# Innovation Policy – A Systemic Approach

by

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## 1. Introduction

*Innovation policy* is public action that influences technical change and other kinds of innovations. *Innovations* are new creations of economic significance of a material or intangible kind. They may be brand new but are more often new combinations of existing elements. A useful taxonomy is to divide innovations into new products and new processes. Product innovations may be goods or services. Process innovations may be technological or organisational. Some product innovations (i.e. investment goods) are transformed into process innovations in their ’second incarnation’.

Innovation policy includes elements of R&D policy, technology policy, infrastructure policy and education policy. At the same time innovation policy is a part of what is often called industrial policy. Industrial policy is, however, a term that is burdened with a lot of deadwood in many countries because of vainly public support to old and dying industries. The term innovation policy arouses associations to change, flexibility, dynamism and the future: Innovation policy should serve as midwife

## 2. Reasons for Public Policy Intervention

First I want to point out that most economic functions in a modern society are best fulfilled by the market mechanism and capitalist firms.[1] The market mechanism co-ordinates the behaviour and resources of private and public actors – often in a smooth and flexible manner. This concerns most production of goods, like bread and automobiles, but also a large proportion of service production like cleaning and IT service provision.

Sometimes there are, however, reasons to complement – or correct – the market and capitalist actors through public intervention. This is true in the areas of law, education, environment, infrastructure, research, social security, income distribution, etc. In some of these fields there is no market mechanism at all and the functions are fulfilled through other mechanisms, e.g. regulation. In other of these fields the market mechanism has been complemented by public intervention in most industrial countries for decades.

What is at issue here is what should be performed by the state or public sector and what should not. This is an issue that is not only subject to ideological judgements, but could – and should - be discussed in a more analytical way.

[1] Capitalist firms include private firms, but also publicly owned firms, which function in a similar way.

Which are then the reasons for public intervention in a market economy? Two conditions must be fulfilled for there to be reasons for public intervention in a market economy - as regards, for example, technical change and innovation:

(1) Firstly, the market mechanism and capitalist actors must have failed to achieve the objectives formulated.[2] There are no reasons for public intervention if the market and capitalist actors fulfil the objectives. Innovation policy – or other kinds of public intervention – shall be a complement to the market, not replace or duplicate it. In other words, there must be a *’problem’* - which is not automatically solved by market forces and capitalist actors – for public intervention to be considered.[3] Such problems can be identified through analysis.
(2) Secondly, the state (national, regional, local) and its public agencies must also have the *ability* to solve or mitigate the problem.[4] If not, there should be no intervention, since the result would be a failure. Therefore I above talked about ’considering’ intervention if a problem exists. Hence this condition is an attempt to make sure that political failures are avoided to the largest extent possible.[5] Adding this condition means that the existence of a ‘problem’, which is not automatically solved by market forces and capitalist actors, is a necessary but not sufficient condition for intervention.[6]

There may be two reasons why public intervention cannot solve or mitigate a problem. One is that the problem is not at all possible to solve from a political

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[2] I assume that the objectives – whichever they are – are already determined in a political process. It should also be mentioned that they do not necessarily have to be of an economic kind. They can also be of a social, environmental, ethical or military kind. They must be specific and unambiguously formulated in relation to the current situation in the country or in other countries. With regard to innovation policy the most common objectives are formulated in terms of economic growth, productivity growth or employment.

[3] Note that I am here using the term ‘problem’ and not ‘market failure’. This is because the approach here is different from traditional economics in a way that is explained in Edquist (1993: 28). ‘Market failure’ in traditional economic theory implies a comparison between conditions in the real world (empirical facts) and an ideal or optimal system. As we shall se in section 4, however, innovation processes have evolutionary characteristics. The system never achieves equilibrium and the notion of optimality is irrelevant. Hence, comparisons between an existing system and an ideal or optimal system are not possible. Thereby ‘market failure’ looses its meaning and applicability.

[4] One difficulty in this context is, of course, that it is not possible to know for sure beforehand – ex ante – if public intervention solves the problem or not. The decision to intervene or not must thus be based upon whether it is probable or not that intervention mitigates the problem. Hence the decision must be taken in a situation of uncertainty. Then one can afterwards – ex post – determine through evaluations whether the problem was solved or mitigated. If this was not the case, we are talking about a political failure.

[5] However, political failures can never be completely avoided because of the uncertainty mentioned. In other words, we must accept some mistakes in public activity – as well as in private. They must, however, be only exceptions and not the rule. In order to determine which was the case through evaluations, it is necessary that the objectives of the policy were clearly formulated – ex ante.

[6] As an alternative to the fulfilment of these conditions for public intervention to be called for, one might argue that it should be discussed for each specific issue (from defence to bread production) whether markets or governments can fulfil the objectives most efficiently.

level. Then all types of intervention would, of course, be in vain.[7] The other reason is that the state might first need to develop its ability to be able to solve the problem. A detailed analysis of the problems and their causes may, for example, be necessary for this ability to exist.[8] New policy instruments or the creation of new organisations and institutions to carry out the intervention might also be necessary. A patent office is an example of such an organisation and a patent law is such an institution.[9]

There are two main categories of policies to solve or mitigate 'problems':

(a) The state may use *non-market mechanisms*. This is mainly a matter of using regulation instead of the mechanisms of supply and demand. One example is taxation of rich people and redistribution of income to poor people. Another is a subsidy to poor regions. The state might also provide educational or hospital services free of charge or to a subsidised cost. Other kinds of regulation are the creation of technical standards, public funding of R&D or tax incentives to R&D activities.

(b) Through various public actions the functioning of markets can be improved or the state may create markets. The *improvement* of the functioning of markets is the objective of competition law and competition (anti-trust) policies. It is often a matter of increasing the degree of competition in a market. This might sometimes be achieved through de-regulation, i.e. getting rid of old or obsolete regulations. One example of market *creation* is in the area of inventions. The creation of intellectual property rights through the institution of a patent law gives a temporary monopoly to the inventor. This makes selling and buying of technical knowledge easier.[10]

In both cases, public policy is very much a matter of formulating the "rules of the game". These rules might have nothing to do with markets (a) or they might be intended to create markets or make the functioning of markets more efficient (b). In other words, policy is very much a matter of creating, changing, or getting rid of institutions in the form of rules, laws, etc.

The example of market creation through the institution of patent mentioned just above indicates that a 'problem' that motivates public intervention might

[7] Hence the problem is not solvable by the market mechanism nor by public intervention.
[8] Hence it might be necessary to carry out a diagnostic analysis – see sections 7.1 and 7.2 in Edquist (1993).
[9] Institutions as used here constitute the "rules of the game", e.g. laws, rules, habits, routines, etc. Organisations are the actors or players, the actions of which are shaped by (and shape) the rules.
[10] Paradoxically, then, a monopoly is created by law, in order to create a market for knowledge, i.e. to make it possible to trade in knowledge. This has to do with the peculiar characteristics of knowledge as a product or commodity. It is hard to know the price of knowledge as a buyer, since you do not know what it is before the transaction. And if you know what it is you do not want to pay for it. In addition, knowledge is not 'disappearing' when used – like other products.

concern the future. In other words policy might well be proactive – and should often be. In other words, a ‘problem’ might be something that has not yet emerged. A problem might be that uncertainty prevents new technologies from emerging. One example is that public funding of R&D might be necessary because capitalist actors do not have the incentive to fund it.

Another example pointing in this direction is the public creation of standards, which decreases the uncertainty for capitalist firms. For example, the creation of the Nordic Mobile Telephony Standard (NMT 450) created by the Nordic PTTs in the 1980s was absolutely crucial for the development of mobile telephony in the Nordic countries. This made it possible for the private firms to develop mobile systems and the global leadership assumed by Ericsson and Nokia in this field would not have happened without the NMT 450 (which later developed into the NMT 900 and the digital GSM standard). A further example of policy leading to market creation is public technology procurement, i.e. the public buying of technologies and systems, which did not exist at the time. Public technology procurement was used in combination with NMT 450 in Finland and Sweden to provoke Nokia and Ericsson to enter the new field – which they were reluctant to do in the beginning. In this way public innovation policy might take the role of a ‘midwife’ in the creation of new technology fields and whole production sectors. It could even be argued that most innovation policies should take this pro-active approach, one reason being that the impact of a minor intervention in the early stages of the product cycle might have a tremendous impact, while a major effort in mature stages might have only a small impact. These issues might be discussed in terms of static and dynamic efficiency, following Schumpeter

## 3. Selectivity in Innovation Policy

When state intervention is intended to improve the functioning of markets, it is normally a matter of increasing the degree of competition. This kind of policy can be argued to be ‘general’ in the sense that it wants to achieve the same thing everywhere. When applied, however, this kind of competition policy has to be specific to certain sectors – or even products - of the economy in certain countries or regions. The degree of competition has to be estimated, if needed means to increase it must be designed, these have to be implemented, etc.

When markets are created by public action the policy is also specific to various functional areas, whether it is inventions or the right to pollute. The creation of standards or public technology procurement is always technology specific.

In most other kinds of public policy, the state does not use the market mechanism. Instead it complements or corrects the consequences of it. This is certainly the Lion's share of all public policy. Most public policy of this kind is *selective*, rather than general. It is selective in the sense that the consequences of it are not uniformly distributed between different activities.[11]

This is, for example, true for devaluations. A devaluation of a country's currency (in a fixed exchange rate regime) means favouring export production and production exposed to competition from imports. Devaluations mean a preservation of the existing structure of production, through contributing to higher profits in existing sectors and since the relative incentives to invest in new areas decrease.

Also public policy for basic research is selective. Politicians and policy-makers must, for example, allocate public research funds between fields of research. Someone must decide which fields of research that shall be given priority. Shall the funds be used for nuclear physics or biotechnology?[12] Regional policies are selective in a similar manner. Someone has to decide which regions to favour, why and how.

Hence it is not relevant to discuss whether innovation policy measures and instruments are selective or not in an absolute sense. It is only relevant to talk about degrees of selectivity. Public funding of basic research and direct support to specific companies – in Sweden called 'the emergency room' – can be seen as extremes in this respect. Other innovation policy instruments are located in between these. To divide industry into two parts and favour one of them – e.g. through devaluations – is, of course, less selective than providing direct support to specific firms.

It is natural that public policy – for example innovation oriented industrial policy – is selective. Policy is a matter of governing, directly or through influencing the structure of incentives of other actors (and thereby their behaviour). To influence and govern is the *raison d'etre of politics and policy*. The degree to which public policy meets the objectives is much more important than its degree of selectivity.

[11] This actually follows from the first of the two conditions that constitute reasons for public intervention: if a certain 'problem' is to be solved, this has to be targeted in a selective manner.
[12] Such allocations are made every year, but are seldomly discussed explicitly and publicly.

## 4. Characteristics of the Systems of Innovation (SI) Approach [13]

*Systems of Innovation* (SI) is a new approach for understanding innovations occurring in an economy. This approach has emerged during the last decade. It points to the fact that innovation processes are evolutionary, and does not therefore make use of the notion of optimality. It also stresses that firms do not normally innovate in isolation but in interaction with other organisations within the framework of specific institutional rules.

### 4.1. Institutions and Organisations

Innovation is a complex phenomenon, embracing both new processes (technological and organisational) and new products (goods and services). Similarly, the processes through which innovations emerge are extremely complex. These processes concern not only the emergence, diffusion, and combination of knowledge elements, but also the *translation* of these into new products and production processes. This translation from basic research to applied research and to the development and implementation of new processes and new products by no means follows a *linear* path. Instead, it is characterised by complicated feedback mechanisms and interactive relations involving science, technology, learning, production, institutions, organisations, policy, and demand.

Most innovations occur in firms. However, innovation is a collective effort whereby innovating firms normally interact with other organisations in the context of existing institutional rules. Innovations emerge, therefore, in systems where organisational actors and institutional rules are important elements. The importance of institutions and organisations is stressed—albeit to varying degrees—in all versions of the SI approach. *Systems* approaches to innovation are essentially an attempt to think through and analyse the nature and implications of the collective character of innovation.

The *organisations* with which innovating firms interact—to gain, develop, and exchange various kinds of knowledge, information and other resources—may be other firms (suppliers, customers, and competitors). Of particular importance are inter-firm relations involving sustained interaction between users and producers of technology. Here the argument is that inter-firm linkages are far more than arm's-length market relationships. Rather they often constitute ongoing co-

[13] This section is based on Edquist 1997 and on section 3 in Edquist et al 1998.

operative relationships that shape learning and technology creation. Firms also interact with non-firm organisations such as universities, research institutes, private foundations, financing organisations, schools, government agencies, etc.

Organisations are formal structures with an explicit purpose and have been consciously created. They are the players or actors (in processes of innovation). It is important to study how firms and non-firm organisations perform in relation to innovations. Is the support that public organisations give to innovation appropriate? Are the technological support organisations doing the right things and doing them reasonably well? In periods of structural change, a country might have to redesign many of its organisations; this has been the case recently in Eastern Europe. The design of new organisations was very important also in the development strategies of Japan, South Korea, and other Asian economies.

The *institutional context* within which organisations interact is constituted by laws, social rules, cultural norms, routines, habits, technical standards, etc. *Institutions are not organisations.* Rather, institutions are the rules of the game; they shape the behaviour of firms and other organisations by constituting constraints and/or incentives for innovation. Some institutions are created by design, for example patent laws or (some) technical standards. Others have evolved spontaneously over extended periods of time, such as various kinds of social rules or habits. Those designed by public agencies may serve as innovation policy instruments. Through institutions the behaviour of firms is also influenced by the social and cultural context in a wide sense. These environmental conditions are often seen as specific to local, regional or national contexts, but they are also dynamic: their forms of operation change with political conditions, changing technological opportunities, economic integration processes and so on. A basic argument of systems approaches is that system conditions have a decisive impact on the extent to which firms can make innovation decisions, and on the modes of innovation which are undertaken.

In any system of innovation it is important to study whether the institutions are appropriate for promoting innovation. How should institutions be changed or ‘engineered’ to induce innovation? How can organisations be influenced by changing the institutional structure around them? Are the incentives for innovation appropriate and strong enough? This dynamic perspective of institutional change is crucial in the SI approach. The evolution and design of new institutions was also very important in the development strategies of the successful Asian economies mentioned above. Change in institutional rules and organisational forms are important engines in the changes of whole systems of innovation. However, many of these changes occur spontaneously and can therefore not be directly influenced by policy-makers.

### 4.2. Interaction

As pointed out above, firms normally do not innovate in isolation. They interact with other organisations and they do so within a context of institutional rules. *Interaction and interdependence* is one of the most important characteristics of the SI approach, where innovations are thought to be determined not only by the elements of the system but also by the *relations* between them. 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. Therefore, a description of a system of innovation must be more than simply an enumeration of its elements. The relations between them must also be addressed.

Both the organisations within a system of innovation and the interdependencies among them are often shaped by—or embedded in—institutions. The relations between different organisations and between organisations and institutions are extremely complex and often characterised by reciprocity, interactivity, and feedback mechanisms in several loops. This makes their measurement and evaluation extremely difficult.

### 4.3. Demand

In contrast to the linear view of innovation, the SI approach emphasises systemic learning processes. Another consequence of the interdependent and non-linear view that characterises the SI approach is that demand is often pointed to as a determinant of innovation. Demand conditions have also been singled out in another complementary approach - put forward by Porter - as one of the four factors determining the creation of a competitive advantage in an industry. Early contributions to the SI approach concentrated on combining the themes of learning and demand. This has been done, for example by focusing on interactive learning as a relation between users and producers of new technology (Lundvall 1992).

A corollary of treating demand as an important determinant of innovation is a widening of the traditional view of innovation policy to include not only supply side instruments, but also demand-oriented instruments. Examples of demand-oriented instruments are government designed institutions such as laws and regulations in the fields of consumer safety and environmental concerns. Another example is technology diffusion policy, including instruments affecting choices between alternatives and their use. A focus on demand also naturally leads to an emphasis on public technology procurement as an innovation policy instrument. Such procurement occurs when a public agency places an order for a product or system that does not (yet) exist, i.e. it can trigger innovation, create a market, lead to the satisfaction of previously unsatisfied needs, and solve previously 'unsolvable' socio-economic problems.

#### 4.4. Levels

Initially the SI approach was dominated by the national level. However, other systems of innovation than those defined by a country criterion, should be, and are being, identified and studied. An innovation system can be 'supranational' in several senses; it can be truly global, or it can include only part of the world (e.g. an integrated Europe). It can also be 'regional' within a country, an example being the Silicon Valley in California, or Route 128 in Massachusetts. Leaving the geographical dimension, we can also talk about 'sectoral' systems of innovation (i.e. 'technological' systems that include only a part of a regional, national, or international system). In Europe policy-making is concentrated on the national and European levels, but the regional level is also being increasingly focused.

#### 4.5. Differences and Comparisons

The SI approach is holistic and interdisciplinary. Potentially, it encompasses all or most determinants of innovation. It is important to go beyond R&D as a determinant of innovation. One important reason for this is that many—or even most—innovations emerge outside the formal R&D system, through the learning processes immanent in ordinary economic activities. In addition, innovations are not only developed but also produced, diffused, and used. They also change during these processes. All the factors and processes mentioned here are included in a system of innovation—but not in an R&D system! Further, the SI approach allows for the inclusion not only of economic factors influencing innovation but also of institutional, organisational, social, and political factors. As mentioned, its scope is not fixed and these factors may be studied in a national, regional, or sectoral context.

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 over time and—still—open ended; it is not clear—even to the actors involved—what the end-result will be, i.e. which path will be taken. History matters! The SI approach has adopted this major contribution from evolutionary theory.

Since innovations occur everywhere – to a larger or smaller extent - in a system of innovation and because of the evolutionary character of innovation processes, an innovation system never achieves equilibrium. Innovations are the enemy of equilibrium. We do not even know whether the potentially 'best' trajectory is being exploited at all, since we do not know which one it would be. This means that the notion of optimality is inappropriate in a system of innovation context. We can not specify an optimal or ideal system of innovation.

Systems of Innovation can be quite different from each other, e.g. with regard to specialisation of production, resources spent on R&D, etc. For example, industrial production in the United States and Japan is much more specialised in the production of R&D intensive ('hi-tech') products than is industrial production in the EU. Further, within the EU R&D intensities vary greatly between countries. 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 legal systems, norms, and values also differ between systems. In all these respects the diversity between systems of innovation is great.

These differences are stressed, rather than abstracted from, in the SI approach. This makes it not only natural but also vital to compare different systems. Without such comparisons it is impossible to argue that one system is specialised in one or the other way, or that a system performs well—or badly.

#### 4.6. Relevance

The clear policy trends towards increasing complexity and the growing importance of policy co-ordination, indicate that implicitly, at least, EU policy-makers have already adopted, though perhaps only indirectly, some elements of a systems approach. This is certainly evident in the broader view of innovation policy that has been adopted in the 1995 Green paper on Innovation. This document has obvious parallels with the holism of the SI approach, its focus on processes of interactive learning, etc. A central challenge is now to explore the potential for making the learning elements in innovation policy as explicit as possible. The SI approach is also used as a framework for designing innovation policy at the national level in some EU member countries, e.g. Finland and Ireland.

## 5. Summary of Policy Implications of the SI Approach

Based on the previous section will here follow a summary of the policy implications of the systems of innovation approach. They are of two kinds:

(1) The Systems of Innovation Approach provides a framework of analysis for identifying **specific** policy issues.

(2) The SI approach contains **general** policy implications (just like standard economic theory).

### 5.1. The SI Approach as a framework for identifying specific policy issues

In section 2 we concluded that a condition for public intervention in processes of innovation is that a ’problem’ must exist – which is not automatically solved by market forces and private actors. This means that neutral or general policies are normally irrelevant (except in creating more competitive markets – see section 3). ’Problems’ must be identified and they should then be subject to policy intervention. Substantial analytical and methodological capabilities are needed to identify these ’problems’ – whether policies are being made at the regional, national or EU level. Such capabilities are also needed to design policies that can mitigate the problems.

In section 4.4. we have seen that comparisons are 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, we can not specify an optimal or ideal system of innovation. Therefore, comparisons between an existing system and an ideal or optimal system are not possible. A ‘problem’ can not be identified in this way.

The only possible comparisons are between existing systems. Historically existing system can be compared with current ones or different currently existing ones can be compared with each other. The comparisons must be genuinely empirical and would therefore be similar to what is often called ‘benchmarking’ at the firm level. Such comparisons are crucial for policy purposes, e.g. for the identification of ‘problems’ that should be subject to policy intervention.

There is no way to identify these problems specifically enough – for purposes of policy-making – on the basis of theory alone. This is true for all existing theoretical perspectives and not only for the SI approach. No theory or approach can tell a politician or policy-maker how to use a hundred million ECU to enhance innovation processes. Let me take standard economic theory as an example.

The market failure analysis 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 to a case for public subsidies for knowledge creation, or for the creation of intellectual property rights. This nicely links up with the ‘linear model’ approaches and economists and 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 in which particular research field one should intervene. And they say almost nothing about how to intervene.

The conclusion is that standard economic theory is not of 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.

If technological change and innovation are evolutionary processes and if optimality is irrelevant, then comparisons between existing systems are necessary to identify problems with regard to innovations - which should be solved or mitigated through policy. There are several reasons why such comparisons are better pursued with the help of the systems of innovation approach, than within the framework of traditional economics. These include the fact the SI approach places innovation at the very centre of focus and that differences between systems of innovation are stressed – rather than abstracted from – in the SI approach. Another reason is that the SI approach allows for the inclusion not only of economic factors influencing innovation, but also institutional, organisational, social, and political factors.

Hence, the SI approach can fruitfully serve as a framework for developing specific policy implications. These implications can, for example, indicate to policy-makers when, where and how to use financial resources for innovation purposes. This might also indicate how to devise institutions and organisations or how to organise education and learning.

In addition the SI approach contains a number of general policy implications which can serve as signposts when carrying out empirical comparisons between systems of innovation – to identify 'problems'. These will be outlined in section 5.2.

Before that I will give an example of how a comparative analysis can identify a problem which should be subject to innovation policy. Through empirical comparisons we know that industrial employment in the Swedish economy decreased by 27 % between 1975 and 1996. Among 17 countries (the 15 EU member states, USA and Japan), only two countries had a larger decrease (Pianta 1999). In Sweden employment in services increased by 21 % during the same period. It was the lowest figure among the 17 countries (Pianta 1999). In addition Sweden has fallen from fourth the 15-17 position in the OECD welfare league.

The Swedish economy has been very successful in the diffusion of process technologies during the latest decades. Sweden has not been as successful with regard to product innovations, as shown by the following comparisons. The proportion of Swedish industrial production that took place in the growth industries was 1990 approximately 60 % of the average for all OECD countries.[14] Hence Swedish industry was not specialised in production of growth products. In addition, employment in the growth sectors has grown much slower in Sweden than in other OECD countries – or rather decreased. In the growth industries there were 210 000 jobs in Sweden 1975 and 190 000 jobs in 1991. In the other OECD countries the increase was 50 % on the average. These jobs are characterised by high productivity and relatively high wages. (Edquist and Texier 1996)

If employment in Swedish industry had grown as rapidly as in the other OECD countries in the growth sectors during 1975-1991, then there would have been 315 000 jobs in these sectors in Sweden in 1991. That is 125 000 more than the actual number. This should be related to the fact that there are about 870 000 employees in manufacturing in Sweden in 1991. (Edquist and Texier 1996)

[14] Growth industries are defined as those industrial sectors that grew most rapidly in the OECD world as a whole during 1975-1990. They are, to a large extent, the same as the so-called hi-tech industries, i.e. those sectors where the R&D intensity is high. (Edquist and Texier 1996)

This means that Swedish industry has not exploited the possibility to create 125 000 'real' high productivity, high wage jobs in the growth industries. The structural change in the direction of more knowledge-based activities has been considerably slower in Sweden than in the surrounding world. Thereby the production structure of Swedish industry has become obsolete. It can be argued that this is a major explanation to the fact that Sweden has now 10 % unemployment, meaning 500 000 unemployed.[15] This empirical and comparative analysis has identified a 'problem' in the Swedish national innovation system that should be the subject of public intervention.[16]

### 5.2. General Policy Implications of the SI Approach

The general policy implications of the SI approach provide signposts that can inform the detailed comparisons of systems of innovation. They can also serve as rules of thumb, suggesting where to look for problems and possible solutions in innovation policy-making. In this capacity they can aid innovation policy-makers to 'learn by doing'—i.e. to improve their performance as problem-solvers by comparing it with past performance. In other words, policy can be used to improve the functioning of systems of innovation without there being any notion of optimality—given certain socio-economic objectives such as economic growth and employment creation.

The general policy implications of the SI approach are different from those of 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 (firm, consumers) towards collective underpinnings of innovation. It addresses the overall system that creates and distributes knowledge, rather than its individual components. Here I will point out some characteristics of the SI approach, which have important implications for policy.

We have seen that the SI approach stresses *interdependence and interaction* between elements in the system. Among these elements we find *organisations*. They are the players or actors and include not only firms but also non-firm organisations like universities, research institute, schools, banks, venture capital organisations and government agencies. Since innovation is a kind of learning,

[15] It is often said that every new manufacturing job creates 3 – 4 service jobs, i.e. 125 000 manufacturing jobs might mean 500 000 jobs in total.
[16] A similar analysis identifying a 'problem' in Europe as a whole with regard to the structure of production has been carried out by Jan Fagerberg (Fagerberg 1999).

this means that *interactive* learning should be targeted much more directly than is the case in innovation policy today.[17]

The SI approach emphasises the fact that economic behaviour of organisations in general, and innovation behaviour in particular, is shaped by *institutions* like laws, rules, regulations, norms and standards. They constitute constraints or incentives for innovations.

This has several important policy implications of a general character. Firstly, it means that policy should not only focus on the elements of the systems, but also – and perhaps primarily – on the *relations* among these elements. This includes the relations among various kinds of organisations, but also those between organisations and institutions.

An important issue is therefore to what extent organisations and institutions that influence innovation can be created. How can organisational actors and institutional rules be designed in order to get an adaptive and efficient system of innovation? How can the actors (organisations) in the systems be influenced through changing the structure (institutions) around them? [18] Such creation or redesign of organisations and institutions might be more important policy instruments than subsidies and other financial instruments.

Another consequence of the interdependent and non-linear view, which characterises the SI approach, is that it is natural to bring in *demand* as an important determinant of innovation. This widens the traditional view on innovation policy to include also instruments working from the demand side. (See four-field table here.) They include laws, regulations and standards - i.e. institutions – influencing suppliers from the angle of the product developed and produced. They also include public technology procurement as an innovation policy instrument. Such procurement means that a public agency, as a sophisticated customer, places an order for a product or system that does not exist. (The way the EU Framework V programme is organised could also be mentioned here.)

From the evolutionary and path dependent character that characterises innovation processes follows the danger of 'lock-in' to existing technologies. (Refer to basis for this in section 4.) Just as firms find it difficult to evolve past

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[17] For example public technology procurement policies could be used more systematically to shape patterns of user-producer interaction. Or the knowledge infrastructure (including the system of intellectual property rights) could be used to develop R&D co-operation more fully, and so on. (Edquist et al 1998)

[18] Behind this question is the distinction between institutions that evolve spontaneously and others that are specifically created or designed. Those that are created by policy-makers are obviously instruments of innovation policy. The same is true for organisations. Institutions and organisations created or adapted by innovation policy-makers are ways to develop the ability of the public sector to pursue innovation policy. See section 2.

their existing technologies, so industries, regions and indeed whole countries (socio-economic systems) can be 'locked-in' to a particular scientific and technological paradigm. Narrowly focused policy actions at the level of individual actors are unlikely to overcome such lock-ins. External actors with powers to generate incentives, to develop technological alternatives and to nurture emerging technological systems are often required. This has to do with the fact that patterns of production specialisation change very slowly. In certain situations such action can be called for. Historical examples might be the modernisation of industry in Japan and South Korea.[19]

The above indicates that 'lock-in' failures imply a role for policy in adapting to shifts in new technologies and demand. This means that a key issue is the choice between supporting existing systems (with their historically accumulated learning and knowledge bases) and supporting the development of radically new technologies and sectoral systems. We know that large-scale technological shifts have rarely taken place without public interaction. In addition a small effort in an early stage in the technology (product) cycle may have major a impact and a large effort in a mature stage may have almost no impact. These are obviously arguments for early intervention and for supporting the emergence of new technological systems.

(There are also other general policy implications of the SI approach which I will not have time to go into now:

- It is natural to focus on product innovations and organisational process innovations and not only on technological process innovations.
- It is important to go beyond R&D as a determinant of innovation.
- It is important to include not only economic factors as determinants of innovation, but also institutional, organisational (both mentioned above), social and political.
- It is important to integrate and co-ordinate policy areas like RTD policies, innovation policies, education policies, regional policies and even macroeconomic policies.)

In summary, concrete empirical and comparative analyses are absolutely necessary for the design of specific policies in the fields of R&D and innovation. The SI approach is an analytical framework suited for such analyses. It is so because it places innovation at the very centre of focus and because it is able to capture differences between systems. In this way specific policy implications

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[19] Another example is the case of public technology procurement of telecommunications equipment in France. The public procurer there maintained technological diversity by supporting two different systems and thereby provided France with the capability to alternate between these. (Edquist et al 1998: section 4.3.4) a further example is the creation of the NMT 450 standard for mobile telephony in the Nordic countries.

can be identified. These do not come out of the approach as such, but from the empirical and comparative analyses that can be carried out with the help of the SI approach. There is no substitute for concrete analyses of concrete conditions in an effort to design innovation policy! However, the general implications of the SI approach might be helpful as signposts in carrying out the empirical comparisons between systems of innovation.

# 6. References

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