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National Innovation System: Analytical Focusing Device and Policy Learning Tool

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Foreword

In the last decade new concepts as innovation and innovation system has becoming more and more used by policy makers around the world. Sweden has not been an exception. The Swedish institute for growth policy studies (ITPS) has since 2006 been working with a project on Swedish innovation policy. The aims with the project are to draw a picture of the Swedish system and to explain why it is organized the way it is, and to discuss how national systems of innovation can be studied.

This work is a part of this project and aims to shed light on the existing literature on innovation systems. This report provides the reader with a theoretical understanding of the innovation concept and how it can be understood in a system perspective. The report also discuss the how an innovation system can be related to policies.

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1.1 Introduction

Today it is possible to follow the diffusion of new concepts in time and space by using search machines on the internet. Giving 'Google' the text strings 'national innovation system(s)' and 'national system(s) of innovation' you end up with a total of more than 200.000 references. Going through the references you find that most of them are recent and that many of them are related to innovation policy efforts at the national level while others refer to new contributions in social science.

Looking closer at the origin of the specific references makes it clear that the concept informs policy makers in almost all countries in the world, including the biggest economies such as the US, Japan, Russia, Brazil, South Africa, China and India.[1] The diffusion is quite impressive taking into account that 15 years ago only a handful of scholars had heard about this concept. Policy makers at the national level as well as experts in international organizations for economic co-operation such as OECD, Unctad, the World Bank and the EU-Commission have adopted the concept as a tool for policy making.

It has also inspired analytical efforts related to different disciplines within social science. Economists, business economists, economic historians, sociologists and especially economic geographers have utilized the concept in their attempts to explain and understand phenomena related to innovation and competence building. In economic geography the diffusion of the innovation system perspective has gone hand in hand with a growing focus on industrial clusters and industrial districts understood as regional knowledge-based networks of firms and institutions. This 'new economic geography' has changed the way geographical location and agglomeration is explained (Clark, Feldman and Gertler 2000).

In this chapter we demonstrate that during the process of diffusion there has been a distortion of the concept as compared to the original versions as they were developed by Christopher Freeman and the IKE-group in Aalborg. This distortion gives rise to so-called 'innovation paradoxes' which leaves significant elements of innovation based economic performance unexplained. In terms of analysis it is reflected in studies of innovation policy that focus on science-based innovation and on the formal technological infrastructure.

In terms of policy it is reflected in a bias in favor of stimulating science-based innovation and in highly problematic attempts to subordinate all academic scientific work to the logic of the market.

The distorted analytical perspective produces 'paradoxes' such as the European paradox. These are not paradoxes since they emanate from lop-sided analytical perspectives. They reflect remnants of the linear model and narrow definitions of the innovation system and are reinforced by Triple Helix and Mode II Production of knowledge models and, not least, by standard economics approaches to innovation. Several of the fundamental weaknesses

[1] *As far as I know, the prime minister of Finland was the first highly placed politician using the concept in referring to the need to strengthen the Finnish innovation system already in the very beginning of the nineties. Early followers were Canada and South Africa. Some ten years later the president of China in a speech to the Engineering Academy made a similar remark referring to the Chinese innovation system.*

in analysis and policy could be repaired by going back to the original versions and to further develop the ideas of analyzing the fundamental role of knowledge and learning and focusing the analysis in the micro-dynamics of user producer interaction.

Without a basic understanding of the combination of organizational and inter-organizational learning it is impossible to establish the link from innovation to economic growth. To put it briefly the focus should be much more on people and competence and upon how the relationships and interactions between people promote learning. This is especially important in the current era of the globalizing learning economy where the key to success for individuals, firms, regions and national systems is rapid learning (Lundvall and Johnson 1994; Lundvall and Borràs 1998; Archibugi and Lundvall 2001).

Section 2 takes a brief look at how the concept originated and developed.[2] Section 3 confronts the theoretical foundations of the concept with standard economics. Section 4 defines a number of analytical challenges for the concept. Section 5 goes further and presents ideas for how to study innovation systems. Section 6 takes a critical look at the way the concept has been adopted and adapted as the basis of policy. Section 7 presents some basic principles for the design of innovation policy. Section 8 comes with some ideas about implications for innovation policy of combining a systemic perspective with insights about the current context: the globalizing learning economy. The chapter ends with the concluding section 9.

[2] *Actually this story has some parallels with how major innovations such as the computer occurred and developed. Put briefly, Friedrich List may be seen as the Babbage and Christopher Freeman as the Shockley of the NSI-concept. The parallel efforts to develop the modern computer and the co-existence of alternative configurations (interpretations) may be found also in the development of the NSI-concept.*

2 A concept with roots far back in history

2.1 From List to Freeman

Some of the basic ideas behind the concept 'national systems of innovation' go back to Friedrich List (List 1841). His concept 'national systems of production' took into account a wide set of national institutions including those engaged in education and training as well as infrastructures such as networks for transportation of people and commodities (Freeman 1995). He focused on the development of productive forces rather than on allocation issues. As a German catch-up economist he was critical to the 'cosmopolitan' approach of Adam Smith, where free trade was assumed to be to the advantage of the laggard (Germany) as well as the lead economy (England).

Referring to the 'national production system' List pointed to the need for the state to build national infrastructure and institutions in order to promote the accumulation of 'mental capital' and use it to spur economic development rather than just to sit back and trust 'the invisible hand' to solve all problems.

The first written contribution that used the concept 'national system of innovation' is, to the best of my knowledge, an unpublished paper by Christopher Freeman from 1982 that he worked out for the OECD expert group on Science, Technology and Competitiveness (Freeman 1982, p. 18). The paper, titled 'Technological infrastructure and international competitiveness', was written very much in the spirit of Friedrich List, pointing out the importance of an active role for government in promoting a technological infrastructure.[3]

It also pointed to the limited relevance of short-term competitiveness strategies such as manipulating national wage and currency rates. One of the major points in the paper is that, in order to explain why and how world economic supremacy moves from one country to another, we need to consider how new technological systems come forward and how they match or mismatch with the existing national patterns of institutions. Some countries thriving in the context of one technological system may become victims of their own success since they will have great difficulties in adapting their institutional set up to the new technological system.[4]

[3] *The paper was published for the first time more than 20 years later in the journal Industrial and Corporate Change (Freeman 2004).*

[4] *Not surprisingly OECD never published Freeman's paper. Its message was not in tune with the neo-liberal ideas of the organization. Actually, the publication of the main report from the expert group, where Ingram was chairman, Francois Chesnais the academic secretary and I represented the Danish government was delayed several years because 'there were problems with the printing capacity of the OECD-secretariat'. Today the most important idea in the report (that there is a need to focus more on 'structural competitiveness' than on 'wage cost competitiveness') is almost generally accepted.*

2.1.1 Parallel efforts to develop the innovation system concept

In the beginning of the eighties the idea of a national system of innovation was immanent in the work of several economists working on innovation research. Dick Nelson and other US-scholars had compared technology policy and institutions in the high technology field in the US with such patterns in Japan and Europe (Nelson 1984).

SPRU at Sussex University pursued several studies comparing industrial development in Germany and the UK covering for instance differences in the management of innovation, work practices and engineering education.

The idea of a national system of innovation was immanent also in the research program pursued by the IKE-group at Aalborg University.[5] The program was inspired by French structuralist economists such as Francois Perroux and his followers, de Bernis and Palloix, who used the concept 'national system of production' as analytical tool in explaining economic growth. But it was also open to the SPRU-tradition with its focus on analyzing innovation at the level of firms and sectors. In several working papers and publications from the first half of the eighties we referred to 'the innovative capability of the national system of production'. The first time the handier 'innovation system' appears in an Aalborg-publication is in Lundvall (1985) but then without the adjective national. In this booklet on user-producer interaction and product innovation the concept was used to analyze innovation processes involving firms and knowledge institutions in interaction. A general assumption behind the analysis, that remains central in more recent work on innovation systems, was that innovation and learning are context dependent, interactive processes, rooted in the production structure.

Again, it was Chris Freeman who brought the modern version of the full concept 'national innovation system' into the literature. He did so 1987 in his book on innovation in Japan (Freeman 1987). Here the analysis was quite inclusive taking into account the intra- as well as inter-organizational characteristics of firms, corporate governance, the education system and not least the role of government. When Freeman collaborated with Nelson and others in the major IFIAS-project on technical change and economic theory the outcome was a book (Dosi et al, eds. 1988) with a section with chapters on 'national systems of innovation' (Freeman 1988; Lundvall 1988; Nelson 1988). After that followed three major edited volumes on the subject (Lundvall 1992; Nelson 1993; Edquist 1997). While the book edited by Nelson brings together a number of national case studies, the books edited by Lundvall and Edquist were organized according to different dimensions of or perspectives on innovation systems.

[5] *It should be mentioned that the IKE-group in Aalborg had the privilege to interact with Christopher Freeman in several projects in this period and that many of our ideas were shaped in a dialogue with him (see for instance Freeman 1981).*

Box 1 Why focus on the national level?

The adjective 'national' is not uncontroversial. Modern social science has, for different reasons, had surprisingly little to say about nation states. But nonetheless social science has focused mainly at the national level and this includes economic analysis where there has been a strong focus on comparing the economic growth and 'the wealth of nations'. In this situation it is actually demystifying to use 'national' explicitly in the NSI-term. Given that our original intention was to confront national economic policy strategies and standard economics – focused on the national level - it was not an option to delete 'national' from NSI.

Over the last decade there have been several new concepts emphasizing the systemic characteristics of innovation but with focus at other levels of the economy than the nation state – regional and sectoral systems. These are not alternatives to national systems. They have important contributions to make to the general understanding of innovation in their own right and to compare sectoral, regional and technological systems across nations is often an operational way of getting a better understanding of the dynamics at the national level.

The most obvious argument against the focus upon the national level is that key factors, processes and outcomes are located either regionally or internationally. It is certainly correct that new development efforts in science and generic technologies typically involve international collaboration. Therefore the narrow definition of innovation systems focusing upon science-based innovation will find that the coherence of the system becomes seriously weakened with globalization and the fact that the dynamic performance differ between national systems becomes difficult to explain.

This is less the case for the broad definition. Workers remain the least mobile across borders and the education systems and the labor markets where they acquire their competences and engage in processes of change tend to remain national. In box 5 we will demonstrate that behind such differences in performance may lie different ways of organizing the economy at the micro-level of the workplace.

It has become even more important to be explicit on the national dimension, as 'globalization' becomes a major theme in the societal discourse. To understand and cope with problems connected with globalization and the regional economic integration in Europe and on other continents calls for an understanding of the historical role of national systems.

The contribution by Michael Porter on the competitive advantage of nations should also be mentioned here. He does not explicitly use the concept of innovation system but there is substantial overlap between his approach and the literature referred to above (Porter 1990). Especially worth noting is his emphasis on feed back mechanisms from and interaction with domestic suppliers and users as a factor that gives competitive advantage.

2.2 Common assumptions behind innovation system approaches

As will be demonstrated below there are different conceptions regarding what constitutes the core elements of an innovation system and different scholars draw the borderlines of the system differently. Still it might be useful to see what the different definitions have in common.

Box 2 What do we mean by system?

System appears in different social and academic discourses (see for instance Bertalanffy, Luhmann as well as literature on eco-systems). While borrowing ideas from any single of these different perspectives may give interesting insights it must be made with care since there are always problems with a transfer of ideas from one analytical universe to another.
The original choice of the term 'system' (rather than 'network' for instance) referred to a few simple ideas. First that the sum of the whole is more than its parts, second that the interrelationships and interaction between elements were as important for processes and outcomes as were the elements and third that the concept should allow for the complex relationships between production structure (hard-ware), institutions (software) and knowledge. Another idea behind the analysis, as developed by Freeman, was that 'not everything goes' – i.e. there may be mismatch problems within and problems with transplantation across systems. There is a lot of theoretical work to do develop a more stringent system concept that makes it possible to understand the intricate interplay between micro and macro phenomena, where macro structures condition micro-dynamics and, vice versa, how new macro-structures are shaped by micro-processes. In a dynamic context this means that we need to understand systems as being complex and characterized by co-evolution and self-organizing.

A first common assumption is that national systems differ in terms of specialization in production, trade and knowledge. In itself, this is not controversial. For instance neoclassical trade theory starts from a similar assumption. The important difference is that among NSI-analysts it is assumed that there is a dynamic co-evolution between what countries specialize in doing and what people and firms in these countries know how to do well. These couplings imply, first, that both the production structure and the knowledge structure will change only slowly and, second, that such change must involve learning. The fact that the specialization in trade is not seen as reflecting 'natural' comparative advantage rooted in factor proportions, opens up for a discussion of what kind of specialization that is most conducive to wealth creation (Reinert 2005).

A second common assumption is that elements of knowledge important for economic performance are localized and not easily transferred from one place/context to another. In a fictive neoclassical world where knowledge equaled information and where society was populated with perfectly rational agents, each with unlimited access to information, national innovation systems would be an unnecessary construct.

A third assumption that makes it understandable why knowledge is localized is that knowledge is something more than information and that it includes tacit elements (Dosi 1999, p. 35). It is assumed that important elements of knowledge are embodied in the minds and bodies of agents or embedded in routines of firms and not least in relationships between people and organizations. This is consistent with the idea that innovation system approaches go beyond the dictum of methodological individualism.[6]

Box 3 What do we mean by Innovation?

It is a tradition to refer to Schumpeter when defining innovation. According to Schumpeter innovation can be seen as 'new combinations' and be separated from invention. The invention becomes an innovation only when the entrepreneur brings it to the market. We will follow Schumpeter in this respect but we will include not only the event of the new combination but also the process of its diffusion and use. It is well known that technical innovation is a cumulative and path-dependent process. New products and new processes become attractive more widely only after a process of broader use. On this basis it is most useful to define innovation as a process.

According to Schumpeter, innovation can be specified as respectively new products, new processes, new raw materials, new forms of organization and new markets. I do not find this list useful because it puts in parallel different forms of change that it is useful to keep separate when it comes to understand the innovation process. It might be difficult to distinguish between technical change and organizational change in real life but this analytical distinction is important and useful for two reasons. First, the way the economy and the firm are organized has a major impact on how innovation takes place. Second the distinction makes it possible to link technical innovation to economic performance. We have pursued a series of empirical studies demonstrating that a key to transform technical innovation into economic results is a combination of new training efforts and organizational change.

A fourth common assumption is that in order to understand the innovation process it is necessary to focus upon interaction and relationships. Firms, knowledge institutions and people do seldom innovate alone and innovation emanates from cumulative processes of interactive learning and searching. This implies that the system needs to be characterized simultaneously with reference to its elements and to the relationships between those elements. The relationships may be seen as carriers of knowledge and the interaction as processes where new knowledge is produced and diffused. Perhaps the single most fundamental characteristic of the innovation system approach is that it is 'interactionist'.[7]

To capture the qualitative dimension of interaction and relationships the term 'institutions' in its broad sociological sense – as informal and formal norms and rules regulating how people interact – may be used (Johnson 1988; Johnson 1992). This is the other major dimension in which national systems are assumed to differ from each other.

Institution is a useful theoretical concept but it is somewhat elusive in empirical and historical studies. Institutional differences are much more difficult to 'measure' than differences in specialization in production and trade.

[6] *It is interesting to note that in this respect it finds support in Arrow (1994) who explains why it is not reasonable to apply the dictum specifically to the production and use of knowledge.*

[7] *Actually the NSI-approach has elements in common with the social psychological pragmatist school of Chicago and not least with the ideas of George Herbert Mead.*

Sometimes NSI-scholars and policy makers sidestep these difficulties by changing the focus from intangible and informal institutions to the tangible and formal 'institutions' (organizations) that constitute the technological infrastructure. It is easier to track and compare the development of the modern R&D-department, universities and professional training of engineers across national systems than it is to capture changes in how people interact and communicate.

How such formal institutions and organizations function and interact with other parts of the system is certainly most relevant for the understanding of the system as a whole. But the aim for a full-blown analysis of innovation systems remains to understand how international institutional differences – where 'institution' refers to norms and habits that shape modes of interaction and innovation outcomes. To illustrate, later on, we will argue that the relative success of the Nordic small welfare state economies in global knowledge based competition cannot be explained simply by focusing on technological infrastructure. More important is a social fabric that supports distinct modes of interaction and learning that are well suited to support firms in a context of global turbulence.

2.3 Different definitions of the 'national innovation system'

Different authors may mean different things when referring to a national system of innovation. Some major differences have to do with the focus of the analysis and some with how broad the definition is in relation to institutions and markets.

Authors from the US, with focus on science and technology policy, tend to focus on 'the innovation system in the narrow sense'. They regard the NSI-concept as a follow-up and broadening of earlier analyses of 'national science systems' and 'national technology policies' (see for instance the definition given in Mowery and Oxley 1995, p.80). The focus of their analysis is upon the systemic relationships between R&D-efforts in firms, S&T-organizations, including universities, and public policy. The analysis may include markets for knowledge – intellectual property rights - and the venture-capital aspects of financial markets but more seldom the broader set of institutions shaping competence building in the economy such as education and training, industrial relations and labor market dynamics.

The Freeman- and the 'Aalborg-version' of the national innovation system-approach (Freeman 1987; Lundvall 1985; Lundvall 1992) aims at understanding 'the innovation system in the broad sense'. First the definition of 'innovation' is broader. Innovation is defined as a continuous cumulative process involving not only radical and incremental innovation but also the diffusion, absorption and use of innovation. Second a major source of innovation, besides science, is interactive learning taking place in connection with production and sales. Therefore the analysis takes its starting point in processes of production and product development assuming, for instance, that the interaction with users is fundamental for product innovation.[8]

[8] *To some degree, these differences reflect specificities of the national system from which the analysts originate. In small countries such as Denmark, as in developing countries (the major concern of Freeman) it is obvious that the competence base most critical for innovation in the economy as a whole is not scientific knowledge. In the US, aggregate economic growth is more directly linked to the expansion of science-based sectors.*

The recent explosion of analytical work and studies using the NSI-concept makes it difficult to establish a classification. Many of the empirical contributions referring to the NSI-concept are highly descriptive and they map public infrastructure and public policies aiming at stimulating science and technology. In these studies both the core system of firms in interaction and the evolution of the human resource base are neglected. If they take a historical perspective it is a history of formal organizations and policies.

An interesting proposal for a classification is Balzat and Hanusch (2004). They draw the distinction between recent studies of highly developed economies with focus on benchmarking and a new wave of studies of less developed countries giving more attention to the historical character of the concept.

There is a growing critical meta-literature on innovation systems. One interesting critical analysis of the concept and its use in theory and policy is (Miettinen 2002).

Innovation system may be seen as a generic concept that has found its application in several other contexts than the national. Over the last decade there have been several new concepts emphasizing the systemic characteristics of innovation but with focus upon other levels of the economy than the nation state. The literature on 'regional systems of innovation' has grown rapidly (Cooke 1992; Maskell and Malmberg 1997). Bo Carlsson with colleagues from Sweden introduced the concept 'technological system' already in the beginning of the nineties (Carlsson and Stankiewicz 1991; Carlsson and Jacobsson 1997) while Franco Malerba and his colleagues in Italy developed the concept of sectoral systems of innovation (Breschi and Malerba 1997).

2.4 Going back to the origins

While Christopher Freeman was a pioneer in analyzing the role of science and R&D-laboratories in economic growth – he may actually be named the father of Science Policy both as academic discipline and as policy field – his approach to the innovation system of Japan included organizational dimensions of the innovation process that supported learning within and between organizations (Freeman 1987).

The same was true for the approach developed by the IKE-group in Aalborg. Lundvall (1992) opens up on page 1 with the statement that in the modern economy the most important resource is knowledge and the most important process in learning.[9] This basic idea referred back to the earlier work on interactive learning in connection with product innovation (Lundvall 1985). In connection with a major study of the Danish innovation system internal organization learning of firms was linked to innovation and growth performance (Lundvall 1999 and Lundvall 2002). In the recent work on innovation systems by the Aalborg-group human resources as shaped by education, labour markets and learning by doing have been given much more weight.

[9] *A serious weakness of the book is that a planned chapter on the role of education and skills did not get finished and included as planned. This might have contributed to the fact that skills and competence has not been taken into the analysis by the majority of following concrete studies of innovation systems.*

These ambitions to understand the performance of national systems as rooted in nation-specific organizational and in human resources have not been followed up in the analysis of innovation in the knowledge-based economy pursued by OECD and international organizations. Here, as in policy discussions, the focus has remained on easy to measure indicators such as R&D and patents, sometimes including the labour market and training of scientific personnel. In what follows we will argue that some of the 'paradoxes' that have been found and shaped the debate on innovation and economic performance come from this neglect.

3 National innovation system as analytical focusing device

The innovation system framework is in direct competition with standard economics when it comes to give advice to policy makers. Therefore it is useful to consider how the two relate to each other. Recently analysts from the Dutch ministry of economics have made a comparison of 'market failure' approach and 'system failure' approach under the heading Babel Tower indicating that the system failure approach has mainly brought confusion for policy makers (Hers and Nahuis 2004). The conclusion they reach is basically that 'system failure' gives little help to policy makers and that it is more useful to stick to the standard economics framework when designing innovation policy. In this section we will try to present the core theoretical ideas behind the innovation system perspective and confront them with standard economics. Our conclusions differ from the ones that the Dutch economists have reached.

In this context we will also address the question about the theoretical status of the NSI-concept. Is it a theory, a theoretical concept or just a framework for descriptive mapping? The problem with posing and answering this question is that it is far from clear what should be meant with 'theory' in social science. As indicated in the earlier section, the innovation system perspective is built upon a series of coherent assumptions. It is also true that most of these assumptions are rooted in systematic empirical work and that they can be tested as well as rejected by further empirical work.[10]

Perhaps the most correct is to say that the national system of innovation is a focusing device. But it might also be argued that it is the equivalent of theory. It helps to see, understand and control phenomena that could not be seen, understood or controlled without using this (or a similar) concept. In this sense it does what theory is expected to do: it helps to organize and focus the analysis, it helps to foresee what is going to happen, it helps to explain what has happened and it helps to give basis for rational action.[11]

It may be argued that, since it takes on different meanings in different contexts (cf. the US-scholars versus scholars from small countries) the NIS-concept is not satisfactory as a theoretical concept. In physics and mathematics (more so than in biology) it is crucial f to agree on strict definitions and operate with a model with as general applicability as possible.

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[10] *Following Popper and using the criteria of falsification on what is acceptable scientific theory the innovation system approach might actually be characterized as being 'more scientific' than standard economics. The basic assumption about rational behavior is difficult to reject through empirical work – there seems always to be possible to find a backdoor way to explain why people actually prefer to do what appears, at first sight, to be irrational seen from the point of view of theory.*

[11] *The fact that the focus is upon* innovation *has important implications for what kind of analysis that can and should be developed. Innovation implies qualitative change. If we stick to the idea that only quantitative as opposed to qualitative concepts can be accepted as scientific we have actually ruled out innovation as analytical object. Georgescu Roegen, who makes the distinction between 'arithmomorphic' and 'dialectic' concepts, points out that this would correspond to a dictum that forced biology to focus on husbandry and exclude it from taking on the analysis of biological evolution.*

Some scholars in social science, especially economists, believe that the objective is to transform social science into something that equates physics in these respects and thereby move away from what they see as loose description toward scientific analysis.[12]

3.1 Theory and history

A more realistic and fertile approach for social sciences, proposed here, might be to combine an aim at creating more general, more valid and more reliable knowledge about causalities with the insight that social science, by definition, always will remain historical – as we shall see this is a point on which Schumpeter certainly would agree. In such an endeavor heuristic concepts and focusing devices such as national systems of innovation may play a major role since they offer a broad and flexible framework for organizing and interpreting case studies and comparative analyses.

The OECD-paper by Freeman from the beginning of the eighties (1982, p. 15) actually raises this issue with a reference to Schumpeter. Freeman points out the limitations of quantitative analysis based on abstract models and calls for a method that he characterizes as 'reasoned history'. And he goes on to quote Schumpeter:

> *It is absurd to think that we can derive the contour lines of our phenomena from our statistical material only. All we could ever prove from it is that no regular contour lines exist……We cannot stress this point sufficiently. General history (social, political and cultural), economic history and industrial history are not only indispensable, but really the most important contributors to the understanding of our problem. All other materials and methods, statistical and theoretical, are only subservient to them and worthless without them.*

Actually, one of the reasons why policy makers have found the NIS-concept useful is that it combines a specific theoretical perspective on the economy with certain flexibility in terms of what parts of the economy should be included and emphasized in the analysis. From a policy maker's point of view it is important that the innovation system concept can be used to understand and explain economic growth and economic development.

As already indicated, the components of the economy related to innovations that have the dominant impact upon economic growth and developments differ over time and in space. To develop 'a general theory' of innovation systems that abstracts from time and space would therefore undermine the utility of the concept both as an analytical tool and as a policy tool.[13]

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[12] *It is interesting to note that Adam Smith was well aware of the fact that the national context could and to a certain should affect the economic theory developed in a specific country (see Smith 1776, p.)*

[13] *If we follow the argument of the Norwegian sociologist Lars Mjøset (Mjøset 2001; Mjøset 2002), we can go even further and point to the type of historical and comparative case based approach that typically is inspired by the innovation system concept as* exemplary *for what social science can and should do to promote theory building. Defining theory as 'accumulated knowledge, organized by the human mind, to be used for purposes of explanation', Mjøset characterizes attempts to establish 'general theory' in economics as well as sociological 'grand theories' that neglect historical context as falling outside this definition – there can be no accumulation of knowledge taking place since the explanatory scheme has been frozen once and for all.*

3.2 Theoretical elements entering into the innovation system concept

The National Innovation System approach is grounded in generalizations from empirical findings through the 1970s and 1980s many of which emanated from scholars connected to SPRU. Of special importance were the Sappho-study and the Pavitt taxonomy (Rothwell 1977; Pavitt 1984). The Sappho-study demonstrated that interaction and feed backs are crucial for the innovation performance of the firm while the Pavitt taxonomy helped us to see how different sectors interact and fulfill different functions in the over all innovation process.

But the concept also reflects some deductive reasoning confronting some of the central assumptions in standard economics and leading to conclusions explaining the stylized facts observed in empirical studies. For instance, on reflection, it is obvious that product innovation could not thrive in an economy with 'pure markets' characterized by arm's length and anonymous relationships between the innovating producer and the potential user (Lundvall 1985).

The only solution to the paradox that product innovations are quite frequent in the market economy is that most markets are not 'pure'; they are 'organized' and include a mixture of trust, loyalty and power relationships. To establish these durable relationships it is necessary for the parties involved to invest in codes and channels of information – and 'social capital'. When it is realized that actual markets are mixed with organizational elements, it opens up the possibility that the elements of organization will differ between national and regional systems. This may be seen as constituting a micro-foundation for the innovation systems concept and it was presented as such by Nelson in Dosi (1988) and in Nelson (1993).

This analysis of user-producer interaction was one of several analytical efforts to understand innovation as an interactive process. The presentation of "the chain-linked model", by Kline and Rosenberg (1986), was important because it spelled out in some detail an alternative to a linear model, where new technology is assumed to develop directly on the basis of scientific efforts, and, thereafter, to be materialized in new marketed products. The chain-linked model constituted another important step toward the idea of a National Innovation System.

3.3 Knowledge and learning

The concepts of knowledge and learning are of course important in all the different contributions to the analysis of innovation systems. In Lundvall (1992, p. 1) it was proposed that 'the most fundamental resource in the modern economy is knowledge and, accordingly, the most important process is learning.' But the concepts of knowledge and learning were not at all well developed at the time. Over the last decade the attempts to get a better understanding of the knowledge based economy and the learning economy have created a more satisfactory theoretical foundation for the understanding of innovation systems (see for instance Lundvall and Johnson 1994; OECD 2002; Foray 2004; Amin and Cohendet 2004)

The understanding has been further developed using the basic distinctions between information and knowledge, between 'knowing about the world' and 'knowing how to change the world' and between knowledge that is explicit and codified versus knowledge that remains implicit and tacit.

In Lundvall and Johnson (1994) we introduced a distinction between Know What, Know Why, Know How and Know Who that has proved to be useful in understanding knowledge creation and learning in innovation systems.

These distinctions are especially helpful when it comes to contrast the theoretical micro foundations of innovation systems with those of standard economics.

If neo-classical models include learning it is understood either as getting access to more or more precise information about the world (know what) or it is a black-box phenomenon as in growth models assuming 'learning by doing'. The very fundamental fact that agents – individuals as well as firms - are more or less competent (in terms of know-how and know-why) and are more or less integrated in knowledge-based networks (know-who) is abstracted from in order to keep the analysis simple and based upon 'representative firms' and agents. This abstraction is most problematic in an economy where the distribution of competence becomes more and more uneven and the capability to learn tends to become the most important factor behind the economic success of people, organizations and regions (Lundvall and Johnson 1994).

This focus on learning is combined with the understanding of decision-making as 'muddling through' based upon use of rules of thumb and routines. This follows directly from the focus upon innovation. Innovation is by definition a process characterized by fundamental uncertainty since the outcome cannot be fully specified in advance (if it could it would not be a true innovation). Here is perhaps the most important point where the innovation system's analysis departs from new growth theory. New growth theory may allow for learning by doing as well as investment in searching activities but in order to remain member of the powerful neo-classical family it has not allowed itself to scrap the basic assumptions about the rational profit maximizing firms.

3.4 The theory behind innovation systems

As pointed out, List was critical to the exaggerated focus on allocation as opposed to knowledge creation and growth. Table 1 illustrates how the analytical framework connected to innovation systems relates to mainstream economic theory and to Austrian economics. The theoretical core of standard economic theory is about rational agents making choices between well defined (but possibly risky) alternatives and the focus of the analysis is on the allocation of scarce resources. The innovation system approach represents a double shift in focus as illustrated by the following table.

Table 1 Four different perspectives in economic analysis

	Allocation	**Innovation**
Choice making	Standard neoclassical	Management of innovation
Learning	Austrian economics	Innovation systems

The table also indicates that learning as well as innovation, in principle, can be analyzed in analytical frameworks closer to that of mainstream neoclassical economics. It is possible (but not logically satisfactory) to apply the principles of rational choice to the analysis of innovation. You might, for instance, assume optimizing 'management of innovation' aiming at getting funds allocated to alternative R&D-projects according to the private rate of return, taking into account the risk that the projects do not succeed.

Austrian economists (Hayek and Kirzner) have in common with neoclassical economics their focus on markets and resource allocation. But Hayek presents the market as a dynamic learning process where the allocation of scarce commodities is brought closer to the ideal of general equilibrium without ever reaching this state.

The analysis of innovation systems is based upon a two-dimensional shift of focus toward the combination of innovation and learning. Innovation is seen as the outcome of efforts made or as side effects of ongoing activities. Crucial for understanding how on-going activities may result in innovation is the understanding of learning processes. On the other hand, innovation may be seen as a process of joint production where one output is innovation and the other is a change in the competence of the involved agents. This double shift in perspective has implications for the relevance of innovation policy. Just to take one example, the analysis of patent races where 'winner takes it all' will, as far as it neglects the learning and competence building taking place in the process, end up with too restrictive conclusions regarding the role of government in stimulating R&D.

Box 4 Different meanings of learning

As any everyday concept learning has many different connotations. In the literature on learning organizations it is often referred to as adaptation: a process where agents when confronted with new circumstances register and internalize the change and adapt their behavior accordingly.
In education we may see learning also as a process of competence-building. We assume that new competences can be established through education and training and thereafter mobilized when coping with and mastering theoretical and practical problems.
In our analysis of innovation systems we see learning as referring both to adaptation and competence building. In our empirical research we find that at the level of the firm there is substantial overlap between organizational characteristics that support adaptive capacities and those that support innovation and competence-building (Nielsen and Lundvall 1999, Lundvall 2002).

3.5 The NSI-perspective is more complex – not less theoretical than standard economics

What has been said obviously implies a more complex theory than standard neoclassical economics. In these models it is assumed that all agents have equal access to technologies and are equally competent in developing and utilizing them. But the theory behind innovation systems is not 'less theoretical'. Basically the theory underlying innovation system analysis is about learning processes involving skilful but imperfectly rational agents and organizations. It assumes that organizations and agents have a capability to enhance their competence through searching and learning and that they do so in an interaction with other agents and that this is reflected in innovation processes and outcomes in the form of innovations and new competences.

Neither is the most important weakness of neo-classical theory that it is too abstract. It is rather that it makes the wrong abstractions. In a context where knowledge is the most important resource and learning the most important process neo-classical theory tends to abstract from the very processes that make a difference in terms of economic performance.

Processes of competence-building an innovation are at the focal point in innovation system analysis. The focus is upon how enduring relationships and patterns of dependence and interaction are established, evolve and dissolve as time goes by. New competences are built while old ones are destroyed. At each point of time discernable patterns of collabora-

tion and communication characterize the innovation system. But, of course, in the long term these patterns change in a process of creative destruction of knowledge and relationships.[14]

3.6 Standard economics favors narrow interpretation of innovation systems

One of the reasons for the narrow interpretation of the innovation system reflects that it is much easier to develop quantitative analysis of R&D and patents than it is to measure organizational forms and outcomes of organizational learning. Standard economics tends to stick to the idea that only quantitative as opposed to qualitative concepts can be accepted as scientific.

Standard economics will typically focus on potential market failure and on the choices to be made between different alternative uses of scarce resources. In the context of innovation policy the concern will be, first, if public rates of return are higher that private rates and, second, if the rate of return of public money is higher in investing in R&D than it would be in other areas of public investment.[15]

The very idea that there might be organizational forms that are more efficient than the ones already in use cannot be reconciled with the basic analytical framework where it is assumed that agents are equally rational and competent.

Standard economics will tend to see the market as the 'natural', if not optimal, framework of human interaction and economic transaction. This leads to biased conclusions when considering how to organize the economy. The concept 'market failure' reflects this bias since it indicates that other forms should be considered only when it is obvious that the market cannot do the job. As we shall argue below (luckily) markets still regulate only a small amount of transactions related to knowledge (Nelson 2006).

[14] *In this situation the new fad of economics has become to see the economy as scene where agents play games. Game theory makes use of rather complex mathematics to explain how agents that are seeking to realize their own interests in their interaction with others. Some of these models make assumptions that are extreme regarding the information that the agents have access to. Either they know everything or they know nothing at all. Learning is in these models synonymous with getting more information. This contrasts with a reality where most 'games' are between agents uneven in competence but striving to become more competent. I see the fact that game theory has become the most prestigious branch of economics as further evidence of how economics retreat from analyzing problems of the real existing economy.*

[15] *Within this narrow logic the neglect of learning effects from engaging in innovation will underestimate both the private and public rates of return.*

4 Theoretical challenges for the innovation system approach

4.1 Understanding knowledge and learning

The most important challenge for innovation system analysis is to get a deeper understanding of how different kinds of knowledge are created and used in the process of innovation. Some kinds of knowledge are local, tacit embodied in people and embedded in organizations while other kinds are global, explicit and can easily be transferred from one part of the world to another. Different sectors in the economy and in society make use of different mixes of local and global knowledge and in some areas such as education and business consulting it is especially difficult to codify knowledge. To understand how learning takes place within organizations as well as in the interaction between organizations is a key to understand how a system of innovation works.[16]

4.1.1 The fundamental co-evolution of the division of labor, interaction and cooperation

Perhaps the most fundamental process in economic development and economic growth is the deepening and extension of the division of labor. Specialization within and between organizations makes it possible to exploit scale economies and it also makes it possible to focus competence building so that it can advance more rapidly.

But as the horizontal and vertical division of labor evolves it has the downside of creating barriers for communication and interaction. This is highly relevant for innovation because innovation often is the outcome of combining knowledge located at different places in a specialized innovation system. It is well documented that different departments (R&D, production, sales etc.) within a firm have difficulties to understand and communicate with each other. At the individual level, experts have difficulties to interact and understand each other. The ease to communicate in a system with vertical disintegration between organizations is especially interesting because it is here product innovations are developed in an interaction between users and producers.

It is a major challenge to understand the co-evolution of the division of labor and the interaction that takes place within and between organizations. In some countries it is much easier to establish co-operation within and/or between organizations than it is in other countries. This will be reflected in the actual division of labor and this will affect the kind of learning and innovation that takes place in the system.

4.1.2 Indicators

There is a strong bias in measurement in favor of knowledge that is explicit. Investment in scientific knowledge is measured by surveys on R&D and innovation. The know-how built up through learning by doing, using and interacting is much more difficult to measure. Human capital measurements may register formal investment in education but what people learn at their job is not visible through standard measurement. The absence of indicators makes the area less visible for policy makers and this contributes to a bias in innovation policy toward promoting STI- rather than DUI-activities (see Box 6 below).

[16] *For an interesting attempt to analyze the character of the knowledge that lies behind different applied fields such as health and education see OECD (2000).*

In recent empirical work by Lorenz and Valeyre it has been shown that there are dramatic differences between national systems in terms of how and how much the average employee learns at her workplace. While a majority of workers are engaged in 'discretionary learning' in Denmark and Netherlands the majority of workers in countries such as Greece and Spain are engaged in taylorist type of work or simple working context with much more limited opportunities for learning (See Box 5 below).

Box 5 National patterns in Work Organization

Table 2 below originates from paper by Lorenz Valeyre forthcoming in Lorenz and Lundvall (2006). The four organizational models were constructed on the basis of factor analysis of responses to surveys in 15 European countries. The factor analysis brought together variables referring to learning opportunities as well as worker's degree of freedom regarding structuring the daily work.

Table 2: National Differences in Organizational Models (percent of employees by organizational class)

	Discretionary learning	Lean production learning	Taylorist organization	Simple organization
		North		
Netherlands	64,0	17,2	5,3	13,5
Denmark	60,0	21,9	6,8	11,3
Sweden	52,6	18,5	7,1	21,7
Finland	47,8	27,6	12,5	12,1
Austria	47,5	21,5	13,1	18,0
		Center		
Germany	44,3	19,6	14,3	21,9
Luxemb.	42,8	25,4	11,9	20,0
Belgium	38,9	25,1	13,9	22,1
France	38,0	33,3	11,1	17,7
		West		
United Kingdom	34,8	40,6	10,9	13,7
Ireland	24,0	37,8	20,7	17,6
		South		
Italy	30,0	23,6	20,9	25,4
Portugal	26,1	28,1	23,0	22,8
Spain	20,1	38,8	18,5	22,5
Greece	18,7	25,6	28,0	27,7
EU-15	39,1	28,2	13,6	19,1

Source : Loenz and Valeyre (2006)

Table 2 shows that people working in different national systems of innovation and competence building have very different access to learning by doing. It also shows that at lower income levels the bigger proportion of the workforce that work in either simple or Taylorist organizations. The richer the country the more workers are employed in discretionary learning contexts. But it is also important to note that countries at similar income levels – Germany and the UK – have quite different distributions of workers between the four forms. While the proportion of workers operating in the lean production is more than 40% in the UK, it is less than 20% Germany. The micro foundation of national systems of innovation differs not only because of levels of income but also because of other systemic features. 1

The national differences in what people do and learn at their workplace are a major factor structuring the national innovation system and affecting its performance: Certainly more fundamental and difficult to change than the R&D-intensity. In countries such as Sweden and Finland these favored measures of 'performance' to a high degree reflects the propensity to do research in a handful of big corporations such as Ericsson and Nokia. This contrasts with indicators of the competence building that takes place in working life since these refer to all parts of the economy.

The same is true for indicators of interactive learning. Organizations in different sectors use different media in their communication. Combining case studies with network theory may help to map the interaction that takes place (see Christensen and Lundvall 2005). The problem is again that it is so much more difficult to capture social interaction than it is to capture formal collaboration in R&D. It is also important to understand the quality of the interaction that will depend on the specific background of the individuals that interact, their organizational surrounding and the wider social setting. Defining social capital as a multidimensional phenomenon and developing indicators that help to capture the different dimensions is another fundamental step towards understanding national innovation systems (Woolcock 1998).

4.2 The weak correlation between strength of the science-base and innovative capability

There has been a lot of focus on the paradox that Europe is strong in science but not in innovation and economic growth. Similar paradoxes appear in countries such as Netherlands, Finland and Sweden – Netherlands has also had its own domestic paradox debate. In a recent OECD-report a general result is that for the countries included in the study it can be shown that that those that 'perform well' in terms of STI-indicators do not perform well in terms of innovation (OECD 2005, p. 29).[17] This indicates that what is registered is not a paradox but rather a systematic weakness in the theoretical analysis and the indicators built upon it.

The reason that these paradoxes appear is our limited understanding of what kind of knowledge that contributes to innovation and growth. It also indicates that heavy investment in science and technology in systems where organizational learning within and between firms is weakly developed has a limited positive impact upon innovation.

In a series of recent papers based upon unique combination of Danish data we have try to demonstrate that firms that engage in R&D without establishing organizational forms that promote learning are much less innovative than firms that are strong both in terms to STI- and DUI-learning (see Box 6).

4.2.1 Innovation and Economic growth

Finally it is important to get a better understanding of how innovation affects economic growth. It is obvious that some major technological breakthroughs have had a great impact on global economic growth.

[17] *After comparing the performance of six countries it is stated that 'A striking feature is the apparent missing link between indicators in A-E and the over all performance indicators in F.* This suggests that priorities and biases in the STI-policy system are weakly linked to general economic performance and policies*.' (OECD 2005, p.29, italics by the author).*

But at the national level, especially in a small country, these kinds of innovation are rare and since they often build upon codified knowledge easy to copy their impact is not localized. Often the necessary investments to bring them to market success are so big that only the biggest transnational firms – typically located in big countries – can make profits from them.

There is a need to clarify how innovation contributes to economic growth in a small economy. How much of economic growth can be explained by the occurrence of new product and processes? Is the key to growth having domestic firms that bring innovations first to the market or is it to have adopters and imitators that move more quickly than those in other countries?

There are different ways to tackle this problem but perhaps the most promising is to establish a kind of micro- to macro- to micro models. This refers to models that start from what takes place inside firms, moves on to study structural change as an evolutionary process and moves on to the aggregate level. What take place within and between firms needs to be analyzed in the light of macro-dynamics that is registered as transformation pressure for the single firm. Lundvall (2001) applies such a perspective on the Danish economy combining detailed register data on firms and employees with survey data. One alternative approach would be to establish a kind of mini-economy with a panel of firms that can be followed over time (there is a long tradition for this kind of modeling at IUI in Sweden).

Current alternatives that use R&D- expenditure, patents and education data as arguments in aggregate functions cannot give us a proper understanding of how innovation impacts upon economic growth.

Box 6 The probability that firms develop a new product or a new service is much bigger if it combines R&D-efforts with using management techniques that support functional flexibility and learning

Table 3: Logistic regression of learning clusters, size, industry, ownership and production on P/S innovation (odd ratios, 95% confidence interval, estimates and P-values)

Variables	Odds Ratio Estimate	Coefficient estimate	Chi-sq	P-value
STI Cluster	2.917	1.0705	12.0273	0.0005
DUI Cluster	1.816	0.5969	6.8832	0.0087
DUI/STI Cluster	4.902	1.5896	39.0346	<.0001
Business services	1.559	0.4438	1.6959	0.1928
Construction	0.491	-0.7116	4.7454	0.0294
Manufacturing (high tech)	1.751	0.5600	3.6994	0.0544
Manufacturing (low tech)	1.259	0.2303	0.7969	0.3720
Other services	0.647	-0.4352	1.1074	0.2927
100 and more employees	1.792	0.5831	6.1889	0.0129
50-99 employees	0.943	-0.0588	0.0708	0.7902

Table 3 demonstrates that firms that combine R&D efforts with modern and flexible forms of organization are five times as innovative as those that do neither (Jensen, Johnson, Lorenz and Lundvall 2004).

5 How to study national systems of innovation

5.1 Does the innovation system have a function?

In some discussions about how to define the innovation systems it at has been argued that innovation systems always can/should be defined by its function(s). Edquist (2005, p. 187) refers with approval to the definition of system given by Ingelstam (2002, p. 19) 'the system has a function, i.e. it is performing or achieving something'. Edquist specifies that 'the main function in SIs is to pursue innovation processes, i.e. to develop, diffuse and use innovations.'

It is not obvious that all, including biological and ecological, systems have a function besides possibly securing survival. In general it might be better to avoid a functionalist approach also to social systems. The experience from standard economics where efficient allocation of scarce resources has been assigned as the major function of the economic system does not constitute an ideal to follow. The 'function' of the innovation system can only be assigned to it with explicit reference to the value system of the assigner – be it an individual researcher or a political body. As can be seen from the first part of this chapter the original intention for those who developed the concept was to understand how innovation contributes to economic performance not just to understand innovation as such. Therefore, if we were to assign a function to the innovation system, it would be the function to 'contribute to economic welfare through innovation'. And then we would have to try to explain what we meant with 'economic welfare' of course!

5.2 Defining the innovation system

It follows that our interest in utilizing the innovation system perspective is not purely academic. We use this concept as a focusing device in order to better understand how innovation affects economic development at the national level. This is why we take a broad view of the innovation system. We are interested both in incremental innovation and radical innovation and we are equally interested in the development, diffusion and use of new technology in the economy as a whole, including sectors characterized by low and medium as well as those with high intensity of R&D-effort. In a small economy such as Sweden the impact on economic development from domestically developed radical innovation remains limited. The major effects on economic performance come from incremental innovation and from absorbing and efficiently using new technologies developed abroad.

Within this broad view we see innovation and its diffusion and use as emanating, not only from scientific research and systematic development work, but also from learning processes taking place in daily economic activities. Actually firms that have a strong science base but lack the capability to organize learning processes within or across organizational borders do not contribute much to economic development. But we also recognize that the innovative capacity of firms that are particularly strong in terms of organizational learning but weak in terms of capability to absorb and use elements from science would benefit substantially from linking up with sources of scientific knowledge (see Box 6).

Within this broad view many factors contribute to innovation and it might be seen as a problem that almost all aspects of society need to be brought in to explain the actual pattern of innovation. To structure the analysis it is useful to take a closer look at the innovation process. On the basis of our understanding of the innovation process we distinguish between the core of the innovation system and the wider setting within which agents belonging to this core operate. And we will conclude that both need to be included in the analysis if the aim is to link innovation to economic development.

5.2.1 The innovation process

The innovation process – the creation of new combinations of knowledge into processes and products aiming at the market - typically takes place within firms. Local knowledge is combined with global knowledge and the resulting combinations are transformed into new products and processes. Firms interact with each other and with organizations belonging to the knowledge infrastructure in this process. Empirical studies show that networking and interactive learning across organizational borders are important prerequisites for successful innovation (Christensen and Lundvall 2005).

This is specifically the case in the context of product innovation where a combination of insights in user needs and technological opportunities is crucial for success. As the vertical division of labor is further developed – in many sectors the degree of vertical disintegration may be seen as an important indicator of economic development – the 'quality' – a multidimensional concept – of such interactions becomes increasingly important for the over all performance and development of the economy (Lundvall 2006).

Inside firms, innovations may be outcomes of accidents but more often they will result from systematic efforts. Teams and project groups interacting across different parts of the firm develop further ideas that may, originally, have emanated from customers, employees or competitors. In big firms R&D-departments may play an important role but in smaller firms small task forces may interact with production engineers and marketing expertise in developing a new product. Sometimes a main collaborator for the task force is an external supplier or customer.

Both in external and internal networking the core activity are human interaction in the form of co-operation, communication and learning. Developing common norms, rules and language within a group and across groups is a costly and time-consuming process. It may be seen as an investment process and it results in 'sunk costs' (Arrow 1974).The interaction is shaped by the roles individuals play in relation to each other and this will reflect both their educational background and the wider cultural and social setting within which they operate. Engineers may be trained to become narrow specialists with little experience of communication with non-engineers or they may early on become used to interact with other kinds of expertise. Managers may be trained to keep a social distance to ordinary workers or they may be used to talk directly with them. Organizational culture may be more or less open to networking and knowledge sharing etc.

These micro-sociological structures have a major impact on the mode of innovation as well as on what kind of innovations the system will give rise to. They will also affect the rate of diffusion and the degree of efficiency in the use of new technologies. This is why similar economic mechanisms and incentives may affect different innovation systems differently and why a 'pure' economics perspective on innovation is too narrow. A major task for innovation system analysis is to make these micro-relationships visible (to open the black box of social interaction) and to see how they shape and are shaped by the macro-processes in the innovation system. This perspective also leads us to make the distinction between the core of the innovation system and the wider setting.

5.2.2 The core and the wider setting of the innovation system

On this basis we can define the core of the innovation system as constituted by firms and organizations belonging to the knowledge infrastructure. In principle we include all firms in the core since we assume that every firm has a potential for developing, absorbing or using new technology.[18] We also include them because they more or less are 'sites of learning' where employees may renew their competences while working. We include all organizations belonging to the knowledge infrastructure in the core as well. Again these include both those involved in science-related activities and those that contribute to competence building through education and training.

The wider setting refers to the institutions that shape human interaction in relation to innovation. These institutions include, first, family pattern, education system, career patterns in labor markets, inequality and social welfare systems. Second, they include in the economic context especially the historical record of macroeconomic stability and the access to finance. Third, they include the final demand from households and public sector organizations. Fourth, they include government and public policy directly aiming at stimulating innovation, including diffusion and efficient use.[19]

5.2.3 A method to study national innovation systems

In what follows I will sketch the outlines a method to study national systems of innovation that moves from micro to macro – and back again to micro. The 'model' starts from the following stylized facts:

- Firms play the most important role in the innovation system.
- Firms innovate in an interaction with other firms and with knowledge infrastructure.
- Firms' mode of innovation and learning reflect national education systems, labor markets, etc.
- Firms belonging to different sectors contribute differently to innovation processes.

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[18] Today with the wide diffusion of information and communication technologies this is not a far-fetched assumption. For instance the wide diffusion of mobile phones in China has certainly changed the mode of operation of drivers of the most primitive transport equipment – including rickshaw bicycles in Beijing.

[19] This way of setting the scene indicates a marginal role for public policy. What is intended is rather to see the public policy mainly as intervening in relation to the core and the wider setting of the national innovation system – we will in later sections develop a theory for public intervention. Alternatively we could see public policy as endogenous. To some degree we take this perspective in Edquist and Lundvall (1993) where we demonstrate how innovation policy in Sweden and Denmark tends to reproduce rather than renew the strengths of the respective system.

Therefore the first step would be to analyze what takes place inside firms in terms of innovation in the light of organizational set up and human resources while taking into account sector specialization.

A second step would be to analyze the interaction among firms and with knowledge infrastructure, including both domestic and international linkages.

A third step would be to explain national specificities in these respects with reference to national education, labor markets, financial markets, welfare regimes and intellectual property regimes.

A fourth step would be to use firm organization and network positioning as factors that explain the specialization and performance of the innovation system.

This method focuses the analysis on the central motor in the innovation system, i.e. the total population of firms, their linkages to each other and to the knowledge infrastructure. But it also recognizes that most parts of the socio-economic system may influence how this motor works and not least how it affects the performance of the economy as a whole.[20]

This was the method used to organize the Disko-project analyzing the Danish innovation system in a comparative perspective (Lundvall 2001). In the next couple of sections we will discuss the design of innovation policy in the light of what we learnt from this project. We will also draw upon experiences from OECD.

[20] *A similar distinction between core and wider setting might be witnessed in medicine. Experts specialize and focus on the cardiovascular system and develop methods to measure and analyze what takes place in this sub-system (EKG, measuring blood pressure and pulse rate). This does not rule out that the expert recognizes that blood pressure and heart rhythm will reflect as 'wider setting' the life style of the patient – including drinking, smoking and jogging. Neglecting this 'wider setting' when making the diagnosis and recommending a cure might make the analysis 'more rigorous' but it would certainly have quite negative effects for the patient.*

6 On the use and abuse of the NSI-concept

6.1 Introduction

The wide diffusion of the NSI-concept in policy circles is a mixed blessing. The concept has been both used and abused. Sometimes policy makers pay lip-service to the concept while neglecting it in their practice. In this section we criticize the exaggerated attempts to commodify all kinds of knowledge and the narrow and lop-sided understanding of the innovation process.

6.2 The commodification of knowledge

As explained, the modern version of the innovation system concept was developed in the middle of the eighties. It is important to note that the early versions were critical both to mainstream economics and to the prevailing economic policy where weak competitiveness was seen as primarily reflecting high costs and especially high wage costs. Combined with the critical perspective was an attempt to understand how and why national systems differ in their mode of innovation. Actually, it is fair to say that the originators of the concept did not expect it to become widely used as a framework for policy-making.

The wide diffusion of the concept among policy makers took place in the nineties. It started in Finland 1990. Two years later came the TEP-report from OECD that actually integrated many of the new ideas including a strong emphasis on innovation as an interactive process and mentioning the NSI-concept (OECD 1992). Another early adopter of the NSI-concept was Canada. At the beginning of the new millennium most OECD-countries had adopted the concept to support the design of innovation policy. In order to understand the interpretation of the concept in policy circles it is important to take into account the ideological and political climate that reigned during this diffusion process.

Basically the nineties was a period with strong emphasis on market regulation and on private property rights as ideal institutions – the break-down of the centrally planned economies in Europe gave new impetus to neo-liberal strategies developed in the eighties. But there were also some nuances in this respect as illustrated by the first Clinton administration where economists with an understanding of innovation such as Laura Tyson, Robert Reich and Joseph Stiglitz were among the top advisors. Another consequence of the end of the cold war was that economic competitiveness came higher on the policy agenda first in the US and gradually also in Europe.

The OECD, thus, took on the concept as framework for policy discussions in the beginning of the nineties but after the TEP-report that was quite true to the basic ideas behind the concept and written by Francois Chesnais, a certain degeneration took place bringing the concept closer to an old concept of OECD – the national science system. Analytical aspects of the concept that might lead to conclusions that went against the logic of markets and free trade were suppressed. Increasingly NSI-analysis was presented together with outcomes of neo-classical growth studies and the critical perspective in relation to standard theory was neglected.

This climate resulted in a problematic interpretation of the innovation system concept. The innovation system approach emphasized that knowledge and learning are crucial for economic performance in the current era (Lundvall 1992). But it does not follow that all knowledge should be 'commodified' and this is what seems to have become the major tendency. There is a growing trend in political circles to regard all knowledge as a potential commodity and to subordinate all knowledge production under the logic of international competitiveness. This is reflected in a movement in favor of expanding and strengthening intellectual property rights to the extreme and far beyond what promotes socio-economic progress and as well in a strong drive toward colonizing academic knowledge and make it subordinate to market demand.

In normally civilized countries such as Denmark research in humanities now increasingly gets evaluated and promoted not according to its contribution to cultural development but according to its contribution to establishing 'creative industries' with positive impact on the balance of payment. Professors in the technical faculty are increasingly getting support for their research according to the number of patents they can produce rather than according to their contribution to generic knowledge. While triple helix (Etzscowitz) and the new mode of knowledge production (Gibbons et al) takes a normative stance in arguing for integrating universities and other knowledge institutions more deeply into the economic process there was no such normative message in the original NSI-perspective.

To make universities more open to society is a necessary process and expectations that the knowledge produced at universities should contribute to economic welfare are legitimate. In section 8 we will come with some ideas on how this can be achieved without undermining some basic positive functions of universities. But the current drive toward the market is driven by the lop-sided understanding of innovation as emanating almost solely from science and therefore it goes to far.

6.2.1 The market offensive – the case of universities

The standard economics argument for public policy intervention is market failure (risk, externalities, indivisibilities and public goods). This analytical framework is not very useful in the context of innovation and knowledge because it presupposes that agents can compare costs and benefits connected to different outcomes.[21] Since innovation is a process with outcomes that cannot be defined in advance we operate in a context of fundamental uncertainty and there is no way for agents (nor for economists and policy makers) to make 'rational' choices.[22]

[21] *The reasoning behind the different forms of market failure is still valuable however but the value is more at the level of common sense than at the level of general equilibrium analysis. It is correct that one reason why firms will not find it profitable to invest in basic research is because they cannot make money by doing so – this is the rational core of public good and the externality argument. It is also correct that some projects are so expensive and results so difficult to estimate that no private firm would engage in them – this is the rational core of the uncertainty argument. But utilizing these concepts to make precise cost benefit analysis when choosing between alternative policy actions is not meaningful.*

[22] *We might even introduce a stronger concept 'radical' fundamental uncertainty since the only thing we know for certain is that the unknown will happen (innovations will take place) and that it will happen again and again.*

The most negative aspect of the market failure perspective is perhaps the underlying assumption that the normal form of economic interaction is market exchange and that private economic incentives are the only ones that can be trusted and its impact on current policy thinking. This contributes to the recent drive to make universities more market oriented everywhere, also in situations where their performance before reforms is highly satisfactory.[23]

The long-term implications and costs of making scholars and universities profit oriented seem to be completely neglected among the protagonists of university reforms in the Bayh-Dole spirit.[24] Scholars who are stimulated to act strategically on their own behalf and on the behalf of their institution will certainly become less engaged in sharing their knowledge with others. Private companies might, in the short run, appreciate that universities become more profit-oriented – not as ivory tower-like as before - but they will soon experience that the barriers around the knowledge accumulated will become higher and that access to the most relevant knowledge will become more difficult.

It is even more intriguing to reflect on what awaits at the end of the current trajectory; at the point in time where the entrepreneurial university has become truly a business corporation operating in international markets. At that point we must expect that WTO restrain the current freedom of national governments to subsidize basic research taking place within universities by competition laws and trade regulations. How could it be argued that private firms (universities) that compete on global markets should be subsidized by national government? To establish controls that make it certain that government support only goes to basic research without affecting services sold internationally would open up for complex legal processes. If governments wanted to go on subsidizing basic research they might need to establish a new set of institutions.[25]

Finally, there is a need to think about the implications for the role of universities of the fact that knowledge becomes more and more fundamental for the economy as for society as a whole. The historical role of universities has been an institution that 'validates' knowledge. It has been an institution that, while aiming at the full truth of matters, at least systematically tries to establish what 'reasonably reliable knowledge' is. This is also one reason why it has been an institution with a relative autonomy in relation to the state as well as in relation to economic interests. This function is even more important in a knowledge-based society.

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[23] The very idea that the market is the normal form of economic interaction is of course false. In real life we only use the market mechanism on the margin. Family life and civil society would not benefit from the introduction of more market-like transactions. Societies where political power and poor people's kidneys can be bought are not something to aim at. There is, for good reasons, still a big public sector and in the private sector most economic transactions take place within organizations. Markets for new products are organized markets where users and producers develop long-term relationships. The pure perfect competition market – where many firms produce a homogenous product for many anonymous consumers – can soon be found only in economics textbooks.

[24] The Bayh Dole act implemented in the US in the eighties gives stronger opportunities and incentives to universities to engage in patenting and protecting their knowledge. As documented by Mowery (2004) and many others the interpretation of the 'success' of this reform in Europe has been exaggerated.

[25] This scenario gains in realism by the fact that some major US-universities would dominate 'the level playing field' and by fact that the US government would still be able to pursue basic research under headings such as health, military defense and space technology since these can be defined as being of strategic importance for its security.

In order to explain this to economists who are eager to market orient universities it is useful to point to the relative autonomy of central banks. To make sure that we can trust the value of money it has been accepted that its main guardian is given a certain degree of autonomy. We need a similar guardian for knowledge and it is difficult to find another institution/organization that is better suited to be the central bank of knowledge than the university.

As a kind of countervailing power to the colonizing tendency emanating from market-oriented innovation policy we see a need to develop a wider field of politics – knowledge politics - that covers all aspects of knowledge production and takes into account that the production of knowledge has much wider scope than just contributing to economic growth. This includes of course knowledge necessary for social and ecological sustainability but not only that. In rich societies it should be possible to afford culture, ethics and knowledge for its own sake not only knowledge that promotes innovation and economic growth. This implies that there might be a need for establishing a new kind of 'academy of science and knowledge' that has as one of its dedicated tasks to set the limits for how far innovation policy may influence knowledge production and use.

6.3 The positive impact of the NSI-perspective

The most obvious important positive impact has been that the concept has supported a general shift in what economists and policy makers see as constituting 'international competitiveness'. It has helped to move the attention toward national policy strategies that constitute positive sum games both internationally and domestically.[26]

The second and more generally recognized impact is that the 'system' dimension of the term has moved the attention in policy circles in charge of research, innovation and industrial development from linear to interactive thinking of innovation. This has extended the traditional set of policy instruments with more attention to building linkages and strengthening the absorptive capacity of users.[27]

But in most countries and international organizations the full implications of the innovation system perspective have not been drawn. In each single country the interpretation of the concept has been shaped by national specificities. The specific constellation of interests and the relative strength of the mainstream economists/ministries of finance have played a role in this formation and deformation process.[28] The barriers to utilizing the concept come from a combination of vested interests and path dependency in the policy community.

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[26] It should be remembered that when the concept was coined in the beginning of the eighties it was still a standard assumption among economists and policy makers that reducing national nominal wages or devaluation of the national currency was the most effective – and perhaps the only - way to enhance international competitiveness of domestic firms. Non-price competitiveness was seen as being of marginal importance. This shift is important since the concept was originally developed as a critical reaction and response to these simplistic ideas of competitiveness.

[27] This can be referred to as a movement from 'Science Policy' and 'Technology Policy' to 'Innovation policy' (see Lundvall and Borras 2004 for an overview).

[28] Perhaps Finland is the country within the OECD where the policy community has been 'most true and loyal to the concept'. They actually adopted the concept before it had been through the OECD-filter. It is interesting that a central policy document in 1990 makes the clear declaration that the economic strategy should focus 'not on allocating scarce existing resources but rather on the creation of new ones': a clear declaration that the focal point of standard economics is misdirected.

Most of the innovation policy efforts at the national and European level operate on the basis of the narrow definition of innovation system where the focus is on an innovation mode based in scientific progress. The strong focus on the amount of private and public investment in R&D has little to do with a systems perspective. It remains to be accepted and draw policy implications from the fact that organizational learning is a major medium to transform innovation into market value and that the capability to engage in such learning is very different among firms.[29]

There is a similar bias in terms of sector focus. The focus is on industries that traditionally have been science-based. The idea that innovation, including science-based innovation, in so-called low (or medium-low) technology sectors matters for innovation and competitiveness has not been understood well in many countries.

While there has been strong emphasis on how universities should be adapted to the (short term!) needs of the innovation system much less attention has been given to the roles of labor markets and education systems in the system. In section 8 we will present the outlines of an innovation policy that brings in these important parts of the innovation system and responds to the challenges raised by the learning economy.

Neither has the concept worked as well as it should as a corrective to standard simplistic ideas. The current emphasis in Europe on benchmarking policies and components of innovation systems that aims at generalizing 'best-practice' tends to neglect the 'system' dimension of the concept. One idea behind the 'system' aspect is that you cannot easily transplant a 'high performance element' from one system to another and expect the impact to be similar to what it was in the system of origin.

While there is a lot to learn from intelligent comparisons across national systems (learning-by-comparing) naïve benchmarking of narrowly defined areas in search of a single 'best-practice' and neglecting the systemic context leads to negative results.

Regional innovation policy studies may have become biased in both analysis and action by the innovation system concept. At this level the broader definition of innovation system concept has had an impact. It has joined forces with other ideas such as industrial districts, industrial clusters and learning regions in setting a policy agenda for regional development. Again, the positive side has been a move away from games where regions compete on offering low costs and tax rates toward positive sum games where they compete through investing in knowledge and infrastructure. But I see the direct application of the core element of the innovation system – interactive learning – to the regional level as problematic.

[29] *This is problematic in two ways. First it underestimates those other processes of knowledge creation which are more based upon learning. Second it sets too strong expectations on what organizations in charge of scientific research can deliver in terms of innovation. At the European level this lop-sided interpretation of the innovation system perspective may have contributed to the fact that the Framework programs have been motivated primarily by their immediate impact on innovation and competitiveness to the neglect of basic research.*

Much of the relevant interaction takes place at the national/international rather than at the regional level and other 'systemic' mechanisms may be more important when it comes to explain the formation and evolution of regional clusters. A local workforce with skills reflecting local and tacit knowledge, the local knowledge and service infrastructure and spin-offs from local firms seem to be as important or more important as compared to constellations of inter-firm interaction.

The wide diffusion of the concept in policy circles is thus a mixed blessing. The concept has been both used and abused. There is no way to control the use of a new idea in social science and when a concept has left the desktop its actual use is shaped by political conjuncture and discursive battles.

7 General principles for designing innovation policy

7.1 Restraining the power of the ministry of finance

Within the public sector there is a hierarchy of organizations and institutions engaged in policy making. In most countries we find the Ministry of Finance at the top together with the semi autonomous national bank. Ministries that can mobilize support from powerful segments of society – mainly private capital – can sometimes become powerful enough to challenge the dominating role of the ministry of finance. MITI in Japan is an interesting example and within the executive branch under Clinton's first presidential period a similar balance was established in the US for a period. The science technology council in Finland seems to have been able to forge an alliance with the Ministry of Industry and Trade in giving innovation policy certain autonomy in relation to the Ministry of Finance.

The relative strength of the Ministry of Finance is fundamental for what kind of policy that can be developed. Most employees in ministries of finance have no insight in innovation and their specialized competence makes it very difficult for them to understand concepts such as innovation systems. Therefore a first stage in developing innovation policy may be to restrict the power of the ministry of finance.[30]

7.2 Establish common vision while promoting diversity

A common vision shared by agents belonging to different parts of the innovation system regarding the general direction of change reduces the need for administrative co-ordination across sectors and professions. To illustrate, in Sweden a general direction of change could be to develop a public and private knowledge infrastructure stimulating the creation and growth of small and medium sized enterprises. Another general direction could be to establish links between innovative big firms and the small and medium-sized firms. A third could be to move toward flexicurity in labor markets – i.e. give more generous and durable unemployment support while making it easier to hire and fire employees.

Such a common vision should be combined with diversity in terms of knowledge infrastructure and governance of innovation policy. For the long term performance of innovation systems diversity is fundamental and that includes the co-existence of alternative ways of doing things and competing governance structures. This is difficult to understand for top level administrators who want to construct uniformity in order to be able to control and compare performance along a few simple dimensions. Even in small countries complaints about duplication is misleading. To illustrate in Denmark there are two institutions (Denmarks Technical University and Aalborg University) and they use very different pedagogical principles when educating engineers. There is little doubt that this enriches the innovation process in Danish firms as compared with a situation where one of the two models was generalized.

According to Nelson (1988) the major advantage of the US as compared with Europe is the high degree of diversity of the support system. It is not, as believed by many European policy makers, that it has a bigger and more standardized knowledge infrastructure.

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[30] *When I worked at the OECD-secretariat deputy secretary general Pierre Vinde – former general director in the Swedish ministry of finance – expressed his concern that the old type policy makers in ministries of finance with extensive sector experience had been substituted by generalists with little insight in the sectors they were responsible for.*

7.3 Not picking but creating winners!

There are many negative references to the idea of policy makers 'picking winners'. The real problem here is less a question of information than a question of path dependency. In the sixties and seventies most governments were promoting 'national champions' not because they housed the most promising activities but rather because they were already there.

An alternative perspective is to start from social, infrastructural and ecological needs where new technology can help develop new solutions and where private investment in R&D is insufficient. The reasons for the insufficiency can have to do with the classical 'market failure' arguments but it may also reflect a combination of path dependency and systemic effects. There are many examples of such systemic effects. It might not be cost-efficient to invest in developing a new type of transport vehicle without major innovation in infrastructure. Investing in developing wind, wave or solar energy sources calls for a parallel effort to develop new ways of accumulating and distributing electrical power.

If a country has some of the key competences within its industrial structure that are necessary to develop such new systemic technologies there are good odds that they can create winners. Even if the commercial success should be limited the positive impact on knowledge accumulation would be substantial and could be transformed to an internationally oriented service industry. The learning effects of engaging in development work are often neglected in the industrial organization literature when it considers a phenomenon such as a patent race where it is said that the 'winner takes it all'. This is not true – often the losers will become winners later on because they learn from the experience.

So the somewhat arrogant negative attitude to governments making strategic choices for the direction of the industrial and technological development needs to be revised. It is worth noting that the US in spite of being ideologically strictly against state interventionism is the single country allocating the most massive amounts of government money to applied research and to development. But they do so under headings such as military defense, space programs and health - not under the heading of industrial policy. It is also worth noting that historically some of the most radical technological breakthroughs would not have taken place the way they did without non-market opening the way. The role of the US military in propelling the development of ICT and the internet are the most recent a well-known examples.

7.4 The competence of the policy maker

A neglected problem in designing best policy is the competence/incompetence of the policy maker. This may come as a surprise in a world where 'government failure' is frequently used as an argument for hands-off policies. But the point is that there are different models for what is a competent policy maker and how you design policy needs to take this into account.

There is the model of 'the generalist policy-maker' who can administer any system on the basis of some general analytical tools such as cost-benefit analysis, game theoretic models or quantitative benchmarking. The opposite is 'the life-long specialized policy maker' who has a very detailed insight in the sector in which she is in charge. Here the analytical tools can be combined with experience-based tacit knowledge.

One advantage of the generalist is that she is easy to move around and easy to replace. In a context where the size of the public sector is seen as a major problem this might be an important argument. The weakness is that the competence to intervene in (as well as design and redesign) complex system is weak. The strength of the sector expert is that she can understand the system that she intervenes with. The weakness may be myopia and tendency to reproduce old routines after that they have become obsolete.

In the real world we find a mixture of the two types in the same organization and most individual policy makers combine some sector experience with being generalists. But nevertheless as the economic rationale for public policy has become more predominating there has been a tendency to move in the direction of the generalist models. Some of the developments in innovation policy – not least the growing emphasis on 'naïve bench-marking' of public policies – that might be difficult to understand have their background in this kind of development.

This tendency of deskilling makes it more difficult to realize the most useful ideas in the innovation system concept. The complexity of the NSI-concept and its application in terms of institutional and policy design is difficult to combine with a staff of policy makers that know very little about the reality in which innovation processes actually take place. Without competence-building among policy makers in charge of innovation policy it might be better to avoid using the innovation system concept and instead to use simple rules of thumb such as trying to keep public R&D-expenditure at a reasonable level, avoid corruption and support the formation and growth of small and medium-sized companies. This is why we will put some effort on discussing how the NSI-concept can support policy learning.

7.5 Policy learning

These short reflections on innovation related policies point to a need for ongoing policy learning focusing on building competences and skills in all parts of society and on integrating narrow perspectives and strategies from different policy areas.

Policy learning is together with technological, organizational and institutional learning an integrated part of the learning economy. It implies that policy making itself is a process of learning. The goals, the instruments, the models, the data, the competence of the bureaucracy, the organizations and the institutions develop over time in interaction with each other and not least with the experience and feed-back from implementing specific policies. This is done partly as a conscious, and maybe even designed, process in which policy makers, bureaucrats, experts and scholars evaluate policies, communicate and develop values, knowledge, competence and institutions over time. It is also done in a less conscious, learning by doing way, or even as learning by accident as, for instance, when policy makers discover that environmental regulations, unexpectedly, increase innovative capabilities as well as well-being.

Policy learning can take different forms. In relation to innovation policy the following may be relevant:

- Forming visions about the learning economy as an environment for learning, innovation and sustainable growth and clarifying the value premises of innovation policy.
- Understanding the fundamental characteristics of the domestic national innovation system.

- Development of new concepts, data, and theories of innovation and systems of innovation.
- Institution building that supports the production and reproduction of human and social capital.
- Locating and diffusing international, regional and local 'good practices' that are compatible with the national system of innovation.
- Stimulating regional and local experiments in policy areas in need of reform and developing new methods to evaluate the outcomes of such experiments that take into account learning effects.
- Gradually trying, testing, evaluating and establishing new practices and routines in the conduct of policies stimulating learning and innovation
- Analysing and comparing systemic features and critically important indicators in a form for benchmarking across regions, organizations and nations.
- Developing new forms of democratic participation in the design and implementation of innovation strategies including forms of ongoing dialogues between employees, unions, researchers and governments.

Above I contrasted the old-fashioned policy maker with deep insight in the sector she is in charge of with a modern one with general qualifications. Actually, also here, there is a need for diversity. The best constellation within a policy agency is probably a mixture of experts and generalists. The way the competences of experts and generalists are developed is important. Narrowly focused experts need to require system-wide insight. Generalists need to get a chance to go deeper into specific fields. Moving experts from one field of expertise to another from time to time may be a way to diffuse ideas from one policy area to another.[31] The point here is that in strategies of policy learning the human dimension and the design of career paths are extremely important.

[31] *MITI – the ministry of industry of Japan – goes very far (probably too far) in systematically circulating the staff in order to support competence building and promote organizational change.*

8 Innovation policy in the globalizing learning economy

8.1 Introduction

In section three we pointed out that there is a need to take into account the historical and local context when conceptualizing innovation systems (and all other socio-economic phenomena). This is of course true also for the use of the concept when designing public policy. In what follows we discuss what kind of innovation policy is the most adequate for a highly developed small country in the current historical context.

8.2 In the learning economy there is a need for a broad definition of innovation policy

As indicated, innovation policy is too often based on too narrow an understanding of concepts such as innovation and knowledge. International organizations dominated by big and medium-sized countries – including OECD and the European Commission – tend to contribute to such narrow perspectives and this may prove especially harmful for small countries. To put it briefly: the focus is almost exclusively on Science Technology and Innovation as the basis of learning (STI-learning) while learning by Doing, Using and Interacting (DUI-learning) tends to be neglected. Another bias is the focus on the competitiveness of High-Technology sectors to the neglect of the knowledge base of all the sectors. One message here is that High Technology sectors may have most to gain from intensifying DUI-learning while firms with weak connections to science institutions may have the most to gain from strengthening the STI-mode.

Other ideas proposed are:

- Bottom up reform of universities in order to stimulate their contribution to the learning economy without undermining their classical role as guarantee of last resort for reliable knowledge – initiative university development contract.
- Strengthen the absorptive capacity of SMEs when it comes to codified knowledge – initiative knowledge ice-breaker program.
- Promote the diffusion of learning organizations in the private and the public sector – Initiative MOC – Management, Organisation and Competence building.
- Establish the Swedish Innovation and Competence building Enterprise under the leadership of the prime minister to co-ordinate policies affecting Innovation and Competence building – Initiative SICE.

8.3 Definitions and assumptions

The policy recommendations build upon a broad definition of innovation system that encompasses not only radical change in technology but also incremental technical change, diffusion of technology as well as introduction of products and processes new to the firm. It is my assumption that at least for small countries like Sweden and Denmark the major economic impact of innovation comes from incremental innovation and intelligent use of new technologies. In the current global economy we should not expect to witness major domestic technological innovations with great impact on economic performance of the domestic economy.

Second it implies that innovation has two different but interconnected and complementary sources. One is systematic search related to science. Research and development efforts in firms and connections to universities and laboratories contribute to innovation especially in pharmaceuticals, chemical industry and electronics (STI-learning). Most direct is the connection between science and innovation in fields such as bio-, micro- and nano-technology. But, it is important to note that more and more these generic technologies enter more traditional industries such as food, clothing and furniture. Such so-called low technology sectors increasingly draw upon science when it comes to innovate production processes, use of materials and design of new products. In high income countries such as Sweden they need to do so even more in the future.

But the other source – experience-based (DUI-) learning taking place in daily production and in the implementation and use of advanced technologies – is equally important. The speed up of science-based innovation tends to run into bottlenecks whenever the capability to absorb and efficiently use new technologies is limited. And many incremental innovations with economic impact have their roots in learning by Doing, Using and Interacting. Any national strategy to promote innovation needs to take both these sources of innovation into account. The importance of DUI-learning in science-based sectors comes out clearly in the following statement made by the former president of EIRMA – the association of European R&D-managers:

> *In a time of intensive global competition, speeding up the innovation process is one of the most important ingredients which enable the company to bring to the market the right product for right prices at the right time...*
>
> *We know that it is not only the R&D process which is important - we have to put emphasis on integration of technology in the complete business environment, production, marketing, regulations and many other activities essential to commercial success. These are the areas where the innovation process is being retarded.*
>
> *This subject is a very deep-seated one which sometimes leads to important, fundamental rethinking and radical redesign of the whole business process. In this respect, especially during the difficult period in which we live today, where pressure is much higher, our organizations may in fact, need to be changed. (Introductory remarks to the EIRMA -conference by the President, Dr. E. Spitz: Eirma 1993, p. 7, my emboldenings).*

8.4 The globalizing learning economy as context

Understanding the current economy as a learning economy is more fruitful than understanding it as knowledge based economy (Lundvall and Johnson 1994, Lundvall and Borras 1998; Archibugi and Lundvall 2001). The learning economy concept signals that the most important change is not more intensive use of knowledge in the economy but rather that knowledge becomes obsolete more rapidly than before. This is why it is imperative that firms engage in organizational learning and that all categories of workers constantly attain new competencies.

This can be illustrated by the reference in a recent report from the Danish Ministry for Education that claims that on average half the skills a computer engineer has obtained during his training will be obsolete one year after the exam has been passed, while the 'halving period' for all educated wage earners is estimated to be eight years (Ministry of Education 1997, p. 56). It is also reflected in the quotation above where accelerating innovation is seen as the major challenge by R&D-managers.

A learning economy is one in which the ability to attain new competencies is crucial for the economic success of individuals and, as well, for the performance of firms, regions and countries (OECD 1999; OECD 2000). The crucial importance of learning reflects that the combination of globalization, information technology and deregulation of formerly protected markets leads to more intense competition and to more rapid transformation and change. Both individuals and companies are increasingly confronted with problems that can be solved only through new competencies. Intensified competition leads to a selection of organizations and individuals that are capable of rapid learning, thus further accelerating the rate of change.

The transition to a learning economy confronts individuals and companies with new demands. Below we will show the importance for innovation performance of establishing 'learning organizations'. The growing emphasis on new organization forms promoting functional flexibility and networking may be seen as a response to the challenge of the learning economy. In a rapidly changing environment it is not efficient to operate in a hierarchical organization with many vertical layers. It takes too long to respond if the information obtained at the lower levels should be transmitted to the top and back down to the bottom of the pyramid. Also it becomes even more difficult to establish all competences within the organization. In house-learning needs to be combined with hiring highly skilled experts in the labor markets and networking with external parties. Increasingly relational contracting and networking must be used to enhance economic performance.

8.5 The small country context as context

It has been shown that small countries are handicapped in international competition in high technology or science-based economic activities (Fagerberg 1995). Actually, one should expect them to be left further behind the big countries the further we move ahead into a knowledge-based economy. This is one of the few clear policy implications of most models in the tradition of the so-called new growth theory (Romer 1990). The argument is that it is much more expensive to produce new knowledge than it is to replicate and use it on a wider scale. Therefore we would expect significant scale economies in all knowledge-based activities. In spite of this we find that among the ten countries in the world with the highest GDP per capita at least 6 must be characterized as small countries. Medium-sized countries in Europe do not do better than small European countries in this respect. Looking at a broad set of indicators of 'the new economy' OECD also finds that many small countries are doing surprisingly well (OECD 2001).

This 'paradox' needs to be resolved and the reasons for the historical strength of small countries such as the Nordic countries, Netherlands, Belgium, Switzerland and Austria need to be understood. A strategy that neglects these advantages and only focuses on overcoming the handicaps in certain science-based technologies may actually hurt the competitiveness of these economies. One interpretation that is supported by empirical work in Denmark and other small countries is that it has a lot to do with 'learning' and 'know-how' in the broad sense of this term. In those countries there is a strong capacity to

absorb and use advanced science-based technologies efficiently in spite of an uneven, sporadic and weak capacity to develop and produce them domestically (Freeman and Lundvall 1998; Lundvall 2001).

This learning capacity has to be understood in the light of a broad set of institutions and social relationships. Education and training is of course important. Welfare states and integrative policies in labour markets and at workplaces support the willingness of workers to contribute to change instead of blocking it (Svennilson 1960, Kutznets 1960). The fact that small countries have been exposed to 'globalization' early on in history has forced them to build such institutions (Katzenstein 1985, Andersen and Lundvall 1988, Freeman and Lundvall 1988). And small size has given no choice but to remain open to the rest of the world. In 'the learning economy' the speed of moving from a technological breakthrough to its nation-wide application may be more important than being the host of the breakthrough.[32]

Actually, in the era of globalization medium-sized countries have more to learn from small countries in terms of institution building and organizational set-ups than the small ones have to learn from the big ones regarding STI-policies. This is illustrated by the strong current international focus on the Danish combination of high mobility in the labor market and easy and long-term access to unemployment support. What is often called flexicurity is now considered as a possible way to enhance the dynamic efficiency of medium-sized countries in Europe.

8.6 The role of universities in the learning economy

We have seen how universities are exposed to a growing political pressure to change. Universities are expected to become more directly involved in market-driven processes and more exposed to competition from other producers of knowledge (Lundvall 2003). This occurs in a situation where knowledge production is characterized by increases in the degree of internationalization and networking. These changes in context raise new demands on the universities' contribution to competence building in society (Cohendet and Joly 2001).

Some of the traditional modes of organization, such as sharp and rigid borders between disciplines and isolation from the society at large are being challenged and alternatives have to be developed. Strategies of alliance and networking have become a key factor behind the success of universities. But it is fundamentally important that the universities' most significant contribution to society and the economy remains well-educated graduates with critical minds and good learning skills in the future.

Also, as universities open themselves up to interaction with outside users in the private and public sector, there is a need for changes in institutional framework to ensure that the long-term, creative and critical aspects of academic research can survive the transformation.

It is important also to consider the ethical and social dimension of universities' knowledge production in order to support the long-term viability of the learning economy. Merely to expose the universities to market processes or to political interventions from governments is not tenable, neither for university nor for society.

[32] *In this context it is damaging to take a national perspective on the innovation system and see it mainly as related to STI-learning and science-based industries. It might for instance lead to the mistaken idea that the ideal state is one where almost all ideas emanating from science should be produced by domestic universities for domestic firms. For a small economy such a perspective is detrimental for innovation and economic progress.*

One interesting result from the DISKO-project (see Lundvall 2001) is that Danish small and medium-sized firms not belonging to High Tech-sectors that acquired competence in the form of academic personnel and that strengthened their collaboration with knowledge institutions were the ones that experienced the most dramatic positive impact on their innovative performance (Lund Vinding 2002).

Human resources are the key to link universities to industry

Over the last decade there have been several new innovation policy initiatives in OECD-countries giving public support to new modes of co-operation such as:

- Co-operation contracts – bringing firms, technological institutes and universities together in common projects.
- Innovation environments – establishing more permanent local collaboration.
- Mobility programs and the Industrial researcher agreements – aiming at creating more mobility between university and industry.

All these initiatives aim at overcoming barriers between 'the three worlds' of science, technology and industry. Especially the last mentioned might be seen as important instruments.

The analyses in the DISKO-project (the project on the Danish Innovation System in a Comparative Perspective – see Lundvall 2002) point to human resources, as the most important underlying element of the innovation system. This is not merely a question of competence in the labor force, but it also refers to network formation between the different parts of the system. This can be illustrated by combining labor market data with survey data on industry-university connections.

In table 4 firms with less than two academic employees are compared with firms where a larger number of the employees have degrees from higher education. Table 4 shows, not surprisingly, that large firms have intensified their co-operation with science institutions more frequently than smaller firms. But the table also shows a difference between firms reflecting the presence of employees with higher education. For small firms the probability of intensifying the co-operation with a science institution is twice as high when the business has more than 2 employees with higher education.

Table 4 Share of firms that have strengthened their co-operation with knowledge institutions divided by size of the business and amount of employees with higher education (HE) - Percentage that have cooperated in connection with product development.

	49 employees or less			**More than 49 employees**		
	HE>2	HE<2	All	HE>2	HE<2	All
Increase in co-operation	19	9	11	35	24	26
No increase in co-operation	81	91	89	65	76	74
Total	100	100	100	100	100	100

Source: Nielsen 1999

One way to link universities stronger to firms with weak links is to subsidize their first hiring of academic personnel. Higher education employees contribute to a change in the mode of innovation in small and medium sized firms as well as giving them more direct access to the kind of knowledge available at science institutions.

A bottom up reform of universities

As an alternative to some of the current efforts to make universities more market oriented it might be considered to initiate reforms that are driven from within the universities. This kind of initiative was taken by the former Danish government. The government asked each single university to present its own development plan. If combined with a real credible commitment for long term funding this kind of initiative is useful since it decentralizes the initiative to those who will be in charge of implementing change.

Such a development plan could be built up from below within the organization and it would typically involve:

- Making explicit basic values and reflection on how to implement these values in the context of scientific work and teaching.
- Specifying the division of labour and alliances with other knowledge institutions in the Sweden (cultural institutions, technological institutes, professional training institutions, private knowledge intensive service firms etc.).
- Promote internationalization of research and education and positioning the activities in international networks. Typically this will take place at the level of research teams, but management may contribute with positive incentives and support.
- Differentiation of the organization of the university that makes it possible to cover basic research needs as well as an interaction with new categories of users of research and training. (Spanning from interdisciplinary centers' of advanced learning to network centers and information services that inform small and medium sized firms about where they can find relevant academic knowledge).
- Defining key functions combined with out-sourcing of peripheral activities, and particularly activities with a negative impact on the main task of universities, i.e. to educate qualified candidates.
- Analyses of internal routines and of the micro organization in order to relieve professors from trivial tasks and free more time for scientific work and teaching.
- Introduction of incentives and evaluation principles that ensure the balance between teaching, scientific work and interaction with the outside world. Taking into account that university scholars are more susceptible to incentives such as time for self-organized research and public acknowledgement than individual economic incentives.
- Pedagogic renewal in order to prepare the students for the learning economy, where interdisciplinary, problem solving, co-operation and communication is emphasized. Increase practical activities in education program to ease the transformation to the labour market.
- Development of systematic systems for life-long learning for their own graduates and for others who need an upgrading of their competences.

In order to master both the classical functions of the university and the new demands such a long term plan would have to include the establishment of a more diverse organizational structure and more variation in scientific careers both among scholars and for the single scholar.

8.7 On the importance of promoting DUI-learning and the diffusion of learning organizations

As indicated above the bottlenecks for technical change are as much on the side of internal and external organization of the firm as it is on insufficient investment in R&D and STI-learning. To illustrate this point some results based on recent data from the DISKO-project will be presented below.

The data

The empirical analysis is based on a survey addressed to all Danish firms in the private sector – not including agriculture - with 25 or more employees, supplemented with a stratified proportional sample of firms with 20-25 employees. 6991 questionnaires were sent to the firms selected. This survey collected information from management. In total, 2007 usable responses from management have been collected and integrated in a cross section data set. This makes the overall response rate of the survey 29%, which is not very satisfying. However, a closer response analysis broken down on industries and size show acceptable variations on response rates here, and non-respondent information on some of the potential dependant variables together with comparison to other surveys, do not indicate unacceptable bias.

As a starting point 14 different characteristics were selected that - on the basis of the literature and on the basis of earlier empirical work – could be assumed to affect the capability to engage in DUI-learning (Argyris and Schön 1978). These are listed in table 5 below:

Table 5 Organizational characteristics promoting DUI-learning

Organizational characteristics and practices
Cross occupational working groups
Integration of functions
Softened demarcations
Delegation of responsibility
Self directed teams
Quality circles/groups
Systems for collection of employee proposals
Education activities tailored to the firm
Long term educational planning
Wages based on qualifications and functions
Wages based on results
Closer cooperation with customers
Closer cooperation with subcontractors
Closer cooperation with universities & technological institutes

The firms were classified in three groups, according to how many characteristics they have adapted in their organizations - in other words - how many organization, quality, human development and external cooperation facets are built into the firm's organization. We have on this basis divided the firms into three groups:

- Low level DUI-learning organization – firms that have introduced zero to four of the dimensions

- Medium level DUI-learning organizations - firms that have introduced five to eight dimensions
- High-level DUI-learning organizations - firms that have introduced nine to fourteen dimensions.

What is the importance of this bundling of organizational dimensions for the knowledge production and learning in the firms, as indicated by product and service (P/S) innovations? In table 6 the different categories, representing increasing levels of learning organization are tested in a logistic model with P/S innovation as dependant variable, and with control for firm size, industry etc.

Table 6 Logistic regression of learning organization level categories, size, industry, ownership and production on P/S innovation (odd ratios, 95% confidence interval, estimates and P-values)

Variables:	Effect	Lower	Higher	Estimate	Chi-sq	P-value
High level	5,18	3,90	6,90	0,82	127,30	<.0001
Medium level	2,20	1,71	2,83	0,39	37,11	<.0001
Manufacturing	2,35	1,62	3,40	0,54	38,69	<.0001
Construction	0,69	0,45	1,08	-0,68	28,35	<.0001
Business services	2,27	1,46	3,54	0,51	15,40	<.0001
100 and more	1,61	1,26	2,07	0,30	14,23	0.0002
Danish group	0,76	0,58	1,00	-0,14	3,93	0.0475
Single firm	0,58	0,44	0,76	-0,28	15,85	<.0001

In the table all variables that have a significant effect on innovation performance are listed while the other has been excluded. 'Effect' refers to the probability for an innovation in the category as compared to a benchmark. We find a five times higher chance of product/service innovation in the high level category, and even in the medium category the chance is twice as high as in the low category. These results should be seen in the light that differences in the size, sector and ownership form has been simultaneously entered in the regression.

Among the other factors included in the model, Manufacturing and Business services remain significant with 2.3 higher chance of P/S innovation and Construction is negatively significant with a chance of 0,7 (benchmark sector is other services). The effects of large size (100+) are positive but moderate. Danish group ownership and single firms have a chance below the foreign-owned firms that were used as benchmark. In sum, the model has shown important and significant effects of the presence of what we call learning organization on P/S innovation.

This demonstrates firms that combine functional flexibility with investment in human resources; incentive systems and networking are much more prone to innovate irrespective of sector and size. It also illustrates that there is no clear distinction between 'innovation management' and 'knowledge management' or between organizational characteristics that promote adaptive learning also promote innovation.

8.8 How to promote organizational change?

It is certainly easier for public authorities to find ways to support private and public R&D activities than it is to stimulate organizational change in the private sector. First, it is seen as a prerogative of owners and management to design the organization of the firm. Second standard economists assume that the market will select good practices by itself. At the same time, empirical research indicates that there is a major hidden productivity reserve that might be realized to the mutual benefit of owners, management, workers and the public sector – if the right approach could be found.[33]

This is an area where sector specific collaboration between management, employees, private consultants, researchers and public agencies is necessary. This kind of collaboration could be developed at the national level as general and sector-specific programs to be supported by national federations of labor and industry. But the emphasis might be on regional initiatives that get closer to the organizational practice of local firms. A first step would be to map the potential and define good organizational practices for firms operating in different contexts. Second step might be to involve employers' and employees' organizations in self-organized campaigns to learn from good practice organizations. Public sector programs might stimulate the use of consultants in diffusing good practice and also intensify training in management for ordinary students in engineering and business as well as people already in the labor market.

In general, competition pressure stimulates organizational change and therefore there are good reasons to avoid protectionist policies and to keep the economy open. The working of the labor market is important since employees that move from one organization to another will carry organizational experiences with them. The use of competition clauses limiting such mobility may be restricted. Education and training of engineers and other involved in technical innovation can give a stronger attention to organizational change.

Research in linking organizational issues to economic performance and innovative capabilities may be stimulated. The LOK-program in Denmark was an attempt to take up this challenge (See Torstensen et al 2001).

8.9 The need for a new type of policy co-ordination

There is growing consensus on the need to focus on long-term competence building in firms and in society as a whole. At the same time, the prevailing institutional set up and global competition tend to give predominance to short term financial objectives in policy making. At the institutional level this is reflected in the fact that ministries of finance have become the only agency taking on a responsibility for co-coordinating the many specialized area policies. Area specific ministries tend to identify with their own 'customers' and take little interest in global long-term objectives of society.

The concept 'the learning economy' has its roots in an analysis of globalization, technical innovation and industrial dynamics (Lundvall and Johnson 1994; Lundvall and Borràs 1999). But the concept also implies a new perspective on a broad set of policies including social policy, labour market policy, education policy, industrial policy, energy policy, environmental policy and science and technology policy. Specifically, the concept calls for new European and national development strategies with co-ordination across these policy areas.

[33] *In other studies we have shown that 'learning organizations' create more and more stable jobs and that they are characterized by less long term sick-leave periods among employees.*

Social and distributional policies need to focus more strongly on the distribution and redistribution of learning capabilities. It becomes increasingly costly and difficult to redistribute welfare, ex post, in a society with an uneven distribution of competence. Therefore there is a need for stronger emphasis on a 'new new deal' where weak learners (regions as well as individuals) are given privileged access to competence upgrading.

The effectiveness of labour market institutions and policy has so far been judged mainly from a static allocation perspective. There is a need to shift the perspective and to focus on how far the labour market supports competence building at the individual level and at the level of firms. This implies for instance that some dimensions of flexibility and mobility are more productive than others and that there may be third roads aside from Anglo-Saxon maximum flexibility and Mediterranean contractual job security. One of the new roads can be represented by the Danish model, characterized by a unique combination of relatively high degree of income security with high participation and mobility rates.

Education and training policy needs to build institutions that promote simultaneously general and specific competencies, while giving students a learning capability and while delivering life-long learning. These points toward a new pedagogy that combines individual plans with collective problem-oriented styles of learning. A real commitment among employers, employees and policy makers to life-long learning with a strong interaction between schools and practice-based learning is necessary.

Industrial policy needs to adjust competition policy and policies aiming at developing learning organizations and competence building networks to each other. Intensified competition may stimulate superficial change or pure destruction rather than competence building if not combined with organizational change and new forms of inter-firm collaboration. Energy and environment policies need to take into account their impact on competence building in the economy.

Science and technology policy needs to support incremental innovation and the upgrading of competence in traditional industries as well as the formation and growth of high technology industries. For instance, the reallocation of academically trained workers toward small and medium sized firms is a key also to the formation of networks with universities and other knowledge institutions.

These specific policies need to be brought together and attuned into a common strategy. In the learning economy it is highly problematic to leave policy co-ordination exclusively to ministries of finance and to central banks – their visions of the world are necessarily biased toward the monetary dimension of the economy and thereby toward the short term.

Sweden might decide to establish a Swedish Innovation and Competence building Enterprise (SICE) with the prime minister as chairman. Such a new institution could have as one of its strategic responsibilities to develop a common vision for how the country should cope with the globalizing learning economy.

The basis of such a vision must be a better qualitative understanding of the Swedish national system of competence building and innovation. Given such an understanding international benchmarking and policy learning may become meaningful. Similar new institutions could be built at the regional level.

It could be decided to develop a National program on Innovation and Competence building where science is treated as only one among several sources to competence building. The SICE could be in charge of the design of the main lines of the program. Again, similar efforts at the European and at regional levels would make the initiative more forceful.

9 Conclusion

In this paper we went back to the origin of the concept the national innovation system. We have argued that the original versions as developed by Christopher Freeman and the Aalborg-group are more adequate for understanding the current situation where there is a growing need both for strengthening the science base for innovation and for promoting rapid experience based learning than narrow versions that focus on the science base only.

As compared to the original approach we would emphasize even more the importance of human resources. While globalization means that both codified knowledge moves quickly the most localized resource remains people – i.e. their tacit knowledge, their network relationships and their accumulated organizational experiences. Therefore all parts of the innovation system that contribute to competence building are becoming increasingly important.

This includes of course reforms of the ordinary education system, training and retraining activities to give a stronger 'learning capability' to all categories of workers. But it is as important to design the labor market so that it supports life long learning through the career paths that it fosters. Perhaps most important, there is a need to see the workplaces as 'learning sites' rather than as 'production sites'.

In some areas more competition and market mechanisms can help stimulating firms to move in these directions while government may serve them with the right 'framework conditions'. But the market is no patent solution and in many instances organizational change and competence building can be promoted only by non-market institutions and sometimes there might even be a need to challenge the prerogative of owners to decide everything within their organization.

It is interesting to note that according to our data the small family owned business, often idealized as the safe-haven of entrepreneurship, is the least innovative both in terms of technology and in terms of organizational change.

In a world that is uncertain and imperfect because it is in constant change it would be wrong to see this as bringing the economy out of a (fictive) state of general equilibrium. But public intervention needs to be designed on the basis of social dialogue, insight and experience. Therefore it is fundamental to design frameworks that stimulate systematic policy learning. Here we have argued that national systems of innovation may be used both as analytical device and as a tool for public policy learning.

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