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Fundamentals and Debate

National Innovation Systems—Analytical Concept and Development Tool

BENGT-ÅKE LUNDVALL

Department of Business Studies, Aalborg University, Aalborg, Denmark

ABSTRACT The term national system of innovation has been around for more than 20 years and today it has become widely spread among policy makers as well as among scholars all over the world. This paper takes stock and looks ahead from a somewhat personal point of view. It also gives some insight into how and why the concept came about. The paper argues that a key to progress is to get a better understanding of knowledge and learning as the basis for innovation and to understand how different modes of innovation complement each other and find support in the specific national context. A *core* of the innovation system is defined and it is illustrated that it is necessary both to understand *micro-behaviour* in the core and understand "*the wider setting*" within which the core operates. Concepts used in organization theory referring to fit and misfit may be used to enrich the understanding of the performance of innovation systems. At the end of the paper I discuss some further developments needed to make the concept relevant and applicable to developing countries. Here special attention is given to institutions and capabilities supporting learning. I point to the need to give more emphasis to the distribution of power, to institution building and to the openness of innovation systems.

KEY WORDS: Innovation system, economic theory, public policy, economic development

1. The Origin, Use and Theoretical Status of the National System of Innovation Concept

1.1. The Origin of the Concept

The innovation system concept was developed in parallel at different places in Europe and in the USA in the 1980s. There is no doubt that the collaboration between Christopher Freeman and the IKE group in Aalborg at the beginning of the 1980s was important in

Correspondence Address: Bengt-Åke Lundvall, Department of Business Studies, Aalborg University, Fibigerstræde 4, 9220 Aalborg Oe, Denmark. Email: bal@business.aau.dk

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coining and shaping the earliest versions of the concept (Freeman, 1982; Lundvall, 1985) but the basic ingredients and the inspiration may be found in the work of many other innovation scholars at the same time and even earlier.

Freeman brought deep understanding of innovation processes, historical insight and wisdom to the collaboration. His reference to Friedrich List in his 1982 paper was crucial since it linked the concept to catching-up processes. The IKE group, inspired by French structuralist Marxists and development economists, contributed with ideas about "national production systems" and "industrial complexes" where vertical interaction was seen as crucial for national economic performance and linked this to the analysis of international specialization and international competitiveness.

Within the IKE group, Esben Sloth Andersen and Gert Willumsen played key roles in respectively developing the systemic aspects and the idea of interactive learning between users and producers as the micro-foundation of the concept. Bent Dalum and Jan Fagerberg made important contributions to respectively technology and trade while Björn Johnson brought in perspectives from institutional economics and applied them to innovation. My own starting point was actually the analysis of slack and diversity at the level of the firm.

The National System of Innovation (NSI) concept became more widely diffused through Christopher Freeman's book on Japan (Freeman, 1987), through a publication edited by Freeman and myself on small countries (Freeman and Lundvall, 1988) and not least through the publication of the Dosi *et al.* book on technical change and economic theory with contributions on national innovation systems by Freeman, Nelson, Lundvall and Pelikan (Dosi *et al.*, 1988). More recent standard references on national systems of innovation are the three books edited by Lundvall (1992), Nelson (1993) and Edquist (1997). Other contributions referring to systems and operating at the national level refer to "social systems of innovation" (Amable *et al.*, 1997) and to "national business systems" (Whitley, 1994, 1996).

1.2. The Original Agenda

It is worth noting that the IKE group was established on the basis of a criticism of national economic policies defining international competitiveness as determined by relative wage costs and that the OECD group for which Freeman worked out the first paper using the concept made a critical analysis of the same set of ideas—the official theme of the group was "Science, Technology and Competitiveness". In the paper by Freeman (1982), what has become known as the Washington consensus was challenged and an active role for government policy was presented as legitimate and necessary for catching-up economies.

The concept was intended to help develop an alternative analytical framework to standard economics and to criticize its neglect of dynamic processes related to innovation and learning when analysing economic growth and economic development. We saw dubious policy strategies as based upon static standard economics and the need to establish an alternative analytical foundation.

The intention was thus not just to give a new tool to those policy makers who were in charge of science and technology policy. The agenda was more ambitious both in terms of theory and practice. We saw a need for a different kind of economic theory and also a need

for a different perspective on economic policy where innovation and learning were seen as important processes behind economic growth and welfare.

To know the original agenda might be useful when it comes to understanding why the concept was developed the way it was. What I am going to say about where to go from here will reflect that, basically, I stick to the original agenda. As we shall see in the next section, the need for a change in theoretical foundations and for a new paradigm for designing public policy has not yet been fulfilled.

1.3. The Current Use (and Abuse) of the Concept

One way to get an idea of the use of a specific concept is to use search engines such as Google and Google Scholar. Using variations on "national system of innovation" as the term for the search you find about 50,000 hits on Google and about 5,000 on Google Scholar.

Looking closer at the specific references found on Google shows that the concept informs policy makers in many countries, including the biggest economies in the world such as the USA, Japan, Russia, Brazil, South Africa, China and India, but it is also referred to in many small countries. Both policy makers at the national level and experts in international organizations for economic cooperation such as OECD, Unctad, the World Bank and the EU Commission have adopted the concept. This rate of diffusion is quite dramatic taking into account that 15 years ago only a handful of scholars had heard about the concept.

This wide diffusion in policy circles is a mixed blessing. The concept has been both used and abused. Quite often policy makers pay lip-service to the concept while neglecting it in their practice.

I would argue that the most important positive impact has been the general shift in what economists and policy makers see as constituting "international competitiveness". The wide use of the concept has helped to move the attention toward national policy strategies that constitute positive sum games both internationally and domestically.[1] The second and more generally recognized positive 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 can be referred to as a movement from "Science Policy" and "Technology Policy" toward "Innovation Policy" (see Lundvall and Borras, 2005 for an overview).

But there are also examples of misunderstandings and crude interpretations. One problematic area is the relationship between university and industry. Here local tendencies in pharmaceuticals and biotechnology in the USA have been generalized to the relationships between university and industry in general. This has sometimes inspired reforms that neglect that universities fulfil other and more important functions than being "immediate sources of innovation" such as educating critical and skilled knowledge workers.

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[1] It should be remembered that when the concept was coined at the beginning of the 1980s it was still a standard assumption among economists and policy makers that reducing national nominal wages or devaluing 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.

More generally, the wider implications of an innovation and learning perspective on general economic policy have not been seriously considered and worked out. Innovation policy has been added to an economic policy based upon static economic theory. Policy implications have been worked out on the basis of a narrow definition of innovation system where the focus is on science based innovation. The wider setting that has a major impact on interactive learning and on the performance of the innovation system has not been given sufficient attention.

1.4. The Theoretical Status of the NSI Concept

Following the definitions made by Mjøset (see below) I would argue that the theory behind the NSI concept is grounded theory. It was based upon an accumulation of empirical studies at different levels of aggregation showing that innovation is an interactive process (Rothwell, 1977; Lundvall, 1985; Kline and Rosenberg, 1986).

> Grounded theory is based on the experience of knowledge accumulation through the craftwork of qualitative social research, fieldwork, and participant observation in particular. Theories are built as the researcher shuttles between empirical research and efforts to analytically distinguish the major explanatory factors. Although rooted in the tradition of case-studies, explanation-based theories are not restricted to knowledge derived from such studies. The same notion of theory appears both in comparative historical social science and can even be found in research based on large data-sets. (Mjøset, 2005: 41)

As we will demonstrate, the further development of the concept has also been rooted in empirical work. I see the DISKO project, to be briefly reported below, as a kind of test of many of the central ideas connected to the concept. As a result of this empirical work we have proposed a redefinition of the concept giving stronger emphasis to people, organizations and "competence building".

But the origin of the concept has something in common also with critical theory (see below for Mjøset's definition). It is worth noting that the IKE group was established on the basis of a criticism of national economic policies defining international competitiveness as determined by relative wage costs and that the OECD group for which Freeman worked out the first paper using the concept made a critical analysis of the same set of ideas.

> Like grounded theory, critical theory relies on sensitivity towards specific cases. Critical theory is grounded theory applied in contexts marked by a certain level of social conflict over the legitimate claims of at least one social group. (Mjøset, 2005: 43)

In the paper Freeman also challenged what has become known as the Washington consensus indicating that an active role for government policy was legitimate and necessary for catching-up economies.

Is NSI a theory/a theoretical concept? It is a question that Edquist (2005: 186) gives a negative answer to. I would be less definite since the assumption behind the negative answer, that there are "formal theories" in social science where causal relations can be tested, may overestimate how far social science can become akin to natural science. NSI has in common with most interesting and useful social science that it is "a focusing device".

And it might also be argued that it serves as equivalent to what is normally defined as 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.[2]

In a booklet Reijo Miettinen (2002) gives a critical assessment of the NSI concept. The discussion of NSI as a "transdiscursive" concept that crosses the world of academia with the world of policy makers is especially intriguing and illuminating. He argues that the looseness and openness of the NSI concept have contributed to it thriving both in academic and in public policy circles. While I agree with Miettinen that there is a need to study not only the national level but also networks at, for instance, the local and regional level I disagree with his conclusion that the transdiscursive character makes the concept "unscientific". Again his contention may reflect an overestimation of how far social theory can become "formal theory".

2. Defining the National System of Innovation

It follows from what has been said about the original agenda that we were interested in a definition of the innovation system that included elements that interact in shaping innovation processes as well as elements that link innovation to economic performance. In Lundvall (1992) we introduced economic structure and institutions as two dimensions of national innovation systems. We emphasized that the most important resource in the current economy was knowledge and the most important process was learning. But many of the concepts introduced remained in rather primitive form. In what follows an attempt will be made to develop and clarify the original ideas. It is natural to start with the three basic ingredients National, System and Innovation.

2.1. Why Focus on the National Level?

Adding the adjective "national" does not make the combination of innovation and system less controversial. Modern social science has, for different reasons, had surprisingly little to say about nation states. Liberal philosophy sees the nation state as a barrier to the free market while Marxists see it as diverting the attention from the class struggle. Historically, nationalism has resulted in anti-scientific ideologies. So the unwillingness to give legitimacy to nation states is understandable. But while social science has said little about the nation state nonetheless it has operated 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. I believe that in this situation it is actually demystifying to use "national" explicitly in the NSI term.

[2] The fact that the focus is on *innovation* has important implications for what kind of analysis 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 have argued that the most dubious element of the concept is "national" since it brings in, *ex ante*, a level of analysis that might not be the most adequate for understanding the process of innovation. 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. It has become even more important to be explicit about 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 how the historical role of national systems is transformed.

Over the last decade there have been several new concepts emphasizing the systemic characteristics of innovation but with a focus at other levels of the economy than the nation state. Bo Carlsson with colleagues from Sweden developed the concept "technological systems" at the beginning of the 1990s (Carlsson and Stankiewicz, 1995). The literature on "regional systems of innovation" has grown rapidly since the middle of the 1990s (Cooke, 1996; Maskell and Malmberg, 1997) while Franco Malerba with colleagues developed the concept of "sectoral systems of innovation" (Breschi and Malerba, 1997). Some of the crucial ideas inherent in the innovation system concept (on vertical interaction and innovation as an interactive process) appear in Porter's industrial clusters as well as in Etzkowitz and Leydesdorff's Triple Helix concept (Etzkowitz and Leydesdorff, 2000).

These are not alternatives to the analysis of *national* systems. They have important contributions to make to the general understanding of innovation in their own right. And it is obvious that a successful research strategy needs to combine empirical and theoretical work at the different levels of aggregation spanning from local to transnational and even global systems of innovation. To compare sectoral, regional and technological systems across nations is often an operational method for understanding the dynamics at the national level. The openness of national systems is certainly important to analyse.

2.2. What Do We Mean by System?

Especially in the current period of globalization the focus on the national level is important and legitimate. Rather I see as more debatable the use of the term "system". System appears in different social and academic discourses (see, for instance, Bertalanffy, Luhmann as well as literature on ecological systems). While borrowing ideas from any one of these very different perspectives may give interesting insights it must be made with care since there are always problems with the transfer of ideas from one analytical universe to another.

The "system" terminology may have had a negative impact on the use of the concept in public policy. Certain policy makers have interpreted the "system" in a mechanistic way assuming that the system can be easily constructed, governed and manipulated. The lack of clear definition has contributed to such misinterpretations. One type of mechanistic interpretation is found in regional development strategies based upon the assumption that "clusters" and "regional systems" may be built from scratch through policy initiatives.

The original choice of "system" referred to a few simple ideas. First that the whole is more than the sum of its parts, second that the interrelationships and interaction between elements were as important for processes and outcomes as were the elements and that

therefore we might expect each national system to develop its own unique dynamics. Today I would emphasize another argument in favour of the "system" concept. The innovation process may be seen as an intricate interplay between micro and macro phenomena where macro-structures condition micro-dynamics and vice versa 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. There is a lot of theoretical work to do to model, measure and compare such processes across national borders.

2.3. What Do We Mean by Innovation?

There is a tradition to refer to Schumpeter when defining innovation. Innovation can be seen as "new combinations". It can be separated from invention that becomes an innovation only when the entrepreneur brings it to the market. We will follow Schumpeter in these respects. But we will include not only the event of the first market introduction 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 I prefer to define innovation as a process encompassing diffusion and use as well as the first market introduction.

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 listing very useful because it mixes different categories that it is useful to keep separate in the analysis. To distinguish between technical change and organizational change may be difficult in real life but I find this distinction important and useful for two reasons. The way in which the economy and the firm is organized has a major impact on how technical 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 training and organizational change.*

In the context of new growth theory Paul Romer has proposed the distinction between respectively hardware, software and "wetware" where the last category refers to what human beings know and know how to do. I am not enthusiastic about the "wetware" term since it reificates human beings so I will use "people" instead of "wetware". And I propose to add "orgware" and "socware" as referring to how people relate to each other within and across organizational borders. Innovation is about discontinuities in the technical characteristics of hardware and software. But the impact of innovation on economic performance will typically depend upon changes in "people", "orgware" and "socware". To avoid confusion I would prefer not to refer to changes in these three dimensions as innovations.

How we define innovation is of course important for how we end up defining and analysing innovation systems. There is no objective way to select between alternative definitions. In what follows we will argue for a definition of innovation that is broad in some dimensions (including diffusion and use) and narrow in others (reserving the concept for technical innovation in hardware and software).

3. Where to Draw the Line around the NSI?

One criticism of the innovation system concept is that it includes almost everything. This criticism may be especially relevant to some of my own writings where I have proposed to include social capital, welfare systems and labour markets in the analysis. In what follows I will try to respond to this criticism by introducing a distinction between *the core* and *the wider setting* of the system. It is possible to define the core with reference to innovation theory and empirical research. The question about what parts of the economy need to be included in the wider setting has much to do with the purpose of the analysis and with *ex ante* insights about causalities and interdependencies in the system.

3.1. A Method to Draw the Line

In what follows I will sketch the outlines of 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:

1. We know that firms are the units that play the most important role in the innovation system and that it matters for innovation and for how innovation affects economic performance how firms organize themselves.
2. We know that firms innovate in an interaction with other firms and that they interact with knowledge infrastructure including universities and technological institutes.
3. We know that firms' innovative activities—their style and mode of innovation and learning—are dependent on national education systems, labour markets, financial markets, intellectual property rights, competition in product markets and welfare regimes. The institutional set-up in these areas shapes people, orgware and socware.
4. We know that firms belonging to different sectors differ in how they innovate, interact with other firms, interact with the knowledge infrastructure and draw upon markets for labour, finance and intellectual property.

Therefore, the *first step* would be to analyse what takes place inside firms in terms of innovation and competence building.

A *second step* would be to analyse the interaction among firms including competition, cooperation and networking, and how firms interact with knowledge infrastructure.

A *third step* would be to explain international differences in these respects with a reference to the specificities of national education, labour markets, financial markets, welfare regimes and intellectual property regimes.

As a *fourth step* firm organization and network positioning may be used to "explain" the specialization, competitiveness and growth performance of the innovation system.

On this basis we can define the borders of the innovation system in two steps. We can locate a core and a wider setting around this core. *The core of the innovation system* is thus *firms in interaction with other firms and with the knowledge infrastructure.*

To explain international differences in these respects we need to include *a wider setting* including *the national education systems, labour markets, financial markets, intellectual property rights, competition in product markets and welfare regimes.*

3.2. Defining the Core of the Innovation System

A minority of firms introduce innovations that are both radical and new to the global economy. They are pioneers and they stimulate economic development by contributing to the diversity of the economy and technological opportunities. Among their competitors there are early and late followers that imitate and adapt the new products and processes. Among user firms and among consumers there are also early and late adopters of new products.

The early followers will be involved in debugging innovations and while doing so they solve problems with the new products and they might see new possibilities for their application. The early users may contribute directly by changing the new technology or they may give feedback information to pioneers. *Early followers and early users have an important role to play in the innovation system as a whole since they host processes that are as important for the overall innovation process as the pioneer firms.*

The late followers and late users may not contribute directly to the overall innovation process to the same degree as the early ones. But their difficulties to absorb and use new technologies may be considerable given their limited competence to do so. And for economic performance of the overall national economy the capacity of late-comers to absorb and use new technology may be as important as the capacity of pioneer firms and early followers and users.

The performance of the economy will depend on the distribution of firms in the three categories, the competence level in each group and not least on the communication and interaction between firms belonging to the different categories. Feedback from early and late users is fundamental for pioneer firms while forward services from pioneers are important for users' successful absorption and use of the new technologies.

Firms may link up and communicate with the different parts of the knowledge infrastructure through different media (market, organized market, collaborative projects or access to free information service) and with more or less mutual commitment. For the innovation system as a whole, in the short and medium term, it is important for performance that there are effective interactions between firms and the knowledge infrastructure. In the long run it is important that the knowledge infrastructure is allowed (stimulated) to evolve with the population of firms but also with some autonomy so that it can give rise to radically new technologies.

We have pointed out that interaction and communication are key both within the population of firms and between firms and knowledge infrastructure. A key to understand interaction and communication is to make a distinction between knowledge transfer and learning through respectively information flows (codified knowledge exchange) and body–body contact (tacit knowledge exchange). A key difference between firms, sectors, regional and national systems is the role played by respectively codified knowledge and tacit knowledge in the innovation process. This has a correspondence in different modes of innovation presented in the next section.

3.3. Avoiding the Bias toward High-Technology Sectors and the STI Mode of Innovation

There is a certain bias both in innovation theory and innovation policy in the direction of High-Technology industries. This has some rational basis in the fact that the rate of innovation in such industries is often high. With the definitions given above the focus on

such industries is too narrow. The frequency of pioneer firms and lead imitators may be higher in these sectors but in order to understand how innovation affects macro-economic performance all kinds of firms and sectors need to be included in the analysis. It has been demonstrated that there is a lot of innovation going on also in so-called Low-Technology industries and that most of these industries, to some degree, base their innovations on the use of science (Tunzelmann and Acha, 2004).

Another bias is to give more emphasis to activities related to science to the neglect of activities related to experience-based learning. On the one hand, innovation activities may give main emphasis to promoting R&D, utilizing and creating access to explicit codified knowledge (STI mode of innovation). On the other hand, there are innovation strategies mainly based on learning by doing, using and interacting (DUI mode of innovation). These will typically involve organizational frameworks and relationships between employees that utilize implicit knowledge and promote interactive learning. One is *experience-based* and the second is *science-based* (see Jensen *et al.*, 2006).

When drawing the lines around the innovation system they should include all firms and they should also include activities related both to experience-based learning and activities related to science-based search. The innovation system needs to encompass agents both in high- and low-technology industries as well activities that refer to the two modes of innovation (see Table 1).

There is a tendency in the innovation literature to assume that only cells 1 and 4 are relevant and among innovation policy makers there is a tendency to focus the attention on cell 4. We see both as examples of bias. The reason why orgware and socware are so important for the performance of the innovation system—for the transformation of technical innovation into economic performance—is that they are crucial for what is going on in cells 1 and 2. Cell 3 is also important to take into account since, in the current phase, it often refers to missing linkages and lack of effective demand among firms.

3.4. The DISKO Project as Illustration

The Danish Innovation System in Comparative Perspective—the so-called DISKO project (Lundvall, 2002)—was organized largely according to the principles laid out above. In the project the research team (more than 15 scholars working together for more than 3 years) worked in four "modules":

Module 1: The firm–product competition, competence building, organization, innovative activities.
Module 2: Inter-firm relationships and interaction with the knowledge infrastructure in the context of product innovation.

Table 1. Dimensions of the innovation system

	Low-technology sectors	High-technology sectors
DUI mode of innovation	1	2
STI mode of innovation	3	4

Module 3: Inter-sectoral knowledge flows in an input–output perspective.
Module 4: Education system and the markets for labour and finance.

The firm. In this module we analysed what factors had an impact on product innovations in Danish firms. The empirical material gathered in 1996 included a major survey with 2,000 firms in the final data-set as well as register data for those firms. One of the most important results was that characteristics that are associated with "learning organizations"—interdivisional teams, job rotation, autonomy in work and investment in training—seemed to have a major impact on innovation. Organizational forms promoting learning seem to be overlapping with the forms that promote innovation. More recent work on the data has shown that the firms that combine a science-based innovation mode with an experience-based mode are much more active in terms of product innovations than those that depend mainly on one of the two modes (Jensen *et al.*, 2006). Lorenz and Valeyre (2006) have shown that there are huge differences in how work and learning are organized in different national systems in Europe.

Inter-firm interaction. In the original version of the NSI concept we referred to the interrelationships between organizations, especially user–producer relationships, as the micro-foundation. Today I would argue that we should aim at an analysis that links together the internal organization of the firm and its external relationships. But combining the two dimensions is a complex and long-term task. In the DISKO project we treated the two in two separate modules.

DISKO module 2 was established as part of an OECD project on inter-firm interaction and this made it possible to compare different patterns in different countries. This analysis demonstrated that Danish firms were more strongly involved in inter-firm networking in connection with product innovation than firms from the other four countries—Norway, Spain, Austria and Canada.

Inter-sectoral knowledge flows in an input–output perspective. The most important results from this module have been reported in Ina Drejer's PhD thesis (Drejer, 1999). To track how different forms of knowledge—emanating from R&D and formal education—are produced and move from one sector to another is one useful way to get an overall picture of the innovation system as a whole. Comparing different states over time gives an understanding of what structural change means in the knowledge-based economy. Another important contribution to inter-sectoral flows of knowledge where the focus is on experience-based and embodied knowledge using labour market surveys is Tomlinson (1999).

Among the interesting results coming out of this module was the insight that business services now have become a kind of strategic sector playing a role similar to the role played historically by the sector producing machinery in the industrial economy. It was not possible to establish comparative analysis bringing in other countries.

Education system and the markets for labour and finance. As reported in Lundvall (2002) certain characteristics of the education system, the labour market and the financial markets are reflected in how firms organize learning and innovation.

The primary and secondary education gives strong emphasis on individual independence and combined with the low inequality in income in Denmark it implies "short power distance" in organizations. The labour market promotes mobility and labour market

training is a public responsibility. Combined with a basic social security net this gives a positive attitude to change in organizations—the fear of falling in between jobs is less than in other countries.

These characteristics tend to support a mode of innovation in firms where there is wide interaction among different categories of employees and among firms and where most innovations are incremental. The core of the system and its wider setting may co-evolve and attempts to manipulate one without changing the other may lead to "mismatch". The Lorenz and Valeyre analysis shows that Denmark together with the Netherlands are the countries where work is most frequently combining autonomy and learning.

Summing up. The most important results of the DISKO project were:

- The interaction between technical innovation in hardware and software on the one hand and human resources, organizational change and networking on the other is crucial both for innovation processes and for what degree innovation is transformed into economic performance.
- The constellations of human resources, organizational forms and network positions that promote innovation are very similar to those that promote adaptation and organizational learning.

As far as it was possible to pursue international comparisons we found important differences in the micro-structure of the innovation systems. Such differences could be seen as interdependent with the wider social setting in terms of education systems, labour markets and welfare regimes.

This led us to give more emphasis to the learning economy hypothesis and to introduce the NICS concept: "*the National Innovation and Competence building System*".

4. Innovation Systems and Economic Theory

In our discussion of the origin of the NSI concept it was made clear that the concept aimed at challenging standard economic theory not only regarding micro-economic aspects of innovation but also in relation to macro-economic explanations of economic growth. In this section we briefly indicate some of the key issues at stake.

4.1. Innovation Systems and Evolutionary Economics

National systems of innovation belong to a family of models forming evolutionary economics. Innovation systems may be defined in evolutionary terms with reference to how different national systems create diversity, reproduce routines and select firms, products and routines. It is also obvious that a focus on co-evolution of production structure, technology and institutions is useful when it comes to understanding the historical transformation of national innovation systems. I would argue though that the most important reason for seeing NSI as an evolutionary concept is the strategic role it gives to knowledge and learning. The analysis of innovation systems may be seen as an analysis of how knowledge evolves through processes of learning and innovation. The assumptions linking knowledge and learning to innovation systems are the following:

- Elements of knowledge important for economic performance are localized and cannot easily be moved from one place to another.
- Important elements of knowledge are embodied in the minds and bodies of agents, in routines of firms and in relationships between people and between organizations.
- Learning and innovation are best understood as the outcome of *interaction.* Perhaps the most basic characteristic of the innovation system approach is that it is "*interactionist*".[3]
- Interactive learning is a socially embedded process and that therefore a purely economic analysis is insufficient.
- Learning and innovation are strongly interconnected (but not identical) processes.
- National systems differ both in terms of specialization in production and trade and in terms of their knowledge base.

4.2. Theoretical Elements Entering into the Innovation System Concept

The National Innovation System approach has certainly been inspired by 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 feedback are crucial for the innovation performance of the firm while the Pavitt taxonomy helped us to see how different types of sectors interact and fulfil different functions in the overall 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 becomes 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). But databases and R&D statistics demonstrate that product innovations (innovations addressing needs of external users) are quite frequent in the market economy.

The only solution to this paradox 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—today we would add "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 (1988, 1993).

The next step was to realize that different national contexts offered disparate possibilities for establishing organized markets. A series of studies pointed, for instance, to the long-term development of selective inter-firm relationships in Japan and contrasted them with the arm's length relationships predominating in the Anglo Saxon countries (Dore, 1986; Freeman, 1987; Sako, 1990).

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[3] 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 and John Dewey.

This analysis of user–producer interaction was one of several analytical efforts to understand *innovation as an interactive process.* For instance "the chain-linked model", by Kline and Rosenberg (1986), was important because it gave specific form to 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.

4.3. 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: 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 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.

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

If, at all, agents are allowed to learn in a neo-classical model learning is either understood as getting access to more or more precise information about the world or it is a black-box phenomenon as in growth models assuming "learning by doing". The fundamental fact that agents—individuals as well as firms—*are more or less competent* in what they are doing and that they may learn how to become more competent 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 it seems as if 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).

Currently the major challenges in national innovation systems are to develop organizations, relationships and career patterns that promote competence building. It is recognized that some firms are much "better" at exploiting technological opportunities than others.[4] Here the innovation system's analysis departs from new growth theory. New growth theory may allow for learning by doing but in order to remain a member of the neo-classical family it has not allowed itself to give up the basic assumptions about rational profit maximizing representative firms.

[4] The empirical results based on Danish surveys reported in Lundvall (1999) are incompatible with a neo-classical world. They show that firms engage in innovation and organization when the competition intensifies and they also show that there are big differences in terms of performance between firms with "good" and "bad" organizational practices among firms operating in the same sectors.

4.4. The Theory behind Innovation Systems

As pointed out above, List was critical to the exaggerated focus on allocation as opposed to knowledge creation and growth. Table 2 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. What is proposed here is a double shift in focus which can be illustrated by Table 2.

Table 2 illustrates that learning as well as innovation, in principle, can be analysed in analytical frameworks closer to mainstream neo-classical economics. It is possible (but not logically satisfactory) to apply the principles of rational choice to the analysis of innovation. It may, for instance, be assumed that "management of innovation" is aiming at funds getting allocated to alternative R&D projects according to the private rate of return, taking into account the risk that the projects do not succeed.[5]

Austrian economics (Hayek and Kirzner) has the focus on allocation of scarce resources in common with neo-classical economics. 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 finding this state.

The analysis of innovation systems moves the focus toward the combination of innovation and learning. Innovation is seen as the outcome of efforts made or as a side effect of ongoing activities. Crucial for understanding how ongoing activities may result in innovation is the understanding of learning processes. On the other hand, innovation processes may be seen as processes of joint production where one output is innovation and the other a change in the competence of the involved agents.

The most important problem with the neo-classical theory is not 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. These processes remain as a crucial foundation for innovation system analysis. The focus is upon how enduring relationships and patterns of dependence and interaction are established and dissolved as time goes by. New competences are built while old ones are destroyed. At each point in time there are patterns of collaboration and communication that

Table 2. Four different perspectives in economic analysis

	Allocation	Innovation
Choice making	Standard neo-classical	Management of innovation
Learning	Austrian economics	Innovation systems

[5] Arrow has pointed out the obvious that innovation is a phenomenon not ideal for that kind of analysis because innovation has as its most fundamental characteristic that it gives rise to something that is not known in advance—and it is not possible to apply the principles of rational choice if the choice set is not defined in advance.

shape the innovation system but, of course, the system is also evolving in a process of creative destruction of both knowledge and relationships.

4.5. Some Ideas for the Future Theoretical Work on NSI

The NSI concept is flexible and open for different developments and ideally it might serve as a framework for bringing together different forms of specialized efforts in the field of innovation research and on the learning economy, what follows are just a couple of ideas among many.

As already mentioned under the discussion of "system" above the innovation process may be seen as an intricate interplay between micro and macro phenomena where macro-structures condition micro-dynamics and vice versa 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. There is a lot of theoretical work to do to model, measure and compare such processes across national borders.

An interesting challenge is to link entrepreneurship, seen as the classical driver of innovation, to the concept of innovation system. There is an inherent risk that "system" brings with it a structuralist mode of explanation that neglects the critical role of agency. The early work by Leibenstein on entrepreneurship and development (Leibenstein, 1968) constitutes an interesting starting point especially since his theory of x-efficiency constitutes an alternative to the theoretical universe of neo-classical economics. It also makes a distinction between "routine" and "new type" entrepreneurship and defines different entrepreneurial activities. It would be interesting to restate Leibenstein's ideas in contexts where learning and innovation are seen as more important than more intensified efforts.

A further step could be taken with inspiration from the organizational and managerial literature on organization situational and contingency fit and misfit (Gresov, 1989; Burton and Obel, 1998; Donaldson, 2001). The idea that organizations experiencing misfit between, for instance, environment and structural configuration will perform less well than those where there is a good fit could be tested on innovation systems. A similar set of ideas has already been developed by Christopher Freeman (1995a, 1997). But he analyses the problem in a historical perspective and puts the tension within system in terms of "match" and "mismatch".

With access to big data-sets and different advanced statistical methods it should be possible to make progress in this direction. It might also be helpful as an antidote to naive international benchmarking. The distinction between international environment, national wider setting and the core of the innovation system could be used to analyse both situational misfit (relating different dimensions of the wider setting to each other) and contingency misfit (relating the dimensions of the wider setting to the structural characteristics of the core).

The third research task is even more "fundamental". To get a deeper understanding of how knowledge and learning relate to innovation and economic performance is a major task in the current era. It has become commonplace among policy makers to refer to the current period as characterized by a knowledge-based economy and increasingly it is emphasized that the most promising strategy for economic growth is one aiming at strengthening the knowledge base of the economy. This discourse raises a number of unresolved analytical

issues. What constitutes the knowledge base? At what level can we locate and define a knowledge base? What are the specificities of local and sector-specific knowledge bases? How stable is the knowledge base?

How to organize empirical studies of innovation systems. When it comes to empirical work two parallel efforts to analyse innovation systems seem to dominate the picture currently (Balzat and Hanusch, 2003). One is focused on the performance of national innovation systems while the other is focused on comparing systems in more qualitative terms. Sometimes the first tends to neglect the systemic aspect and degenerates to looking for "general best practice" (Lundvall and Tomlinson, 2002) while the other emphasizes the unique systemic features of each single system. Research that bridges the gap between the two approaches may be especially important.

Recent empirical and methodological papers have come up with new ideas for how to study innovation systems. One idea developed originally in Liu and White (2001) and adopted and recommended by Edquist (2005) is that it is useful to organize the analysis according to different generic "functions". This might be useful especially when comparing systems with very different institutional set-ups—the USA and China for instance. But without theoretical backing and without making the assumptions on interdependencies between functions there is a risk that such a listing ends up with something similar to "growth accounting exercises".

Another approach was used in Park and Park (2003) where a great amount of data on the structure of production and the structure of R&D were pooled and analysed statistically in an exploratory way. One interesting conclusion put forward is that it is only when national R&D constitutes more than 2 per cent of GDP that we can identify a *system* of innovation. This conclusion seems to follow from a biased perspective on innovation where the STI side is emphasized and the DUI side is largely neglected. The idea of understanding innovation more as linked to the DUI side has led to the concept of national learning systems (Mathews, 2001).

Finally there is work in progress by Shin (2004) that argues convincingly in favour of a kind of pragmatic approach where the analytical concepts are adapted to the specific context be it a sector, region or an epoque. This is very much in line with the style of research that Christopher Freeman recommended in his pioneering paper on national innovation systems (Freeman, 1982).

Work on Social Systems of innovation (Amable *et al.*, 1997) and work on national business systems (Whitley, 1994, 1996) are important in this context since they tend to develop taxonomies where national systems are grouped according to how they are structured. Recent work on the micro-organizational basis for learning by Lorenz and Valeyre indicates that the systemic features distinguishing the taxonomic categories are rooted in different types of micro-organizational structures.

In various contexts we have introduced an interpretation of what actually takes place in the economy under the term "the learning economy" (Lundvall and Johnson, 1994; Lundvall and Nielsen, 1999). The learning economy concept signals that the most important change is not the more intensive use of knowledge in the economy but rather that knowledge becomes obsolete more rapidly than before; therefore, it is imperative that firms engage in organizational learning and that workers constantly develop new competencies.

This hypothesis needs to be developed and tested. A first step is to make distinctions between learning as information gathering and learning as competence building. A second step is to make a distinction between individual and organizational learning. The third step is to develop methods to measure learning processes, including processes of interactive learning and to relate them to innovation and economic performance. Here there is a need for openness to different disciplines. When it comes to understanding knowledge and learning economics is still at a very primitive stage (Lundvall, 2000).

The final major task is to adapt and develop the innovation system so that it becomes useful for analysing the innovation systems of developing economies. This will be discussed briefly in the last section of this paper.

5. National System of Innovation as Economic Development Tool

5.1. On the Need to Adapt the Concept

The system of innovation approach has been used mainly as an *ex post* rather than as an *ex ante* concept. It has been used to describe and compare relatively strong and diversified systems with well-developed institutional and infrastructure support of innovation activities. Usually the perspective has been that innovation processes are evolutionary and path dependent and systems of innovation evolve over time in a largely unplanned manner. The system of innovation approach has not, to the same extent, been applied to system building. When applied to the South the focus needs to be shifted in the direction of system construction and system promotion—something that was central in List's ideas for catching up—and to the fact that innovation policy is a conscious activity that needs to stimulate and supplement the spontaneous development of systems of innovation.

Another weakness of the system of innovation approach is that it is still lacking in its treatment of the power aspects of development. The focus on interactive learning—a process in which agents communicate and cooperate in the creation and utilization of new economically useful knowledge—may lead to an underestimation of the conflicts over income and power, which are also connected to the innovation process. Interactive learning and innovation may be positive sum games, in which everybody may gain. But in a global context where the access to technical knowledge is becoming restricted not only by weak "absorptive capacity" but also by more and more ambitious schemes to protect intellectual property worldwide this perspective gives a too rosy picture. Class privileges may block learning possibilities and existing competences may be destroyed for political reasons related to the distribution of power.

Furthermore, the relationships between globalization and national and local systems need to be further researched. It is important to know more about how globalization processes affect the possibilities to build and support national and local systems of innovation in developing countries. "Borrowing" and adapting technologies that the technological lead countries control today are important keys to development. The combination of reverse engineering, licensing, sending scholars abroad, inviting foreign firms and experts and engaging in international scientific collaboration may be difficult to achieve but all these elements need to be considered in building the national innovation system. When building such systems it is a major challenge to develop national strategies

that make it possible to select technologies and institutions from abroad that support innovation and competence building.

It is thus clear that the innovation system approach proposed here needs to be adapted to the situation in developing countries, if it is to be applied to system building. It is also clear that what is most relevant for developing economies is a broad definition of the NSI including not only low-tech industries but also primary sectors such as agriculture. While it is important for developing countries, especially the bigger ones, to build competence in new generic technologies related to information and pharmaceuticals activities contributing to competence building need to be taken into account and narrow innovation policy perspectives that focus only on the STI mode must be avoided.

5.2. Common Roots

The history and development of the concept of "national system of innovation" indicates that it can be useful for analysing less developed economies. Some of the basic ideas behind it go back to Friedrich List (List, 1841) and they were developed as the basis for a German "catching-up" strategy. His concept of "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, 1995b).

List's analysis focused on the development of productive forces rather than on allocation issues. He was critical and polemic to the "cosmopolitan" approach of Adam Smith, where free trade was assumed always to be to the advantage of the weak as well as the strong national economies. Referring to the "national production system", List pointed to the need 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. It was a perspective and a strategy for the "catching-up" economy of early 19th-century Germany.

The first written contribution that used the concept "national system of innovation" (Freeman, 1982), "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 technological infrastructure. It also discusses in critical terms under what circumstances free trade will promote economic development.

It is also interesting to note that while the modern version of the concept of national systems of innovation was developed mainly in rich countries (Lundvall, 1992; Nelson, 1993; Edquist, 1997) some of the most important elements in the concept actually came from the literature on development issues in the Third World. For instance, the Aalborg version (Andersen and Lundvall, 1988) got some of its inspiration concerning the interdependence between different sectors from Hirschman (1958) and Stewart (1977). Other encouragements come from Myrdal (1968).

To apply the NSI concept to developing countries may therefore be seen as a kind of "re-export". Gunnar Myrdal's ideas, inspired by Veblen and developed in *Asian Drama* (1968), of positive and negative feedback, cumulative causation, virtuous and vicious circles and the importance of institutions, are all easily reconciled with the idea of innovation systems and have to some extent inspired its development.

5.3. A Capability-Based Approach

Amartya Sen (1999) presents a capability-based approach where development is seen as an expansion of the substantive freedoms that people enjoy. Substantive freedoms are defined as the capabilities people have to live the kind of lives they have reason to value. They include things like being able to avoid starvation and undernourishment, diseases and premature mortality. It also includes the freedoms of being literate, able to participate in public life and in political processes, having the ability and possibility to work and to influence one's work conditions, having entrepreneurial freedom and possibilities to take economic decisions of different kinds. Enhancement of freedoms like these is seen as both the ends and means of development.

This way of looking at development refers to the capabilities people have to act and to choose a life they value, rather than to their level of income and possession of wealth. Poverty, for example, is in this perspective more a deprivation of basic capabilities than just low income. Human capabilities rather than resource endowments are the fundamental factors of development.

Sen's approach fits well into a system of innovation approach. It is noteworthy, however, that learning and innovation capabilities generally do not seem to be explicitly included in this capability-based approach to development. Extending capabilities may be the result of changing the setting in which the agent operates but even more important is if the setting gives incentives as well as opportunities for agents to engage in learning and competence building.

A similar "omission" seems to be common also in approaches, with a focus on information and knowledge. Expressions like "information divides", "technology divides" and "knowledge divides" between North and South have become common and accepted by dominating policy actors such as the World Bank. This is an important shift from earlier positions. As an aspect of a capability-based development concept, however, it may be more important to identify and analyse a learning and innovation divide between North and South. The learning divide, more than the technology divide, may, thus, be the crucial factor in the North/South relationship, which development policies have to take into account (Arocena and Sutz, 2000).

We have demonstrated that there is a close connection between learning and innovation. In economic terms development depends on technical and organizational change brought about by continued processes of innovation. Innovations introduce technical and organizational knowledge into the economy. We can think of them as "learning results" contributing to the removal of "unfreedoms" like ignorance, lack of learning opportunities and lack of economic opportunities and we can think of them as contributing to the enhancement of substantive freedoms like the capability to work, communicate, learn and to participate democratically in political processes. They are important means in the process of development.

The learning capability is thus one of the most important of the human capabilities. It does not only have an instrumental role in development but also, under certain conditions, substantive value. When learning takes place in such a way that it enhances the capability of individuals and collectives to utilize and coexist with their environment it contributes directly to human well-being. Furthermore, to be able to participate in learning and innovation at the workplace may be seen as "a good thing" contributing to a feeling of belonging and significance.

5.4. On the Sustainability of Innovation Systems

National Systems of Innovation may be regarded as a tool for analysing economic development and economic growth. It aims to explain how innovation and learning processes may be stimulated in such a way that they contribute to economic growth.

But such a perspective may be too narrow. As pointed out by Freeman (1997), the ecological challenge ought to be integrated in any strategy for economic development and here we will argue that in the learning economy not only intellectual capital but also social capital are important elements in the development process. The extended perspective can be introduced as in Table 3.

The table illustrates that economic growth is faced with a double challenge in terms of sustainability and that there is an immanent risk of undermining not only the material basis of material production. The creation of tangible capital may be threatened by a neglect of environmental sustainability. We will argue that the production and efficient use of intellectual capital is fundamentally dependent upon social capital. A development strategy that focuses only on production capital and intellectual capital may not be sustainable.

This is equally true for developed as for developing economies. But in most developed economies there has been a long history of institution building that helps to cope with sustainability (Russia is a case where there is imbalance between the level of technical development and institutions checking unsustainable development). Even if they are insufficient in many respects these kinds of institutions are more developed than in the developing part of the world. A success in terms of economic growth in a less developed economy may therefore create extreme tension between growth and sustainability. Directing the efforts of the innovation system toward solving crises in ecological and social terms may be necessary in order to avoid real "limits to growth".

Innovation may have a positive role in bolstering sustainability. Technical innovation, for instance, in terms of developing substitutes to naturally scarce raw products, may help to overcome the fact that natural capital cannot always be reproduced. In a similar vein new social institutions may help to overcome a crisis where social capital is foundering. In both cases it is important to note that the workings of unhampered market forces may in the longer term erode the basis of economic growth.

This perspective indicates a broader and more interdisciplinary approach to economic growth than standard economics. It also differs in being more explicit in terms of the institutional assumptions made and especially in avoiding any assumption about factors being independent. This reflects the system's perspective and the emphasis on virtuous and vicious circles or match and mismatch between elements and subsystems.

Table 3. Resources fundamental for economic growth—combining the tangible and reproducible dimensions

	Easily reproducible resources	Less reproducible resources
Tangible resources	1. Production capital	2. Natural capital
Intangible resources	3. Intellectual capital	4. Social capital

5.5. How to Study Innovation Systems in Developing Countries

The approach used in the DISKO project presented above may, for different reasons, appear to be difficult to apply when it comes to studying the reality of less developed countries. First the population of firms is less engaged in innovation and learning to begin with. This has led some scholars to argue in favour of the concept *national technological system* for instance when referring to sub-Saharan African countries (Lall and Pietrobelli, 2003). I largely agree with their analysis but I would argue that the broader understanding of innovation as including the diffusion, adaptation and use of new technology, proposed here, would make it less necessary to develop an alternative terminology for less developed countries.

Second it might be virtually impossible to gather data on what goes on inside firms through surveys and register data may also be scarce and unreliable. The standard indicators on research, innovation and competence may not capture the reality of the innovation systems. To find ways to define the embryonic elements of the innovation process is therefore a challenge and to develop alternative indicators that capture these elements is a major challenge and probably this needs to be done through testing different concepts and ideas in empirical work. Innovative approaches of data gathering using students as scouts and trying out mini-questionnaires in close interaction with firms may be helpful.

In developing countries it is easier to map and analyse public infrastructures and what goes on in the public sphere than it is to study what takes place in the core of the system. Even so I believe that keeping the firm in focus is crucial for understanding what works and what does not work in the national innovation system. The experience from the former Soviet Union as well as from middle income developing countries is that the separation and lack of interaction between the knowledge infrastructure and the firms is the most important element slowing down processes of learning and competence building with relevance for economic development.

One important dimension is the use of educated labour inside firms. Higher education and training systems that address only public administration or produce large numbers of unemployed scholars are not sustainable in the long run and it is a problem that in developing countries industry's "effective demand" for highly skilled labour is quite limited. Innovative approaches and experiments stimulating the interaction between students and industry during their period of study combined with problem-based learning bringing in problems from the external world may be more important than more glamorous policy initiatives such as "science parks" when it comes to stimulate knowledge transfer. Studying "good practice" in these respects could be an important part of the system analysis. A similar perspective on the international inwards and outwards mobility of highly trained workers is important because such movements of people may be one of the most important vehicles of bringing new technology and new ideas into the system.

6. Concluding Remarks—Reflections on Where to Go from Here

I believe that the most efficient way to enhance the analytical capacity of the NICS concept is to use it as a framework for empirical work making use of what we already know. Much of the work so far has been too descriptive and the outcome has often been a description of

formal organizations directly contributing to the STI mode of innovation sometimes combined with reports on STI policy. These kind of studies need to be developed in two different directions.

First, it is useful to get a better understanding of what goes on inside and between firms in connection with innovation and competence building. The first attempts in this direction tend to indicate that there are important international differences at this level and that those may be crucial for the way the innovation system as a whole is working. They indicate different modes of innovation and learning that may be more or less well suited to pursue certain types of innovation. Without knowledge about the micro-structures we might get little out of attempts to manipulate institutions and organizations at the meso- and macro-level.

Second, there is a need to understand how the core of the innovation system is embedded in the wider set of institutions that shape people and relationships between people. Education systems, welfare regimes, labour markets and financial markets may be more or less supportive to the micro-structure. The core of the innovation system may evolve at a more rapid rate than the wider setting making radical reform necessary. On the other hand there is a lot of slack and incompetence in the micro-structure and changes in the wider setting may be helpful to overcome such weaknesses.

In developing countries the material conditions are sometimes so difficult for people that the primary focus should be on creating order and basic living conditions. This may be a precondition for people's incentives and opportunities to engage in learning new competences and become innovative. On the other hand there is little doubt that the long-term effort to promote economic development needs to be oriented towards competence building and innovation also in what may appear to be a dismal situation.

But perhaps what seems like a contradiction may be eased by a simultaneous focus on basic living conditions and competence building. Building institutions to create order and stable living conditions is necessary to give people the opportunity and incentives to engage in learning new competences. But such institution cannot be built without engaging people in competence building and learning. Seen in that light learning and innovation are not luxuries but necessary and basic processes, which have to be parallel to and interact with poverty alleviation (for the case of China see Gu and Lundvall, 2006).

A classical question in the development literature is what role the state should play in the promotion of economic development. Seen from a historical perspective there is strong evidence that there is a need for the mobilization of autonomous forces outside the market to create economic development. Some of the development pessimism in certain regions, not least Africa, reflects that in many countries the state is in the hands of vested interests with little motivation to create the necessary institutional setting for learning and innovation. Here "radical social innovations" brought about by social movements might be necessary to overcome the stalemate.

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