in which the innovating firms operate. What is then this context? A general, theoretical answer to this question is that the context is all those things that **influence** innovation processes, i.e. all the **determinants** of innovation processes. (This can be specified as in section 2.2.) The literature on systems of innovation shows that this **approach** is about the **determinants** of innovation processes – not about their **consequences** (Edquist 1997b).[6]

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, i.e. organizations and institutions. Organizations are the players or actors. Institutions are the rules of the game, which constitute constraints for the actions of the organizations. 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. What we, from now on, 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 the development of economically relevant knowledge that can provide a basis for innovations, or the *financing* of the commercialization of such knowledge, i.e. its transformation into innovations.

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

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

Box 1: Key Activities in Systems of Innovation

I. Provision of knowledge inputs to the innovation process

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

2. Competence building, e.g. through individual learning (educating and training the labour force for innovation and R&D activities) and organisational learning.

II. Demand-side activities

3. Formation of new product markets.

4. Articulation of quality requirements emanating from the demand side with regard to new products.

III. Provision of constituents for SIs

5. Creating and changing organisations 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 organisations, policy agencies, etc.

6. Networking through markets and other mechanisms, including interactive learning between different organisations (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 – e.g., patent laws, tax laws, environment and

safety regulations, R&D investment routines, cultural norms, etc. – that influence innovating organisations 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 can facilitate commercialisation of knowledge and its adoption.

10. Provision of consultancy services relevant for innovation processes, e.g., technology transfer, commercial information, and legal advice.

Source: Edquist (2005)

An alternative term for 'activities' could have been 'functions'. We chose 'activities' in order to avoid the connotation with '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 innovation approach - see above - is a strong argument for not using the term 'functions' in this context. (Edquist (2005), p. 204, n. 16).[7] Hence we use the term **activities** as equivalent to **determinants** of the innovation process.

This approach has also been used as a basis for a general definition of an SI. According to this definition 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, p. 14; Edquist 2005, p 183; Edquist and Hommen 2008, p 6). If an SI definition does not include all the determinants of innovation processes, one has to argue which potential determinants that should be excluded – and why. This is quite difficult since, at 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 to 30 years ago, it would have been natural to exclude the interactions between organisations as a determinant of innovation processes. Now we know that these interactions are important

[7] 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.

determinants of innovation processes. This definition, moreover, is fundamental to the 'activities-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 multi-causal, and therefore should specify the relative importance of various determinants. These determinants cannot be expected to be independent of each other, but instead must be seen to support and reinforce - or offset – one another. Hence, it is important to also 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 issue of specification of activities influencing the overall function of SIs (Galli and Teubal, 1997; Johnson and Jacobsson, 2003; Liu and White, 2001; Rickne, 2000). 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. It can capture how various activities that influence specific innovation processes can change the performance with regard to these innovations – and thereby how the whole systems 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 large importance for the design and implementation of innovation policies. The activities approach is simply more useful for **policy** purposes.

In this contribution we are placing greater emphasis on activities than much of the early work on SIs. Nonetheless, this emphasis does not mean that we can disregard or neglect the components of SIs and the relations among them. Organisations or individuals perform the activities; institutions provide incentives and obstacles influencing these activities. To understand, explain and influence innovation processes, we therefore need to address the relations between activities and components, as well as among different kinds of components (i.e. organisations and institutions). However, we believe that understanding the dynamics of each of the activities and the division of labour between public and private organizations in performing them can be a useful departure point for discussing the role of the government 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 that should be included. 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. In Box 1 we presented a hypothetical list of ten activities. This list of activities is based on the literature and on our own knowledge about 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. The different activities can each be considered to be partial determinants of the development and diffusion of innovations.

2.3. Activities Specified [8]

We will now discuss the ten activities introduced in Box 1 in more detail from a **policy point of view;** pointing out the role of public agencies influencing or directly carrying out these activities. Part of the activities is performed by private organizations and another part is performed by public organizations, i.e. through policy. We will focus on this division of labour between private and public organizations with regard to each of the activities

2.3.1. Provision of knowledge inputs to the innovation process

2.3.1.1. Provision of research and development (R&D)

"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 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 undertaken in order to acquire new knowledge. It is, however, directed primarily 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 between determinants of innovation processes and innovation processes as such to the largest possible extent. Obviously, 'Experimental development', according to the Frascati definition, highly overlaps with innovation activities. Therefore, experimental development is here excluded from the concept of R&D.

[8] This section is directly based on Edquist and Chaminade 2006 and Chaminade and Edquist 2006.

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 agencies. This applies to basic research, but – in some countries – also to applied research. This publicly performed R&D is carried out in universities and other public research organisations. NSIs can differ significantly with regard to the balance between these two kinds of organisations in the provision of R&D. In Sweden, less than 5 percent of all R&D is carried out in public research organisations. In Norway, this figure is more than 20 percent. In 1999, the proportion of all R&D financed by firms in the OECD countries ranged from 21 percent in Portugal to 72 percent in Japan (OECD 2002b)**;** privately funded R&D is much more important in advanced countries that 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 most of this is performed in public organisations. Most of these countries are poor and medium-income countries. The few countries that spend a lot on R&D are rich, and much of their R&D is carried out by private organisations. This includes 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 materialise and the generation of diversity may be reduced or blocked. In such situations, governments may favour experimentation and use R&D subsidies and public innovation procurement, for instance, to support possible alternatives to the winning technologies (Edquist *et al*. 2004).

In sum, public organisations can influence R&D activity in different ways, ranging from allocating funds for specific research activities in public universities and research centres to stimulating alternative technologies via R&D subsidies. However, much research is needed to understand the relationship between R&D, innovation, productivity growth, the role of R&D in innovation in different sectors, and the impact of different instruments in the propensity of the 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 labour 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.

In most countries, the education and training that is important for innovation processes (and R&D) is primarily provided by public organisations – schools, universities, training institutes, and so on. However, some competence building is done by firms through learning-by-doing, learning-by-using, and learning-by-interacting. 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.[9]

The organisational 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 on the scope and structure of such differences. There is little systematic knowledge about the ways in which the organisation of education and training influences the development and diffusion of innovations. Since labour, including skilled labour, is the least mobile production factor, domestic systems for competence building remain among the most enduringly national of elements of NSIs.

Competence building should not, however, be limited to human capital. Organisations have competences that exceed those of the employees. 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 organisational knowledge. There is also learning at the social level – i.e. neither individual nor organisational learning, but involving society outside these spheres. This may be called accumulation of social capital. Organising the processes of learning within the firm and in networks is part of the competence-building activity. Scholars have started only very recently to analyse such processes, and many questions remain unanswered (Chaminade 2003, Edvinsson and Malone 1997, Guthrie and Petty 2000, Nooteboom 2004, Sanchez *et al.* 2000).

2.3.2. Demand-side activities

2.3.2.1. Formation of new product markets

The government might need to intervene in the market from the demand side for two main reasons: a market for certain goods and services might not exist yet 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.

In the very early stages of the development of new fields of innovation, there is uncertainty whether a market-demand exists. A telling example was the belief that the

[9] There is also organisational learning, the result of which is controlled or owned by firms and other organisations. Organisational 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 is a patent. Organisations have an interest in transforming individual knowledge into organisational knowledge.

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. This makes selling and buying of technical knowledge easier.[10] Policy makers can 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 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).

In some cases, the instrument of public innovation procurement has been important for market formation.[11] In other words, a market emerged because the public-sector demanded products and systems that did not exist before the public innovation procurement. This has been – and still is – an important instrument in the defence 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 agencies require a certain product mix, such as a minimum share of electricity based on renewable resources or of 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 quality requirements, which may be regarded as another activity of the SI. Articulation of quality requirements emanating from the demand side with regard to new products is important for product development in most SIs, enhancing innovation and steering processes of innovation in certain directions. Most of this activity is performed spontaneously by demanding customers in SIs. It is a result of interactive learning between innovating firms and their customers. However, quality requirements can 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 innovation procurement normally includes a functional specification of the product or system wanted, and this certainly means demand articulation that influences product development significantly.

But we know very little about the formation of new markets and the articulation of quality requirements. Instruments such as public procurement, regulation, or subsidies

[10] 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.

[11] Edquist *et al*. (2000) analyse public innovation procurement in more detail.

can influence these activities, but further discussion is needed on the adequate division of labour between public and private organizations.

2.3.3. Provision of constituents for SIs

2.3.3.1. Creation and change of organisations

As pointed out above, organisations are considered key components in systems of innovation. Entry and exit of organisations, as well as change of incumbent organisations, are therefore important activities contributing to the change of systems of innovation as such. Organisations include not only firms, but also universities, business services, research institutes, financing bodies, and so on. But since firms are ultimately responsible for commercialising new products, and as there is only so much one can say in one paper, we will focus here on the creation and change of firms.

Creation and change of organisations 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. New R&D organisations and innovation policy agencies 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 characterised by different capabilities, and they may be the socio-economic carriers of innovations. They bring new ideas, products, and processes. Hence, governments should create an environment favourable 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 can 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 characterised by high productivity growth. Governments could therefore create opportunities and incentives for changes in the production structure. Policy issues in this context concern how policy

makers can help develop alternative patterns of learning and innovation, and nurture emerging sectoral systems of innovation.

In any system of innovation it is important to study whether the existing organisations are appropriate for promoting innovation. How should organisations be changed or engineered to induce innovation? This dynamic perspective on organisations is crucial in the SI approach, both in theory and in practice. Creation, destruction, and change of organisations were very important in the development strategies of the successful Asian economies and they are crucial in the ongoing transformation of Central and Eastern Europe. Hence, organisational 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., organisations such as firms, universities, public agencies and institutions such as established practices, rules, and laws) are a basic component (constituent) of systems of innovation. Relations facilitate interactive learning which, in turn, is the basis for innovation. The SI approach emphasises interdependence and non-linearity. This is based on the understanding that firms normally do not innovate in isolation, but interact with other organisations through complex relations that are often characterised 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 between them. This captures the non-linear 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.[12] Innovation policy should not only focus on the organisations of the systems, but also – and perhaps primarily – on the relations among them. Relations between organisations might occur through markets but also through other mechanisms. This implies integrating new knowledge developed in different spheres of the SI and coming from outside with knowledge already available in the innovating firms.

Most interaction between 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 interactions between 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 sub-section.

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

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 sub-section 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 laws that govern these organizations and their relations to private ones – that is, create institutions (Edquist *et al.* 2004).

2.3.3.3. Creation and change of institutions

Institutions are normally considered the second main component (in addition to organisations) in SIs. Creating, demolishing, and changing institutions are activities 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 organisations and innovation processes by providing incentives or obstacles for organisations and individuals to innovate. Many institutions are publicly created (such as laws and regulations) and therefore easy to modify by governments. However, others are created by private organisations, such as firm routines, and they are much more difficult to influence by government 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 considered to influence innovation processes. An important question here is which kinds (and levels) of taxes hinder or facilitate innovation and entrepreneurship.

We have already mentioned the important role of institutions in facilitating the interaction between organisations in the previous sub-section. Governments may, for example, support collaborative centres and programmes, remove barriers to cooperation, and facilitate the mobility of skilled personnel between different organisations. 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 also 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 agencies. They are often codified and constitute policy instruments (such as the aforementioned IPR laws). Public innovation policy is largely a matter of formulating the rules of the game that will 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 agencies. Other institutions develop spontaneously over history without public involvement, such as culture, norms, routines, etc.

As in the case of organizations, it is important to study 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 organisational) 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 commercialisation of knowledge. That this activity has become partly public has to do with the uncertainty characterising 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 understand better the conditions under which incubation needs to be a public activity and when it should be left to the private initiative.

2.3.4.2. Financing

Financing of innovation processes is crucial for turning knowledge into commercially successful innovations and to facilitate their diffusion. Finance comes primarily from private actors within innovating firms, stock exchanges, venture capital funds, or individuals ('business angels'). However, in many countries – including the United States – public agencies provide finance, in the form of seed capital for instance, in support of innovation activities.

As with public intervention in general, public funds should only come forward when firms and markets do not spontaneously perform this activity (for example 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 the list of 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 organisations (such as specialised consultancy firms or entrepreneurial associations), and they can be instrumental when innovations result from diversification processes and when new firms are established around innovations.

But there are cases (certain SMEs and mature sectors, for example) 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 agencies, 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 made clear in section 2, our approach is to focus on the **activities** in the system of innovation (instead of 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.[13]

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 several sub-questions here:

1. What is a 'problem'?

2. How can we identify the problems?

A quick glance at the activities specified in section 2.3 above (Box 1), reveals that each of them is partly performed by private organizations and another part is performed by public organizations.[14] There is a 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.[15] When public organizations carry out part of the activities, this is the way in which they can influence the *context* in which the innovating organizations operate, i.e. the determinants of innovation processes. Since innovation policy is public actions that influence the development and diffusion of innovations, innovation policy is that part of the ten activities that is performed by public organizations. To determine this division of labor is a matter of strategic choices in innovation policy-making.[16]

[13] Also Private-Public Partnerships can be addressed in these terms.
[14] 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.
[15] Examples were provided in section 2.3.
[16] These strategic choices are closely related to the rationales for public action and the additionality issue – see section 3.2.

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)

A **problem**, in our sense - i.e. from a policy point of view - has to do with (a low) **performance** of the innovation system and the **explanations** of that (low) performance.

This is related to the reasons for public policy intervention in a market economy, i.e. the rationales for public policy intervention. Two conditions must be fulfilled for there to be reasons for public intervention in a market economy:

(1) The market mechanism and private actors must fail to achieve the objectives[17] formulated; a *problem* must exist;

(2) The state (national, regional, local) and its public agencies must also have the *ability* to solve or mitigate the problem. (Edquist 2001)

The **performance** of an innovation system is the same as the output of the system, i.e. what 'comes out' of it. That output is - simply - **innovations**. The innovation can be of different categories:

1. It may be a question of the development of innovations ('new to the world') or the diffusion ('new to the firm' or 'new to the region') of innovations.

2. The innovations may be of certain kinds:

- product innovations or process innovations;
- radical innovations or incremental ones;
- 'New to the world', 'new to the firm, country or region', etc.

3. Innovations may also be related to specific sectors of production (material goods, intangible services; specific goods producing sectors, specific service producing sectors, etc).

4. Or innovations may be related to certain objectives of innovation policy: economic, social, environmental, military, etc.

[17] Policy objectives are formulated in a political process, normally not - or only to a very limited extent - by analysts. I will return to a discussion of this issue later.

Hence, a policy problem is a low innovation intensity for a certain category of innovations.

From a policy point of view, it is very important to, in the way hinted at above, divide innovations in different categories. Hence, *taxonomies* of innovations are important. So 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.*

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 just above). This is why the Community Innovation Surveys (in Europe) and similar surveys carried out in non-European countries are important. They measure (describe) - among other things - the propensity to innovate for specific categories of innovations in various innovation systems (national, sectoral and regional ones). If we do not know these propensities we can not 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.**

To be useful for policy purposes, these measurements and descriptions must be comparative between systems. The reason is that it is not possible to say that an 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 intensity (just as we can not specify an ideal innovation system).

This means that problems cannot be identified through theoretical analysis alone.[18] The problems can not be identified through a comparison between an empirically existing system of innovation and an optimal one. The simple reason is that 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 system over time, or between different existing systems.[19] Only in this way can we 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.

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

[19] It is also possible to compare an existing system with a 'target system'. Such a system can be specified. However, we can never argue that it is an optimal one.

If a policy problem is a low innovation intensity, it might seem that "more innovation is always better". However, this is not the case. We can not take for granted that innovation is always good and that more is better. At the same time we can not determine how much innovation that is 'optimal'. This is certainly a dilemma – which means that it is not solvable and that we have to live with it, and handle it. Let me discuss this briefly.

Firstly, I have argued that we can only determine if an innovation intensity is high or low in one system of innovation by comparing 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 between different categories of innovations may be preferred.

I briefly mentioned four taxonomies of innovations in the beginning of section 3.2. A balance between the categories in those taxonomies may be motivated:

- Some balance between product and process innovations
- Some balance between radical and incremental ones
- Some balance between 'new to the world' and 'new to the firm innovations
- Some balance between innovations in specific sectors of production
- Some balance between innovations related to certain objectives of innovation policy: economic, social, environmental, military, etc.

There are certainly 'dual use' innovations, e.g. innovations that fulfill both military and economic objectives. In addition these taxonomies - and others - can be combined with each other, and hence there are a very large number of categories of innovations that can 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 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 that may have caused the environmental problems.

However, 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. The 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 for creating 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: 234-5)[20]

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 scientific method, the propensity to innovate is *explanandum* and the determinants are the *explanans*.[21] These determinants were referred to as 'activities' in section 2, where we hypothetically listed ten such activities, clustered in four main categories. In a recent book on the national systems of innovations in ten small countries in Asia and Europe (Edquist and Hommen 2008) these ten activities are discussed in depth for each of the ten countries.[22] The research question asked there was: 'What were the national characteristics of the activities that influenced (product and process) innovation processes in the ten national systems of innovation'. We wanted to discuss the explanations of the propensity to innovate.

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 to be able to point out only the man 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 can provide a basis for an efficient therapy or treatment – namely, an innovation policy. Without a diagnosis it is impossible to know which prescriptions to make, and without timely prescriptions there is a risk that we shall become pathologists – that we shall 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 clue about the most important causes behind a problem.

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

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

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

4. Strategic Use of Diagnostic Analysis for Policy Purposes

A diagnostic analysis is firstly related to the performance of an innovation system. We must be able to point out with regard to which kinds of innovations the system is performing badly. This is defined as a *problem*. We discussed this problem identification in section 3.2.

However, a diagnostic analysis also includes an identification of the causes behind the problems identified. We proposed – in sections 2 and 3 - that such an analysis can be carried out in terms of the ten 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. How **is** the division of labor with regard to the activities influencing a low performance with regard to a certain category of innovations? (Where is the border line between the part of a certain activity which is performed by private and public organizations respectively?)

2. How **should** the division of labor be? Should there be **more/less** public intervention, i.e. should the border line between the part of each activity that is performed by the private and public organizations be moved?

3. Which **are** the characteristics of the part of the different activities that are performed by public organizations (i.e. which are the characteristics or features of the public intervention)?

4. How **should** the characteristics of the public intervention be changed?

These four questions should be asked with regard to each of the activities! In addition, they should be asked concerning each of the relevant categories of innovations.[23] To **determine** the - existing and/or wanted - **division of labor** is a matter of **strategic choices** in innovation policy-making.

[23] Therefore taxonomies of innovations become very important.

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