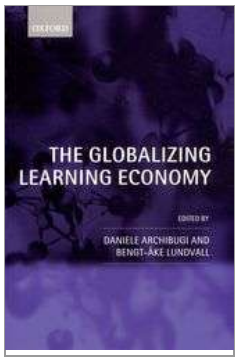

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Innovation Policy—A Systemic Approach

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Abstract and Keywords

Many innovations arise spontaneously as a result of the market mechanism and the actions of capitalist firms, but some, especially the more radical ones, require public intervention. The first part of this chapter discusses when such policy interventions might be necessary and why. The next section discusses selectivity in innovation policy. The last (main) section of the chapter discusses the general and specific policy implications of the new 'system of innovation' (SI) approach; this studies innovations as an endogenous part of the economy and has emerged only in the last decade or so. An SI can be defined as encompassing all the important factors that influence the development, diffusion, and use of innovations, as well as the relations between these factors, which can be studied in a national, regional, or sectoral context.

Keywords: economic policy, innovation policy, public intervention, state intervention, system of innovation (SI) approach

12.1. Definitions

Innovations are new creations of economic significance of either a material or an intangible kind. They may be brand new but are 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. It is a matter of *what* is being produced. Process innovations may be technological or organizational. It concerns *how* goods and services are produced. Some product innovations (investment goods) are transformed into process innovations in their 'second incarnation', for example, an industrial robot.[1]

Innovation policy is public action that influences technical change and other kinds of innovations. It includes elements of R&D policy, technology policy, infrastructure policy, regional 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 dead wood in many countries because of vain efforts to provide public support to old and dying industries. The term

innovation policy is naturally associated with change, flexibility, dynamism, and the future. Innovation policy should serve as midwife; not provide support towards the end of life.

12.2. Reasons for Public Policy Intervention

First, I want to point out that the market mechanism and capitalist firms best fulfil most economic functions in a modern society.[2] The market mechanism co-ordinates the behaviour and resources of private and public actors—often in a smooth and flexible manner. This concerns production of most goods, like bread and automobiles, and also a large proportion of service production, like cleaning and IT service provision. It is also true for many innovations, in particular incremental ones. Most of them occur in a spontaneous way through the actions of firms and in collaboration projects between firms. **(p.220)** This is, however, less true for radical innovations, especially in the early stages of the development of new technology fields.

Sometimes there are reasons to complement—or correct—the market and capitalist firms through public intervention. This is true in the areas of law, education, environment, infrastructure, social security, income distribution, research, radical innovations, etc. In some of these fields there is no market mechanism operating at all and the functions are fulfilled through other mechanisms, for example, regulation. In other of these fields the market mechanism has for decades been complemented by public intervention in most industrial countries. 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 an analytical way.

What, then, are the reasons for public policy intervention in a market economy? As regards, for example, technical change and other kinds of innovations, two conditions must be fulfilled for there to be reasons for public intervention in a market economy:

(1) the market mechanism and capitalist actors must fail to achieve the objectives formulated; a *problem* must exist (see below);
(2) the state (national, regional, local) and its public agencies must also have the *ability* to solve or mitigate the problem.

Let me discuss these two conditions in somewhat more depth.

1. There are no reasons for public intervention if the market and capitalist actors fulfil the objectives.[3] Innovation policy—or other kinds of public intervention —should 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'. Such problems can be identified through analysis (see section 12.4.2).

Note that I am here using the term 'problem' and not 'market failure'. This is because the approach here is different from traditional economics. The 'market failure approach' in economics is a part of a formal model: general equilibrium theory in an abstract economy. '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 see in section 12.4.1, however, innovation processes have evolutionary characteristics. The system never achieves equilibrium and the notion of optimality is irrelevant. **(p.221)** Hence, comparisons between an existing system and an ideal or optimal system are not possible. Thereby the notion of 'market failure' loses its meaning and applicability.

It is normally considered advantageous to argue within the framework of a strict and formal model of some kind and use a theory-based criterion—for example, Pareto optimality—when formulating policy. However, for reasons mentioned, it is not meaningful to use the market failure approach in innovation policy design (Edquist 1994: sections 3.1 and 5). It is therefore necessary to take a step backwards as regards the degree of formality and rigour. Therefore, when I talk about a 'problem' I do so on an empirical basis and in a pragmatic way, not within the framework of a formal model. This is conscious and intentional. The reason is that this approach is more useful as a basis for policy design in the field of innovations and technical change. There is no alternative to a pragmatic basis for innovation policy design (Edquist 1993: 28).

2. If the public sector does not have the ability to solve or mitigate a problem, there should, of course, be no intervention, since the result would be a failure. Therefore, I spoke above 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. 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.[4]

One difficulty in this context is, of course, that it is not possible to know for sure beforehand—*ex ante*—if public intervention can solve the problem or not.[5] The decision to intervene or not must thus be based upon whether it is likely 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. In other words, political failures can never be completely avoided because of the uncertainty mentioned. We must accept some mistakes in public activity—as well as in private. They must, however, be exceptions and not the rule. In order to determine the success or failure of a given policy intervention through an evaluation, it is necessary that the objectives of the policy were clearly formulated *ex ante*.

There may be two reasons why public intervention cannot solve or mitigate a problem. One is that it is not at all possible to solve the problem from a **(p.222)** political level. Then all types of intervention would, of course, be in vain.[6] The other reason is that the state might first need to develop its ability to solve the problem. A detailed analysis of the problems and their causes may, for example, be necessary means of acquiring this ability.[7] The creation of new organizations and institutions to carry out the intervention might also be necessary, that is, new policy instruments might need to be created. A patent office is an example of such an organization and a patent law is such an institution.[8] There are two main categories of policies to solve or mitigate 'problems'.

1. 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 services free of charge or at a subsidized cost. Other kinds of regulation—particularly related to innovation activities—are the creation of technical standards, public subsidies to firm R&D, or tax incentives to R&D and to innovation activities.

2. 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 (antitrust) policies. It is often a matter of increasing the degree of competition in a market. This might sometimes be achieved through deregulation, that is, getting rid of old or obsolete regulations.[9] 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 patent owner. This makes the selling and buying of technical knowledge easier.[10] **(p.223)** Public policy makers can also enhance the creation of markets by supporting legal security or the formation of trust. Another example is public technology procurement—to be discussed below.

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, or they might be intended to create markets or make the functioning of markets more efficient. 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 law mentioned above indicates that a 'problem' that motivates public intervention might concern the future; a problem might be something that has not yet emerged. In other words policy might well be proactive—and should often be! A *problem-solving* policy of this kind might alternatively be called an *opportunity-creating* policy.[11] One of the problems to be solved might be that uncertainty prevents new technologies from emerging. One example of such a problem is the case where public funding of basic R&D might be necessary because capitalist actors do not have the incentive to fund it. Another example could be that training people and stimulating research in public organizations in a certain field—for example, multimedia—could create new opportunities that would not be realized without policy. I will come back to these opportunity-creating kinds of innovation policies when discussing lock-in situations in section 12.4.1.

Another example pointing in this direction is the public creation of standards, which decreases the uncertainty for firms. For example, the creation of the Nordic Mobile Telephony Standard (NMT 450) created by the Nordic PTTs in the 1970s and 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. Ericsson and Nokia would not have assumed global leadership in this field without the NMT 450 (which later developed into the NMT 900 and the digital GSM standard).[12]

A further example of policy leading to market creation is public technology procurement, namely, 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 (Fridlund 2000 and Palmberg 2000). In this way public innovation policy might take the role of a 'midwife' in the emergence of new technology fields and whole production sectors. It could even be argued that **(p.224)** most innovation policies should take this proactive approach—an issue that will be further discussed in section 12.4.

12.3. Selectivity in Innovation Policy

When state intervention is intended to improve the functioning of markets, it is often a matter of increasing the degree of competition rather than increasing the rate of innovation. This kind of policy can be argued to be 'general' in the sense that it tries 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, and if means to increase it are needed, they must be appropriately designed and implemented. When markets are created by public action the policy is also specific to various functional areas, whether they concern 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 the market or influences the consequences of its operation. This applies to 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 its consequences are not uniformly distributed among different activities. This actually follows from the first of the two conditions that constitute reasons for public intervention (see section 12.2): if a certain 'problem' is to be solved, this has to be targeted in a selective manner. 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. They contribute to higher profits in established sectors while decreasing the relative incentives to invest in new areas.

Public policy for basic research is also selective. Politicians and policy makers must, for example, allocate public research funds among fields of research. Someone must decide which fields of research shall be given priority. Should the funds be used for nuclear physics or biotechnology? 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 can be seen as extremes in this respect.[13] Other innovation policy instruments are **(p.225)** located in between them. To divide industry into two parts and favour one of them—for example, through devaluations—is, of course, less selective than providing direct support to specific firms. It is natural that public policy—for example, innovation 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'être* of politics and policy. The degree to which public policy meets its objectives is much more important than its degree of selectivity.

12.4. Policy Implications of the System of Innovation (SI) Approach

'Systems of innovation' (SI) is a new approach for the study of innovations as an endogenous part of the economy. The SI approach has emerged only during the last decade or so. An SI can be defined as encompassing all the important factors that influence the development, diffusion, and use of innovations as well as the relations between these factors. These factors can be studied in a national, regional, or sectoral context; that is, national, regional, and sectoral systems of innovation coexist and complement each other. The SI approach can also be said to synthesize much of what we know today about innovation processes, their determinants and consequences.[14]

The SI approach places innovations at the very centre of focus; they are not treated as exogenous phenomena. Less obvious is that this is also true for other learning processes of various kinds. This is because learning in the form of formal education and searching through R&D is behind much of innovation. This is why there is currently so much talk about 'the learning economy'. The SI approach has diffused surprisingly fast in the academic world as well as in the realms of public innovation policy making and firm innovation strategy formulation.[15] 'Systems of innovation' is simply at the centre of modern thinking about innovation and its relation to economic growth, competitiveness, and employment.

(p.226) 12.4.1. Characteristics of the SI Approach and General Policy Implications

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, that is, 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, that is, 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. 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 inappropriate in a system of innovation context. We cannot specify an optimal or ideal system of innovation. Even if it exists, we are unaware of it. As mentioned in the discussion of reasons for public policy intervention in section 12.2 above, 'the market failure approach' implies a comparison between conditions in the real world and an ideal or optimal system. Since such comparisons are not possible in our field, we have instead used the notion of 'problem'. We can identify two main kinds of policy implications of the systems of innovation approach.

1. The SI approach contains *general* policy implications (just like standard economic theory), that can be extracted from the characteristics of the approach. They are 'general' in the sense that they are of a 'signpost' character. In the rest of this section some further characteristics of the SI approach will be discussed.[16]
2. The Systems of Innovation approach provides a framework of analysis for identifying *specific* policy issues. It is helpful in identifying 'problems' that should be the object of policy and for specifying how innovation policies to solve or mitigate these problems could be designed. Since this cannot be based on comparisons between existing systems of innovation and an optimal one, it will have to be based upon comparisons between different existing ones—geographically and/or historically. These issues will be addressed in section 12.4.2.

Organization

Most innovations occur in firms. The SI approach stresses, however, that firms do not innovate in isolation but in interaction with other *organizational actors* (other firms, universities, standard-setting agencies, etc.) and that this interaction is shaped by (and shapes) the framework of existing *institutional* **(p.227)** *rules* (laws, norms, technical standards, etc.). Hence, interaction and interdependence is one of the most important characteristics of the SI approach, where innovations are considered to be determined not only by the elements of the system but also by the relations among them. Innovations emerge, therefore, in systems where organizational actors and institutional rules are important elements. The importance of institutions and organizations is stressed—albeit to varying degrees and with different degrees of clarity—in all versions of the SI approach (Edquist 1997 ; Edquist and Johnson 1997).

The *organizations* 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 innovations. Here the argument is that inter-firm linkages are far more than arm's length market relationships; they involve more than exchange of quantitative information about prices and volumes. They often constitute ongoing co-operative relationships that also involve the exchange of other kinds of knowledge and information that shape learning and technology creation. Firms also interact with non-firm organizations such as universities, standard-setting agencies, research institutes, private foundations, financing organizations, schools, government agencies, policy organizations, etc.

A general policy implication of 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.[17] Innovation 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 organizations, but also those between organizations 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. Hence these interactions should be facilitated by means of policy—if they are not spontaneously functioning smoothly enough. The laws and rules governing the relations between universities and firms also shape these interactions—and it is therefore important that these are appropriate for enhancing collaboration.

Organizations are consciously created formal structures with an explicit purpose. They are the players or actors in systems of innovation. Some organizations are created by public policy makers and can therefore serve as policy

instruments; others are not. In periods of structural change, a country might have to redesign many of its organizations; this has been the case recently in Eastern Europe. The design of new organizations was very important also in **(p.228)** the innovation policies and more general development strategies of Japan, South Korea, and other Asian economies.

Some general policy implications of this view of organizations are the following. It is important to study how firms and non-firm organizations interact with each other and how they perform in relation to innovations. A number of relevant questions can be posed in relation to this area of research and analysis. Is the support that public organizations give to innovation appropriate? Should new public organizations be created? Are the technological support organizations doing the right things and doing them reasonably well? How can the formation of new firms be enhanced? How can the relations between organizations be influenced in order to facilitate innovations? In relation to these questions, it should be emphasized that some of the key tasks of public policy are to create new organizations, to change some, and to wipe out others.

Institution

Laws, social rules, cultural norms, routines, habits, and technical standards constitute the institutional context within which organizations interact. Institutions are not organizations. Rather, institutions are the rules of the game; they shape the behaviour of firms and other organizations by constituting constraints and/or incentives for innovation (North 1990). Some institutions are designed or created by public agencies, for example, patent laws or (some) technical standards. These institutions may serve as important innovation policy instruments. Others evolve spontaneously over extended periods of time, as do various kinds of social rules, habits or routines (Edquist and Johnson 1997). Policy makers cannot directly influence these. A general policy implication of this view of institutions is that a country or a region might need to redesign the institutional rules in the field of innovation and learning (namely, those that policy makers can influence). Of particular importance might be those institutional rules that influence interaction among firms and between firms and other organizations in the field of learning and innovation. Much innovation policy takes this form.

In any system of innovation it is important, from a policy point of view, to study whether the existing institutions are appropriate for promoting innovation. How should institutions be changed or 'engineered' to induce innovation? How can organizations be influenced by changing the institutional structure (framework conditions) around them? Are the incentives for innovation appropriate and strong enough? This dynamic perspective on institutional change is crucial in the SI approach. Not only organizational change but also the evolution and design of new institutions was very important in the development strategies of the successful Asian economies mentioned above, as well as in the ongoing transformation of Eastern Europe. These general policy implications of the SI approach are no surprises. To change organizational actors and institutional rules is what innovation **(p.229)** policy makers already do in their efforts to develop the ability of the public sector to pursue innovation policy. Such changes are important engines in the development of whole systems of innovation. These instruments are the most important ones at the disposal of policy makers in the field of innovation and learning. Such creation or redesign of organizations and institutions might be more important policy instruments than subsidies and other financial instruments (which are, of course accompanied by rules, that is, institutions).

Lock-In Situations

Earlier in this section we saw that the SI approach considers innovation processes to be evolutionary and path-dependent. From this follows the danger of (negative) 'lock-in' to existing patterns of innovation, for example, trajectories leading to low growth, decreasing employment, etc. This may apply to patterns of learning and production specialization of firms, industries, regions, and countries. We also know that large-scale and radical technological shifts—that is, shifts to new trajectories—have rarely taken place without public intervention.[18] In addition, a minor intervention at an early stage in the product cycle may have a tremendous impact, as we saw in the case of the NMT 450 mobile telecommunications standard. At the same time, a major effort at a mature stage might have only a small impact; the large support to the shipyard industry in Sweden in the 1970s only marginally prolonged the life of that industry.

These are obviously arguments for early policy intervention and for supporting the emergence of new technological systems, which would facilitate transitions from dead-end trajectories for regions, countries, and firms. Negative lock-in situations imply a role for policy in adapting to shifts in technologies and demand. Policy issues in this context might be the following. How can policy makers contribute to the development of alternative patterns of learning and innovations and the nurture of emerging sectoral systems of innovation? A key issue here is the choice between supporting existing

systems (with their historically accumulated knowledge bases) and supporting the development of radically new technologies and sectoral systems.

Demand-Side Instruments

Another consequence of the interdependent and non-linear view that characterizes the SI approach, as discussed earlier, is that it is natural to bring in *demand* as an important determinant of innovation (Edquist and Hommen 1999). This widens the traditional, supply-side oriented, view on innovation policy to include also instruments working from the demand side. They include various laws, regulations, and standards—that is, institutions—influencing suppliers from the angle of the product that is developed and **(p.230)** 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 (yet) exist. It can trigger innovation, create a market, lead to the satisfaction of previously unsatisfied needs, and solve previously 'unsolvable' socio-economic problems.

The SI approach can be characterized as 'holistic' in the sense that it has the ambition to encompass a wide array—or all—of the determinants of innovation. Many—or perhaps even most—innovations emerge outside the formal R&D system in a narrow sense, for example, through the learning processes immanent in ordinary economic activities (learning-by-doing, learning-by-using, learning-by-interacting). 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. The general policy implication is that it is necessary to go beyond R&D as a determinant of innovation when designing innovation policies.

The determinants of innovation—as seen by the SI approach—include not only economic factors, but also institutional and organizational factors (both discussed earlier), as well as political and social ones. One general policy implication of this is that it is obviously important to take all these different determinants into account when designing policies. Another is that it is important to integrate and co-ordinate policy areas like R&D policies, education policies, regional policies, and even macroeconomic policies when formulating innovation policies. This also has to do with the fact that innovation is only one integrated part of more general processes of learning in society, which also include formal education, training, and R&D.

Summing Up

The general policy implications of the SI approach discussed in this section provide signposts that can inform detailed comparisons of systems of innovation (to be discussed in section 12.4.2). They can 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'—that is, 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. Such objectives can be achieved, for example, by creating incentives for changes in the production structure promoting sectors characterized by rapid growth and a high degree of employment creation.

The policy implications discussed in this section have been of a general character. They do not tell a policy maker exactly how to intervene in **(p.231)** order to improve the functioning of the system of innovation. It would be much more interesting if we could provide some of the answers to the many questions formulated in this section! Which organizations and institutions should be changed, and in what way, if the objective is to get an efficient and adaptive system of innovation? How could policy ensure that negative lock-in situations are avoided? What should the balance be between supporting existing innovation activities and promoting the emergence of new sectoral systems of innovation? Which new sectoral systems should be supported? Which demand-side policy instruments should be used, and in what way? The SI approach as such cannot provide answers to these specific questions. Neither can any other approach nor theory. However, in section 12.4.2 we shall discuss how the SI approach can be helpful in finding answers to such specific questions.

12.4.2. The SI Approach as a Framework for Identifying Specific Policy Problems and for Designing Policies to Mitigate These

As seen above, certain general policy implications can be extracted from the characteristics of the SI approach. However, this is certainly not sufficient as a basis for designing specific innovation policies. In this section, I will indicate how the SI approach may serve as a framework for identifying problems that should be the object of policy and for designing specific

innovation policies. In this work, the general policy implications may be helpful by serving as signposts and rules of thumb.

To decide on the appropriate division of labour between private and public actors in the field of innovation is a very complicated task. In section 12.2 we concluded that a necessary (but not sufficient) condition for public intervention in processes of innovation is that a 'problem'—which is not automatically solved by market forces and private actors—must exist. This means that neutral or general policies are normally irrelevant (see section 12.3). Substantial analytical and methodological capabilities are needed to identify 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.

Problem Identification by Means of Comparisons

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 exactly how to use 100 million ECU to enhance innovation processes. Let us take standard economic theory as an example. The market failure analysis argues that a completely competitive, decentralized market economy would provide suboptimal 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 **(p.232)** 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 subsidize 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. And they say almost nothing about how to intervene, namely, which policy instruments that should be used. 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 provides only general policy implications; for example, that basic research should sometimes be subsidized. As we have seen, the same is true for the SI approach.

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 (firms, consumers) towards that of the collective underpinnings of innovation. It addresses the overall system that creates and distributes knowledge, rather than its individual components.

Systems of innovation can be quite *different* from each other, for example, with regard to specialization of production, resources spent on R&D, etc. For example, industrial production in the United States and Japan is much more specialized in the production of R&D intensive ('hi-tech') products than is industrial production in the EU (Fagerberg in this volume, Edquist and Texier 1996). Further, within the EU, R&D intensities vary greatly between countries. In addition, organizations and institutions constituting elements of the systems may be different. For example, research institutes and company-based research departments may be important organizations in one country (for example, Japan) while research universities may perform a similar function in another (for example, the United States). Institutions such as laws, norms, and values also differ considerably between systems.

An important characteristic of the SI approach is that these differences are stressed, rather than abstracted from, as is the case in neo-classical economics. 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 specialized in one or the other way, or that a system performs well, or badly. 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, as argued in section 12.4.1, we cannot specify an optimal or ideal system of innovation, since innovation processes have evolutionary characteristics. Therefore, comparisons between an existing system and an ideal or optimal system are not possible. A 'problem' cannot be identified in this way.

(p.233) The only possible system comparisons are between existing systems. Historically pre-existing systems can be compared with current ones, or different currently existing ones can be compared with each other.[19] The comparisons must be genuinely empirical and very detailed. They would then be similar to what is often called 'benchmarking' at the

firm level. Such comparisons are crucial for policy purposes, for example, for the identification of 'problems' that should be subject to policy intervention.

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, organizational, social, and political factors. Hence, the SI approach can fruitfully serve as a framework for developing specific policy issues. These 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 organizations, how to organize education and learning, etc.

I shall now provide an example of how a comparative analysis can identify a problem that 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 and Vivarelli 1999). Sweden's employment in services increased by 21% during the same period. It was the lowest figure among the 17 countries (Pianta and Vivarelli 1999).

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 in 1990 approximately 60% of the average for all OECD countries.[20] Hence, Swedish industry was not specialized in production of growth products. Employment in the growth sectors has grown much slower in Sweden than in other OECD countries. In fact it has decreased. In the growth industries there were 210,000 jobs in Sweden 1975 and 190,000 **(p.234)** jobs in 1991. In the other OECD countries there was an average increase of 50% in employment in the growth industries during the same period. These jobs were characterized 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 (on average) in the growth sectors during 1975–91, 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 were only about 870,000 employees in manufacturing in Sweden in 1991 (Edquist and Texier 1996). This means that Swedish industry has not exploited the possibility of creating 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 more obsolete. It can be argued that this is a major explanation for the fact that Sweden had an unemployment rate of about 10%, meaning about 500,000 unemployed, in the late 1990s.[21]

This empirical and comparative analysis has identified a 'problem' in the Swedish national innovation system that should have been subject to public intervention, since it seems not to have been solved spontaneously by market forces and private actors during a long period of time.[22] It should only be so, however, if the public agencies also have the ability to solve or mitigate the problem. The policy recommendation emerging from this discussion is that explicitly comparative empirical analyses should be carried out as a basis for policy making in countries (and regions). They can serve the purpose of identifying 'problems' that should be the object of policy.

Causal Explanation and Policy Design

However, an identification of a 'problem' by means of benchmarking is certainly 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 sector must also have the ability to solve or mitigate the problem. A detailed analysis of the problems and their causes might be necessary and new organizations and institutions might be necessary for creating this ability. To know *that* there is reason to consider public intervention is not enough. A symptomatic description 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. A causal **(p.235)** analysis might also reveal that public intervention might be unlikely to solve the problem identified, due to lack of ability.

The combination of a symptom describing (problem identifying) analysis and a causal explanation may be called a 'diagnostic' analysis (Edquist 1993, 1994). Such an analysis can provide a basis for an efficient therapy or treatment, namely, a 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.

Within a systems of innovation framework an identification of the causes behind the problems is the same as identifying deficiencies in the functioning of the system. It is a matter of identifying functions that are missing or inappropriate and which lead to the 'problem' in terms of comparative performance. Let us label these deficient functions 'system failures'. When we know the causes behind a certain 'problem' (for example, low performance), we have identified a 'system failure'. The OECD has addressed what they call 'systemic failures' and defined them as 'mismatches between the components of an innovation system' (OECD 1998:102). Let me try to be somewhat more specific with regard to what a 'system failure' might be. On the basis of the discussion of the characteristics of the SI approach, at least three main categories of systems failures can be mentioned:[23]

- organizations in the system of innovation might be inappropriate or missing
- institutions may be inappropriate or missing
- interactions or links between these elements in the SI might be inappropriate or missing.[24]

We pointed to an area of low performance of the Swedish economy which is likely to be closely associated with the functioning of the national system of innovation, namely, too little product innovation and insufficiently rapid change in the structure of production in the direction of a higher proportion of R&D intensive goods in manufacturing production. However, a detailed causal analysis of the problem identified is necessary to find out which kind **(p.236)** of system failure is behind this problem.[25] Not until they know the character of the system failure do policy makers know whether to influence or change organizations, institutions, interactions between them; or something else.[26] Hence, an identification of a problem should be supplemented with an analysis of its causes as a part of the analytical basis for the design of an innovation policy. Benchmarking is not enough.

'Problems' and 'system failures' are different from 'market failures' in that they are identified through comparisons between existing systems. The result is that the identification of 'market failures' and 'system failures' can be expected to point in different directions, or at different issues—at least partly. It is also likely that there are more systems failures than market failures in most innovation systems (of course depending on their performance). Hence, the resulting innovation policies will be different.

12.5. Conclusion

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 appropriate for this purpose because it places innovation at the very centre of focus and because it is able to capture differences between systems. In this way specific problems that should be objects of innovation policy can be identified.

In order to design specific policies, it is also important to identify the causes—or system failures—behind the problems. These problems and their causes do not come out of the SI approach as such, but from the empirical and comparative analyses that can be carried out with the help of it. There is no substitute for concrete analyses of concrete conditions in an effort to design innovation policy. However, the general policy implications of the SI approach may be helpful as signposts in carrying out the empirical comparisons between systems of innovation.

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Notes:

(1) These distinctions are used in an analysis of the relations between innovations and employment in Edquist, Hommen, and McKelvey (2000).

(2) Capitalist firms include private firms, but also publicly owned firms which function in a similar way.

(3) I assume that the objectives—whatever they are—are already determined in a political process. It should 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 and/or in comparison to other countries. With regard to innovation policy the most common objectives are formulated in terms of economic growth, productivity growth, or employment (Edquist 1994: section 4).

(4) As an alternative to calling for the fulfilment of these conditions for public intervention, one might argue that it should be discussed for each specific issue (from defence to bread production and radical innovation) whether markets or public actors can fulfil the objectives most efficiently—or if collaboration between them is called for.

(5) This is especially the case with innovation. Here, by definition, it is highly unlikely that there will be any clear-cut precedents for the problem to be solved.

(6) Hence, the problem is not solvable by the market mechanism and private actors or by public intervention.

(7) Hence, it might be necessary to carry out a detailed comparative empirical analysis, see section 12.4.2. in this chapter.

(8) Institutions as used here constitute the 'rules of the game', e.g. laws, rules, habits, routines, etc. Organizations are the actors or players, the actions of which are shaped by (and shape) the rules. See North (1990) and Edquist and Johnson (1997).

(9) However, markets are always institutionally embedded and there might be a contradiction between 'perfect competition' and innovation. If a market is 'perfect', in the neo-classical sense, the only information exchanged between producers and users relates to products already existing in the market and it contains only quantitative information about price and volume. Anonymous relationships between buyer and seller are assumed. Producers have no information about potential user needs and users have no knowledge about the characteristics of new products. 'If the real economy was

constituted by pure markets, product innovations would be haphazard and exceptional' (Lundvall 1988: 350). Hence, markets supporting product innovation are normally not pure, but institutionally embedded. If policy makers are trying to create conditions that resemble perfect competition in their rule making, it may therefore constitute an obstacle to product innovation. Elsewhere, we have shown that this applies to the rules governing public technology procurement created by the European Commission: ' . . . too great a stress on "perfect competition" can undermine competitiveness' (Edquist, Hommen, and Tsipouri 2000: 307).

(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 worn out when used—unlike other products.

(11) There might even be reasons to treat the solving of existing problems and the creation of future opportunities as two different situations calling for public intervention.

(12) The NMT story is told in Fridlund (2000) and Palmberg (2000).

(13) Public funding of basic research is provided in all countries, but direct support to specific companies only in some. This is probably because direct support to individual firms has negative side effects, for which reason it should be avoided, to the largest extent possible.

(14) The first two books exclusively devoted to analyses of 'national systems of innovation' were Lundvall (1992) and Nelson (1993). However, Chris Freeman (1987) first used the expression in published form. Regional systems of innovation have been addressed, for example, in Braczyk *et al.* (1998). Sectoral systems of innovation have been analysed in Carlsson (1995), Breschi and Malerba (1997), and Nelson and Mowery (1999). All these books—and others—are reviewed in the introduction to Edquist and McKelvey (2000) which is a collection of 43 central articles on systems of innovation of various kinds.

(15) For example, EU policy makers have adopted some elements of the systems of innovation approach, which is evident in the broader view of innovation policy that was adopted in the 1995 Green Paper on Innovation. Prime Ministers Paavo Lipponen (Finland) and Antonio Guiterres (Portugal) also used the concept of 'innovation system' when they were outlining the immediate future agenda of the EU in terms of 'a Europe of innovation and knowledge' (letter to the Members of the European Council of 16 October, 1999). The OECD also uses the approach intensively (e.g. OECD 1998). 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.

(16) The discussion of the general characteristics of the SI approach is based upon the more detailed discussion thereof in Edquist 1997: 15–29.

(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) Lipsey and Carlaw (1998) have shown this for the case of the United States.

(19) This includes comparisons against averages for more than one, or all, systems for certain variables. A final kind of comparison would be between a value for a certain variable in an existing system and some norm, or goal. However, this would, of course, not be a comparison with another existing system, nor with an optimum.

(20) 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). Some of the data presented here are not up to date, but the example still serves the purpose of identifying a 'problem'. The data are, however, updated in an ongoing project.

(21) 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.

(22) 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, in this volume.

(23) Two of these three categories (organizations and interaction) were mentioned by Andersen, Metcalfe, and Tether (2000), in their short discussion of system failures.

(24) The interactions might, for example, lead to lock-in situations. This could be a consequence if conservative users with a weak technical competence put their suppliers at a competitive disadvantage, as a result of the interaction between the two.

(25) Such a causal analysis was attempted in Edquist (1993)

(26) It should be mentioned that a certain system failure might be solved in several different ways, since, for example, different organizations may perform the same function. For example, research institutes and company-based research departments may, in one national system, perform the same function as research universities in another.