3 Innovation Policy in the Systems of Innovation Approach: Some Basic Principles

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3.1 Introduction

This contribution aims to deal with innovation policy from the perspective of the systems of innovation approach. The intention is to address basic principles related to national, regional or local as well as sectoral systems of innovation and the policy implications emerging from these. Hence, there will be a very strong emphasis on policy in what follows. However, it is essential, of course, that any observations should be adapted to the specific conditions in particular sectors, regions or countries to be fully relevant[1].

3.2 Innovation Policy

Innovation Policy is public action that influences technical change and other kinds of innovation. It includes elements of research and development [R&D] policy, technology policy, infrastructure policy, regional policy and education policy. This means that innovation policy goes beyond science and technology [S&T] policy, which mainly focuses on stimulating basic science as a public good. Innovation policy also includes making use of the knowledge produced – for socio-economic purposes.

It is necessary to go beyond S&T as a determinant of innovation when designing innovation policies, since many innovations emerge outside the formal S&T system – for example, in everyday economic routine activities. At the same time, innovation policy is a part of what is often called industrial policy. But

industrial policy is a term that is burdened with a lot of deadwood in many countries because of vain efforts to provide support from public finances for old and dying industries. The term innovation policy is naturally associated with change, flexibility, dynamism and the future. Innovation policy should therefore serve as a midwife, not provide support towards the end of a life.

3.3 Objectives of Innovation Policy

Let us now turn to the objectives of innovation policy. These objectives have normally been economic ones – like economic growth, productivity growth, increased employment and competitiveness. However, innovation policy can also have non-economic objectives, such as social, military or environmental ones. There may be conflicts between the objectives when several are being pursued at the same time. For example, an exclusive emphasis of economic growth might lead to environmental consequences that preclude 'sustainable' development. Or, the objective of productivity growth might conflict with the creation of employment, an issue to which I shall return later.

These objectives are, of course, determined in a political process. However, it is absolutely essential that they are specific and explicitly formulated. Otherwise, the policy may lack a sense of direction and become a victim of pressure groups and nepotism. Afterwards, if the objectives were not specified clearly in the beginning, it will also be impossible to judge whether the policy was a success or a failure. Policy learning, i.e. the possibility that politicians and policy-makers learn from their successes and failures – which is so important – then becomes impossible.

3.4 Reasons for Innovation Policy Intervention

What, then, are the reasons for public intervention in the field of innovation in a market economy? Most innovations are carried out by manufacturing firms. This is quite natural, since firms are most familiar with their own production processes, as they are with the markets for their products. It is often argued that national, regional and local governments should rely on firms to the largest possible extent in the field of innovation.

However, markets are not independent from governments. It is important that governments help to make markets function well. This is because the appropriate balance between the activities of governments and markets in the field of innovation depends on how well the markets function. Governments can make

markets operate better by creating laws and rules about competition, contracts, property, patents and so on. However, even if markets function well and companies are innovation-oriented, there are certain things in the field of innovation that firms cannot achieve efficiently, if at all. Therefore, there is a role for government innovation policies in all countries.

One fundamental question this raises is what should be performed by the state or public sector and what should not[2]. In other words, what should be the division of labour between the state, on one hand, and markets and companies, on the other? As I see it, two conditions must be fulfilled for public intervention to be justified in a market economy.

Firstly, the market mechanism and firms must be failing to achieve the objectives formulated, i.e. a '*problem*' must exist. A problem exists when firms and markets do not automatically realise the objectives that have been politically determined. There is no reason for public intervention if the firms and the markets are fulfilling the objectives, i.e. if there are no problems. This is in line with the principle that innovation policy should complement firms and markets, not replace or duplicate them. I will come back to these 'problems' several times later on.

Secondly, the state [national, regional, local] and its public agencies must also have the *ability* to solve or mitigate the problem. If the public sector does not have this ability, there should of course be no intervention, since the result would be a failure. In other words, this condition is an attempt to make sure that political failures are avoided to the greatest possible extent[3].

There may be two reasons why public intervention cannot solve or mitigate a problem. One is that it is simply not possible to solve the problem by political means. In this case, any type of intervention would, of course, be in vain – and the problem would remain. The other reason is that the state might first need to *develop* its ability to solve the problem. For example, a detailed analysis of the problems and their causes may be necessary means of acquiring this ability. Or, new policy instruments might need to be created. For example, the creation of new organisations and institutions to carry out the intervention might be necessary. A patent office is an example of such an organisation and a patent law is such an institution.

3.5 The Role of Different Kinds of Innovation

In mainstream economic theory, the notion of innovation is often assumed to be limited to process innovations. However, the category of innovation is extremely complex and heterogeneous. It is therefore useful to make analytical distinctions between different categories of innovation. Technological innovations are not the only ones that are important for economic growth and employment.

A useful taxonomy is to divide innovations into new products and new processes, as follows:

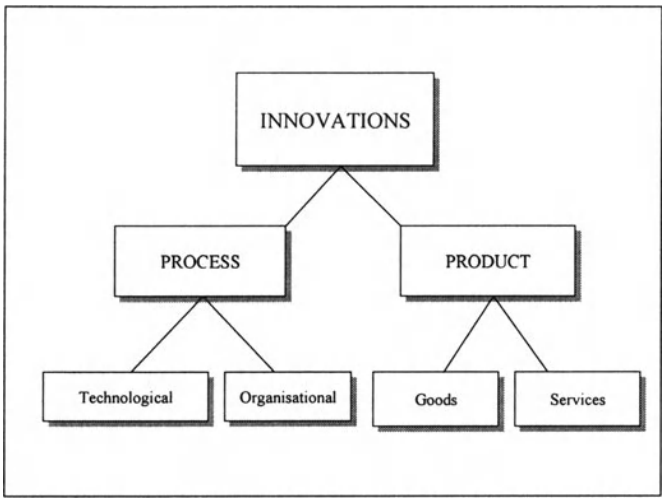

Fig. 3.1 A taxonomy of innovations

Product innovations may concern either goods or services, depending on what is being produced. Process innovations, on the other hand, may be technological or organisational. This depends on how goods and services are produced. Some product innovations are transformed into process innovations in a 'second incarnation' [or 'second appearance'], but this concerns only 'investment products' – not products intended for immediate consumption. For example, an industrial robot is a product when it is produced and a process when it is used in the production process. Product and process innovations are also closely related to each other in many other ways. In spite of this, it is important to make distinctions between different kinds of innovation, i.e. to disaggregate and pursue the analysis at a micro and meso level. In this taxonomy, only goods and technological process innovations can be considered 'technological innovations' of a 'material' kind. Organisational process innovations and services are 'intangibles'. It is crucial to take these intangible innovations into account as well, since they are increasingly important for economic growth and employment!

The distinction between process and product innovations is particularly important to a policy for increasing employment. The main reason is that – on the whole – process innovations are labour saving whereas product innovations are employment creating. This is true even when counter-acting compensation and substitution effects have been taken into account[4]. Product innovations that neither substitute an existing product nor are later used as process innovations have the greatest positive effect on employment creation. Product innovations are also the main mechanism behind changes in the production structure – another issue that I shall come back to later. It is therefore dangerous to ignore product innovation, as is often done by mainstream economics.

3.6 Systems of Innovation

The 'systems of innovation' [SI] approach is a fairly new approach for the study of innovations. A system of innovation can be defined as including all the important factors that influence the development, diffusion and use of innovations as well as the relations between these factors (Edquist 1997). These factors can be studied in a national, regional or sectoral context. In other words national, regional and sectoral systems of innovation coexist and complement each other. Initially, the SI approach was dominated by a national perspective Later regional studies and sectoral ones became more important.

The SI approach has diffused surprisingly fast in the academic world as well as in the field of public innovation policy-making. The OECD, the European Union, UNCTAD, UNIDO and many individual countries have used it for policy purposes. In Sweden, a Public Agency for Innovation Systems [VINNOVA] was established in January 2001. 'Systems of innovation' are simply at the centre of modern thinking about innovation and its relation to economic growth, competitiveness and employment[5].

3.7 General Policy Implications of the SI Approach

In the SI approach, a long-term perspective is natural and important. This is because innovation processes take time, sometimes decades. They also have evolutionary characteristics, i.e. the processes are often path dependent. It is often not clear – even to the actors involved – what the end-result will be, i.e. which path will be taken over time. The SI approach has adopted this major contribution from evolutionary theories of innovation.

An evolutionary theory of innovation generally contains the following components:

- The point of departure is the existence and reproduction of entities such as genotypes in biology, or a certain set-up of processes and products in innovation contexts.
- Certain mechanisms introduce novelties into the system, i.e. mechanisms that create diversity: mutations and innovations.
- There are also mechanisms that select among the entities present in the system: diversity is reduced. Together, the selection mechanisms constitute a 'filtering' mechanism that functions in several stages and leads to a new set-up consisting, for example, of processes and products. Then the process starts all over again.

Since innovations occur – to a greater or a lesser extent – everywhere in a system, and because of the evolutionary character of innovation processes, an innovation system never achieves equilibrium. We do not even know whether the potentially 'best' or 'optimal' trajectory is being exploited at all, since we do not know which

one it would be. This means that the notion of optimality is irrelevant in a system of innovation context. We cannot specify an optimal or ideal system of innovation. This means also that we cannot compare an existing SI with an ideal or optimal one – which is done in the market failure approach in traditional economics.

We can identify two main kinds of policy implications:

- The systems of innovation approach contains *general* policy implications, which can be derived from the characteristics of the approach. They are general in the sense that they are of a 'sign-post' character. They can serve as rules of thumb and point out relevant issues.
- The systems of innovation approach also provides a framework of analysis for identifying *specific* policy issues. It is helpful in identifying the 'problems' that need to be the object of policy and in specifying how innovation policies to solve or mitigate these problems could be designed.

We first address the general policy implications and issues. The SI approach emphasises that innovation is a process that involves more than individual firms and other organisations. Interaction and interdependence is one of the most fundamental characteristics of the SI approach. Let us give an empirical example. In a survey carried out in the region of East Gothia in Sweden, about 50 percent of all firms made a product innovation during the period 1995 to 1997. Of these firms, 76 percent developed the new product in *collaboration* with other organisations, e.g. firms and public organisations (Edquist, Ericsson and Sjögren 2000). This provides a strong support to one of the central characteristics of the systems of innovation approach.

The interactions in a system of innovation take place between the most important components of the system. These are organisations and institutions. Organisations in this context are 'actors' or players with an explicit objective, like firms, universities and government agencies, which interact in the creation of innovations. The framework created by institutions, consisting of laws, norms, routines, technical standards and so on, helps to shape this interaction between organisations. Institutions are not organisations, but the *rules of the game*. Two general policy issues, which emanate from the SI approach, are therefore:

(1) *Organisational actors might need to be created, redesigned or abolished.*
(2) *Institutional rules might need to be created, redesigned or abolished.*

In any system of innovation, it is important from a policy point of view to study whether the existing organisations and institutions are appropriate for promoting innovation. How should institutions and organisations be changed or 'engineered' to induce innovation? This dynamic perspective on institutions and organisations is crucial in the SI approach, both in theory and in practice. Not only organisational change, but also the evolution and design of new institutions was very important in the development strategies of the successful Asian economies as well as in the ongoing transformation of Eastern Europe. Hence organisational and institutional changes are particularly important in situations of rapid structural change.

A general policy implication which derives from the fact that much learning and innovation is interactive, is that this interaction should be targeted much more directly than is normally the case in innovation policy today.

(3) *Innovation policy should not only focus on the elements of the systems, but also – and perhaps primarily – on the relations between them.*

This includes the relations between various kinds of organisation, but also those between organisations and institutions. For example, the long-term innovative performance of firms in science-based industries is strongly dependent upon the interactions of these firms with universities and research institutes. These interactions should be facilitated by means of policy – if they are not spontaneously functioning smoothly enough. This can partly be done by changing the laws and rules which govern the relations between universities and firms. Incubators, technology parks, and public venture capital organisations may also be important. This means that the public sector may create organisations to facilitate innovation. At the same time, however, it needs to establish the rules and laws that govern these organisations and also its relations with private ones. In other words, the state has a double role.

We argued earlier that the SI approach considers innovation processes to be evolutionary and path dependent. From this follows the danger of negative 'lock-in' situations, that is patterns or trajectories of innovation, which lead to low growth and decreasing employment. This may apply to patterns of learning and production specialisation of firms, industries, regions, and countries. The next general policy issue is therefore:

(4) *That innovation policy should ensure that negative lock-in situations are avoided.*

What can governments do then to support transitions from dead-end trajectories? The answer is that:

(5) *Governments should facilitate changes in the production structure.*

In manufacturing industries across the world, there has been a growing divergence between those with high levels of product innovation and those concentrating on process innovation. The former are clearly the 'growth industries', which have experienced net gains in employment. The process innovation oriented sectors of production tend to be 'declining' industries with net employment losses (Edquist, Hommen and McKelvey 2001).

There are three mechanisms through which the production structure can change through the addition of new products:

- Existing firms may diversify into new products [examples are Japan and South Korea].
- New firms in new product areas may grow rapidly [this mechanism is more common in the USA].

- Foreign firms may invest in new product areas [Ireland might be a good example here].

If a time period, country, firm or region is dominated by process innovations, this constitutes a tendency to decrease employment. If product innovations dominate, there is an opposite tendency to generate new employment. So, if the objective of innovation policy is to secure job creation:

(6) *Governments should support structural changes in the direction of production sectors dominated by product innovations rather that process innovations.*

Such a policy must not, however, be directed towards preventing process innovations. Process innovations are necessary for increases in productivity and they might also provide the basis for product innovations. To prevent them, in the present era of globalisation and competition, would be self-defeating. Firms, regions or countries doing so would be overtaken and go bankrupt.

Those sectors that generate most product innovations are generally the R&D intensive sectors – or high-technology sectors – in manufacturing and the knowledge intensive sectors in service production. These are often the 'new' sectors emerging in our economies. Which means they are increasingly becoming 'learning economies' or 'knowledge-based economies'. The knowledge intensive sectors are of far greater strategic importance for job creation than other sectors, since they are engaged in the creation of new products and new markets. In general, the demand for new products grows more rapidly than for old ones. The implication is that firms, regions and countries producing new products tend to do so for markets that are growing rapidly. Growing markets mean an increase in demand and output – which reinforces the intrinsic employment creation effect of product innovations.

Governments should therefore create opportunities and incentives for changes in the production structure. They should promote sectors characterised by high knowledge intensity and a high proportion of product innovations. 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. A key issue here is therefore the choice between supporting existing systems – with their historically accumulated knowledge bases – and supporting the development of radically new products and sectoral systems. Radical innovations and the emergence of new sectoral systems of innovation seem to be more of a problem for markets and private firms than reproduction and incremental innovation in established sectors[6]. We also know that large-scale and radical technological shifts, i.e. shifts to new trajectories, have rarely taken place in the OECD countries without public intervention. This is true for most of the electronics sector as well as for aircraft and biotechnology, also in the USA. Therefore:

(7) *Governments should primarily be proactive, supporting the emergence of new product areas and new sectoral systems of innovation.*

This is particularly important in a world characterised by rapid technological change and economic globalisation. Whether it is in a national, regional or local context, the support of new sectoral systems is the key. This means that geographically delimited systems of innovation should be combined with sectoral perspectives. National or regional policies should include sectoral specialisation strategies. It is important to develop geographically defined systems that promote development in new or immature sectors.

These arguments are closely related to the final general policy issue we wish to mention:

(8) *Governments need to intervene early in the development of product innovations and new sectoral systems of innovation.*

Such intervention at an early stage in the product cycle may have a tremendous impact. In the case of the creation of the NMT 450 mobile telecommunications technical standard in the Nordic countries about twenty years ago, this proved to be extremely important. It was crucial for the emergence of the mobile telephone industry and for the fact that both Ericsson and Nokia became global leaders in this field[7]. On the other hand, there are many examples showing that massive government support to old and dying industries have had limited effect. Often it has only marginally delayed the death of these industries. One example is the Swedish shipyard industry in the late 1970s and early 1980s. The cost of the support to the shipyard industry was several hundred times greater than the cost of developing NMT 450.

The general policy implications of the SI approach are different from those suggested by standard economic theory. This has to do with the fact that the characteristics of the two frameworks are very different. The SI approach shifts the focus away from actions at the level of individual, isolated units within the economy [firms and consumers] towards the collective underpinnings of innovation. It addresses the overall system that creates and distributes knowledge, rather than its individual components. Within these systems, innovations are seen as evolutionary processes.

The general policy issues listed above can serve as sign-posts, suggesting where to look for problems and possible solutions in innovation policy-making. However, they are not a sufficient basis for designing specific innovation policies. These policy issues do not tell a policy-maker exactly what to do in order to improve the functioning of the system. The SI approach as such cannot provide this, but neither can any other approach or theory. Let us take standard economic theory as an example. Market failure analysis in standard economic theory argues that a completely competitive, decentralised market economy would provide sub-optimal investment in knowledge creation and innovation. Firms underinvest in R&D because of uncertainty and appropriation problems. This leads, for example, to a case for public subsidies for knowledge creation, or for the creation of intellectual property rights. This links up nicely with the 'linear model' approaches and economists, and hence policy-makers often consider this to be a justification – or theoretical foundation – for governments to subsidise R&D.

However, the policy implications that emerge from the market failure theory are actually not very helpful for policy-makers from a practical and specific point of view. They are too blunt to provide much guidance. They do not indicate how large the subsidies should be or within which specific area one should intervene. Also, they say almost nothing about *how* to intervene, i.e. which policy instruments should be used. Standard economic theory is therefore not much help when it comes to formulating and implementing specific R&D and innovation policies. It only provides general policy implications, e.g. that basic research should sometimes be subsidised.

3.8 The SI Approach as a Framework for Designing Specific Innovation Policy

The SI approach can be used as a framework for designing specific innovation policies. we shall now, very briefly, outline how this can be done. Previously, we concluded that a necessary condition for public intervention in processes of innovation is that a 'problem', which is not automatically solved by markets and firms, must exist[8]. Substantial analytical and methodological capabilities are needed to identify these problems.[9]

Systems of innovation can be quite *different* from each other, e.g. with regard to specialisation of production, resources spent on R&D, etc. In addition, organisations and institutions constituting elements of the systems may be different. For example, research institutes and company-based research departments may be important organisations in one country [e.g. Japan], while research universities may perform a similar function in another [e.g. the United States]. Institutions such as laws, norms, and values also differ considerably between national systems.

In the SI approach, the considerable differences that exist between various systems of innovation are stressed, rather than ignored. These differences may be between national, regional as well as sectoral systems of innovation. This makes it not only natural but vital to compare different systems. Without such comparisons, it is impossible to argue that one system is specialised in one way or the other, or that a system performs well – or badly. Comparisons are therefore the most important means for understanding what is good or bad, or what is a high or a low value for a variable in a system of innovation. However, since we cannot specify an optimal or ideal system of innovation, comparisons between an existing system and an ideal or optimal one are not possible. The existence of a 'problem' cannot be identified in this way.

The only possible comparisons are between existing systems. The comparisons must be genuinely empirical and very detailed. They are similar to what is often called benchmarking at the level of the firm. Such comparisons are crucial for policy purposes. They can identify the problems that should be subject to policy

intervention. However, to know that there is reason to consider public intervention is not enough. It is only a first step. It only indicates where and when intervention is called for. It says nothing about how this should be pursued. In order to be able to design appropriate innovation policy instruments, it is also necessary to know the causes behind the identified problems – at least the most important ones[10].

Within the systems of innovation framework, the identification of the underlying causes of the problems is the same as identifying deficiencies in the functioning of the system. It is a matter of identifying those functions that are missing or inappropriate and which have led to the problem in terms of comparative performance. Let us call these deficient functions 'system failures'. When we know the causes behind a certain problem – for example low economic performance - we have identified a system failure.

There are at least three main categories of system failure:

- Organisations in the system of innovation might be inappropriate or missing.
- Institutions may be inappropriate or missing.
- Interactions or links between these elements in the system of innovation might be inappropriate or missing.

Not until policy-makers know the character of the system failure, do they know whether to influence or change organisations, institutions, interactions between them – or do something else. Therefore, an identification of a problem should be supplemented with an analysis of its causes as part of the analytical basis for the design of an innovation policy. Benchmarking is not enough.

To sum up, concrete empirical and comparative analyses are absolutely essential for the design of specific innovation policies. National, regional, local and sectoral systems of innovation must be systematically compared with each other in a very detailed way. Only in this way can specific innovation policies be designed. In the effort to design innovation policy, there is no substitute for concrete analyses of concrete conditions! The SI approach is an analytical framework suited for such analyses. It is appropriate for this purpose because it places innovation at the very centre of focus and because it is able to capture the differences between systems.

Endnotes

1 This chapter is largely based on two other studies: Edquist (2001) and Edquist, Hommen and McKelvey (2001). Detailed references to the work of others are given in these two publications. Some background references can also be found in Edquist (1997), Edquist and Riddell (2000) and Edquist and McKelvey (2000).

2 The 'state' may be national, regional or local.

3 However, political mistakes and failures cannot be completely avoided. Public actors may fail, just as markets and private actors do.

4 This has been shown in Edquist, Hommen and McKelvey (2001) where the relations between [different kinds of] innovations, [different kinds of] growth and [different kinds of] employment are dealt with.

5 Edquist and McKelvey (2000) is a collection of 43 articles which deals with:
- national, regional and sectoral systems of innovation, including case studies,
- theoretical origins of the systems of innovation approach: interactive learning, evolutionary theories, institutional theories,
- innovations, growth and employment, and
- public policies and firm strategies.

6 If incremental innovation is not a problem for most traditional sectors, then there should be no public intervention there – see Section 3.4.

7 Incubators, technology parks and the financing of new technology-based firms, as well as the creation of standards, are examples of policy instruments relevant for the early stages of innovation.

8 This means that neutral or general policies are normally irrelevant; selectivity is necessary if specific problems are to be solved or mitigated.

9 Such capabilities are also needed to design policies that can mitigate the problems.

10 A causal analysis might also reveal that public intervention is unlikely to solve the problem identified, due to lack of ability on the part of the government.