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NATIONAL INNOVATION SYSTEMS - ANALYTICAL CONCEPT AND DEVELOPMENT TOOL

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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 scholars all over the world. In this lecture I will take stock and look ahead from a rather personal point of view. I will give some insight in why the concept came about and give some space to criticism and self-criticism. I will mention but certainly not give justice to alternative conceptualizations of innovation system.
In the paper I reflect on the origin and use of the national innovation system concept in terms of theory and practice. I will argue that the concept has some characteristics in common with an engineering approach but also with critical theory and grounded theory. The intuition behind the Aalborg-version of the NSI-concept pointed in the right direction but the concept was certainly not fully worked out when first introduced. Some of the major weaknesses have been repaired but some remain.
In the paper I criticize attempts to make the concept 'more rigorous' through organizing the definition and analysis around a list of 'functions', 'factors' and 'activities' and I present the principles used to organize the Danish DISKO-project as an alternative and less agnostic

approach.[1] Here a *core* of the system is defined and it is illustrated that it is necessary to both to understand *micro-behavior* in the core and understand '*the wider setting'* within which the core operates.
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.

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National Innovation Systems - Analytical Concept and Development Tool

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Second version of paper to be presented at the DRUID-conference in Copenhagen June 27-June 29, 2005

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In the paper I criticize attempts to make the concept 'more rigorous' through organizing the definition and analysis around a list of 'functions', 'factors' and 'activities' and I present the principles used to organize the Danish DISKO-project as an alternative and less agnostic approach.[1] Here a *core* of the system is defined and it is illustrated that it is necessary to both to understand *micro-behavior* in the core and understand '*the wider setting'* within which the core operates.

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I. Introduction

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 scholars all over the world. In this lecture I will take stock and look ahead from a personal point of view. I will give some insight in why and how the concept came about and give some space to criticism and self-criticism. I will mention but certainly not give justice to alternative conceptualizations of innovation system.

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I.1 The Origin of the Concept

The innovation system concept was developed in parallel at different places in Europe and in the US in the eighties. There is no doubt that the collaboration between Christopher Freeman and the IKE-group in Aalborg in the beginning of the eighties was important in coining and shaping the earliest versions of the concept (Freeman 1982 and Lundvall 1985) but the basic ingredients and the inspiration may be found in the work of many other innovation scholars before that.

Freeman brought deep understanding of innovation processes, historical insight and wisdom to the collaboration. His reference to Friedrich List was crucial since it linked the concept to the role of the state in 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 crucial for performance and outcome and linked this to the analysis of international specialisation 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 on innovation. My own starting point was actually the analysis of slack and diversity at the level the firm.

The 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 by Freeman, Nelson, Lundvall and Pelikan (Dosi et al 1988).[2] More recentstandard references on national systems of innovations are three books edited by Lundvall (1992), Nelson (1993) and Edquist (1996). 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 and 1996).

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. Bo Carlsson with colleagues from Sweden developed the concept 'technological systems' in the beginning of the nineties (Carlsson and Stankiewitz, 1993). The literature on 'regional systems of innovation' has grown rapidly since the middle of the nineties (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&Leydesdorff's Triple Helix-concept (Etzkowitz and Leydesdorff 2000).

[2] Actually the prominent presentation of NSI in a specific section of the Dosi-book that played an important role in diffusing the concept was the accidental outcome of difficulties to find a suitable structure for the book as the whole.

I.2 The hidden agenda

Following the definitions made by Mjøset (see below) I would argue that the concept reflected grounded theory. It was based upon an accumulation of empirical studies at different levels of aggregation showing that innovation is an interactive process.

> 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, p. 41).

As we will demonstrate the progress made since the concept was first introduced has also been rooted in empirical work. I see the DISKO-project as a test of many of the central ideas connected to the concept. As a result of the empirical work we have proposed a redefinition of the concept giving stronger emphasis to people, organisations 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, p. 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.

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.[3] We saw dubious policy strategies as based upon static standard economics and the need to establish an alternative analytical foundation.

I believe that Christopher Freeman would agree that our research reflects that we share an interest for the practice of economic policy. We are not afraid of developing ideas that might be used in the design of economic policy, well aware that the ideas can not be fully founded in irrefutable formal theory. Somebody might refer to this as a 'social engineering' approach – and it is correct that engineering is more about what works than about what can be formally explained. I would like to add 'critical' to this concept and argue that what we aim at is 'critical social engineering with theoretical ambitions'.

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[3] For these reasons especially non-economists may be confused by the concept, as presented originally, since it kept the focus on national economic performance while at the same time bringing into the analysis wider categories, such as knowledge and learning: Concepts that are much more developed in other disciplines than economics.

This specification of the agenda might be useful when it comes to understand why the concept was developed in the way it was and it will also be reflected in what I am going to say about where to go from here.

I.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 machines such as Google and Scholar Google. Using variations on 'national system of innovation' as term for the search you find about 50.000 hits on Google and about 5000 on Scholar Google.

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 US, 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 co-operation 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.

Box 1: Miettinen on National Innovation Systems

In a booklet from 2002 Reijo Miettinen gives a critical assessment of the NSI-concept. The discussion of 'transdiscursive' terms that cross the world of academia with the world of policy makers is especially intriguing and illuminating.

The author makes many strong critical points where it is difficult to disagree. His criticism of the use of the concept in policy making in Finland is quite convincing. In the context of its epistemological use I agree on three of his major points:

- Understanding interactive learning and knowledge calls for other disciplines than economics.
- Future research on innovation has to go into more detail referring to specific clusters, regions and technologies rather than remain at an aggregate national system's level.
- A 'scientification approach' that declares the intention to establish complete and final explanations of national innovation performance is not commendable.

There are two points where his arguments call for closer scrutiny. He rightly points out that 'the system' term of the concept is vague and that interactive learning could be seen as leading to 'network level' rather than to 'system level'. It is also true that the attempts to anchor 'system' in general system theory or in biology have not been successful. Should we therefore adopt the concept 'national innovation networks'? Here I would, in spite of the problems raised, prefer the current terminology. Alternatively I would prefer the cumbersome 'national innovation socio-economic formations'.

Some of his criticism takes on an unnecessarily polemic form – he repeats again and again a quote where Edquist says that the NSI-concept is 'conceptually diffuse and ambiguous'. He contrasts it with academic work as aiming at 'conceptual coherence, empirical accountability and solid theoretical foundations'. Here I see a risk that first Edquist and then Miettinen become victims for a different kind of scientification. Some of the conceptual openness of the term NSI refers to the fact that historical and local context affects where the limits of innovation systems are set. I do not see this as being in conflict with academic ideals – on the contrary. If it would exclude analytical tools that may be adapted to historical and local context I would accept to live without 'solid theoretical foundations'.

This wide diffusion 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 practise.

I would argue that the most 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. 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.[4]

The second and more generally recognised 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' to 'Innovation policy' (see Lundvall and Borras 2004 for an overview). This has extended the traditional set of policy instruments with more attention to building linkages and strengthening the absorptive capacity of users. I think that much of what has been done in terms of policy development along these lines has been helpful in promoting learning and utilising knowledge more widely.

But there are also examples of misunderstandings and crude interpretations. One of the most obvious problematic areas is the relationship between university and industry. Here local tendencies in pharmaceuticals and biotechnology in the US have been generalised 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. At the European level 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.

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 generalising '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. Another problem is that, 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 idea that 'interactive learning' within and between firms belonging to low technology sectors matters for innovation and competitiveness has not been reflected in the development of European innovation policy.

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[4] Since the wide acceptance of the concept in the developed world moved the attention toward knowledge and learning as strategic factors for international competitiveness the introduction of the concept may actually have – against our original intentions - deepened the gap between the North West and the rest of the world. This is one reason why I see it as important to support GLOBELICS – the Global network on Innovation and Competence building Systems.

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. 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. Specialised labour in the local labour market, the local knowledge infrastructure and spin-offs from local firms seem to be as important or more important as compared to inter-organisational 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. Attempts to correct the users are not always welcome and not always successful. I have taken part in Danish debates and written on the role of universities in Lundvall (2002) but the impact has been limited. I have criticized the bias toward the STI-mode of innovation at the EU-level and proposed a different structure of the Framework program giving legitimate spaces for basic research, science-based innovation and experience-based innovation. Again the forces that prefer a policy that focus on the STI-mode are strong.[5]

I.4 NSI - a strange combination with great rhetorical power

The combination of elements forming the NSI-concept makes it highly 'dialectical'. Some have found this very disturbing and argue that it is a contradiction in terms. Innovation signals discontinuity while 'system' is associated with a stable structure. In a sense one might see this tension as akin to the one built into Anthony Giddens' 'structuration theory' where it is assumed that agents shape social structure while social structure shapes the actions of the agents.

It might also be seen as 'Schumpeter Mark III' (not designed by Schumpeter though). While Mark I referred to individual entrepreneurs, Mark II referred to big corporations as major drivers of innovation and growth. The innovation system perspective brings in a broader set of actors and institutions as shaping the innovation process. It takes collective entrepreneurship one step further by bringing networking among firms and knowledge institutions into the picture.

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 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

[5] The concepts STI-mode and DUI-mode of innovation will be discussed below.

to use ‘national’ explicitly in the NSI-term and as we shall argue below it may be especially useful in the current context where ‘globalisation’ is seen as a major new trend.

Perhaps the concept has been so widely spread because of its dialectical character. It provokes traditional ways of thinking that are based either on models of stable reproduction, incremental change or radical ‘saltationist’ change and it brings the national level into the picture in a period where the nation states are exposed to a dramatic transformation pressure. This may explain why it got what Miettinen refers to as great rhetorical power.

1.5 Is NSI a fruitful combination?

Looking back it might be asked if ‘the national system of innovation’ was the best way to characterise what we wanted to capture by the concept. 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 – very much focused on the national level - it was not an option to delete ‘national’ from NSI. I also believe that it has become even more important to be explicit about the national dimension as ‘globalisation’ becomes a major theme in the societal discourse. To cope with the problems connected with globalisation and the formation of the European Union calls for an understanding of the historical role of national systems. The analysis of how different countries differ in terms of institutional set ups supporting innovation and learning is important in this context.

Rather I would see as more debatable our use of the term ‘system’. System appears in different social and academic discourses. Mechanistic versions indicate something that can be constructed, governed and manipulated by policy makers. Understanding systems as being complex and characterised by co-evolution and self-organising brings us closer to what we wanted to signal with our ideas. But it is true that we did not give any sophisticated specification of the theoretical status of ‘system’ in 1992. Mechanistic interpretations of system may be seen in regional development strategies based upon the assumption that ‘clusters’ and ‘regional systems’ may be built from scratch through policy initiatives.

What about the ‘innovation’ part of the concept? How innovation is defined is as we shall see crucial for where we draw the limits of the innovation system. I would argue that it is through a better understanding of innovation, learning and knowledge that progress can be made in making the NSI concept more pregnant. This will be the theme of much of this lecture.

1.6 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 as something brought to the market by the entrepreneur and it can be specified as respectively new products, new processes, new raw materials, new forms of organisation and new markets. I do not find the last listing very useful because it mixes different categories that it is useful to keep separate.

To distinguish between technical change and organisational change is often difficult in real life but I find this analytical distinction important and useful for two reasons. First the way the economy and the firm is organised will have 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 training and organisational 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 for the 'wetware' term since it reificates human beings but despite that I will build upon his handy conceptual scheme in what follows. I propose to add 'orgware' and 'socware' as referring to how people relate to each other within and across organisational borders. Innovation is about discontinuities in the technical characteristics of hardware and soft-ware. But the impact of innovation on economic performance will typically depend upon changes in 'wetware', 'orgware' and 'socware'. To avoid confusion I would prefer not to refer to changes in these dimensions as innovations.

It is well known that technical innovation is a cumulative and path-dependent process. Often it is not possible to distinguish the innovation as an event from its diffusion and use. New products and new processes will have to go through a process of broader use in order to be made attractive and more widely used. On this basis I prefer to define innovation as a process encompassing:

1. The discontinuity in the technical characteristics or in the use of a new product or process.
2. The introduction, diffusion and adaptation of the new artefact.

In order to understand the economics of innovation it is necessary to relate innovation to changes in the wetware, orgware and socware either triggered by the development, diffusion and adaptation of the new artefact or constituting prerequisites for these processes.

1.7 The high technology bias and modes of innovation

Given the definitions above, innovation and innovation policy is not of interest only for industries that invest intensively in R&D. industries. But all the same there has been a certain bias in the direction of these so-called High Technology industries. Keith Smith and other innovation scholars have 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. On the other hand empirical work shows that it is fundamental for the performance of firms in high technology industries to engage in organisational learning.

To clarify these relationships we have developed a distinction between two modes of innovation. On the one hand innovation activities may give main emphasis to promoting R&D, utilising 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, Johnson, Lorenz and Lundvall 2004).

My point here is that the innovation system needs to encompass all combinations of high and low technology industries as well as all elements that refer to the two modes of innovation (se diagram 1):

Diagram 1: Dimensions of the innovation system

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

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 most of 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.

At this stage I will argue that the distinction between the two modes of innovation is useful when it comes to define the borders of the innovation system. Later on I will show that the two modes of innovation are highly complementary.

National systems of innovation 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 understand 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. As I see it the assumptions forming the core of the concept are the following:

A first assumption is that elements of knowledge important for economic performance are localized and cannot easily moved from one place to another.

A second assumption is that important elements of knowledge are embodied in the minds and bodies of agents, in routines of firms and in relationships between people and organizations.

A third assumption is that learning and innovation is best understood as the outcome of *interaction*. Perhaps the most basic characteristic of the innovation system approach is that it is *'interactionist'*.[6]

[6] 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.

A fourth assumption is that interactive learning is a socially embedded process and that therefore a purely economic analysis is insufficient.

A fifth assumption is that learning and innovation are strongly interconnected (but not identical) processes.

A sixth assumption is that national systems differ in terms of specialization both in production and trade and in terms of knowledge base.

A seventh assumption is that national systems are systemic in the sense that the different elements are interdependent and that interrelationships matter for innovation performance.

Box 2: Is the National System of Innovation an Evolutionary Concept?

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A seventh assumption is that national systems are systemic in the sense that the different elements are interdependent and that interrelationships matter for innovation performance.

Most of these ideas were hinted at already in the introduction to Lundvall (1992) where it was stated that 'the most important resource in the economy is knowledge and the most important process is learning'. But at that time the ideas were presented in an intuitive and crude form. Basically the references to knowledge and learning were still presented as 'black-box' concepts and at best they could be seen as 'finger-posts' indicating future research agendas.

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I.8 Innovation and learning

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

Authors from the US having a background in studying science and technology policy, tend to focus the analysis 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 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 seldom the broader set of institutions shaping competence building in the economy such as education of ordinary workers, industrial relations and labour market dynamics. The interaction and relationships at the centre of the analysis is the one between knowledge institutions and firms.

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 there are other major sources of innovation than science. Innovation is seen as reflecting interactive learning taking place in connection with on-going activities in production and sales. Therefore the analysis takes its starting point in the process of production and the process of product development assuming, for instance, that the interaction with users is fundamental for product innovation.

To a certain degree, these differences in focus reflect the national origin of the analysts. In small countries such as Denmark, as in developing countries – a 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. Incremental innovation, 'absorptive capacity' and economic performance will typically reflect the skills and motivation of employees as well as inter- and intra-organisational relationships and characteristics. Science-based sectors may be rapidly growing but their shares of total employment and exports remain relatively small.

In the US, aggregate economic growth is more directly connected with the expansion of science-based sectors. In these sectors big US-firms have an international lead and they introduce radical innovation in areas where the interaction with science is crucial for success. Even so, it may be argued that the broader approach could be useful also in the US since some of the weaknesses of the US-system may reflect the limited mobilization of employees in processes of technical and organizational change and a general weakness when it comes to establish co-operation between people and firms. This was actually one of the major conclusions from the 'Made in America' MIT-study (Dertoutzos et al 1989).

Another factor explaining the difference may be that the ambition of the analysis is different. When the analysis addresses STI-policy issues the need for a broader perspective is less obvious than when it addresses issues having to do with economic performance in terms of economic growth and international competitiveness.

I.9 Defining the innovation system through its functions/activities/factors

In a number of contributions, most recently in Edquist (2005), Charles Edquist has argued that the lack of agreement on where to draw the lines around the innovation system makes the concept 'diffuse' and that this lack of clarity constitutes a barrier for further progress toward a more 'rigorous' and 'theoretical' concept. The way he contributes to a more rigorous analysis in Edquist (2005) is through proposing a distinction between organisations on the one hand and activities/functions/factors influencing innovation. Rather than defining the system as constituted by organisations it should be defined by specifying different functions. He lists ten such activities/functions/factors influencing innovation (see box 2 for a brief version of his 10 factors).

Box 3: Edquists 10 activities/functions/factors influencing innovation

1. Research and development*
2. Competence building*
3. Formation of new product markets
4. Articulation of user needs
5. Creation and change of organisations
6. Networking around knowledge
7. Creating and changing institutions
8. Incubating activities*
9. Financing innovation*
10. Consultancy services*

It is true that all factors on the list may be seen as contributing to or being media for innovation. And the point made that the same activity (appearing in the list with * - as R&D, competence building, incubating activities and consultancy services and finance) may be organised differently in different national systems is certainly relevant. The other five elements are difficult so see as 'activities' and therefore difficult to see as 'organised' by any specific type of organisation. But, even so, to conclude that agreeing on such a list is the most useful way to 'create rigour' and scientific progress might not be correct. Several other activities/functions/factors influencing innovation could be listed (five candidates that might enter the top ten as 'factors influencing innovation' are: competition, openness to international trade and capital flows, labour market dynamics, social welfare systems and the quality of social capital). Saying that further research will help us converge on the right ones is not a useful response to this selection problem.

The listing reminds of the 'growth accounting' exercises where attempts were made to reduce the relative size of the 'residual'. It has in common with such efforts a certain agnostic approach where all factors are treated as equally important and without systematically linking them to each other. In this sense it a move toward less theory rather than one toward more theory. This is reflected in the disturbing lack of consistency in the list, i.e. the heterogeneous character of its elements. This reflects that, Edquist actually *exaggerates what we do not know and defers from drawing upon what we do know regarding innovation*. Theoretical debates and empirical results can bring us to a more structured 'model' of the innovation system than his list of activities/functions/factors influencing innovation.

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 stylised 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 performance how firms organise 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 of these shape wetware, orgware and socware.

4. We know that firms belonging to different sectors contribute differently to innovation processes and that they differ in how they innovate, interact with other firms, interact with the knowledge infrastructure and draw upon markets for labour, finance an 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, co-operation 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 organisation and network positioning may be used to 'explain' the specialisation and 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.*

Edquists says that 'Within a geographical area the whole socio-economic system cannot, of course, be considered to be included in the SI.' (op. cit. p.200). I would say yes and no to this apparently self-evident observation. It is possible to focus on the aggregate of firms as being the core and the central motor in the innovation system and to see their linkages to each other and to the knowledge infrastructure, to venture capital and to markets for highly skilled labor. But most parts of the socio-economic system may actually influence how this motor works and not least how it affects the economy as a whole.

It might correspond to the fact that medical 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 has to revise methods and explanations when confronted with new results from genetic and microbiology studies or that she recognizes that blood pressure and heart rhythm will reflect as a wider setting the life style of the patient – including drinking, smoking and jogging. Neglecting these 'external' factors 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.

It should be observed that this disagreement with Edquist reflects, to some degree, that I do not see the ultimate objective of the research as 'explaining innovation' but rather as 'explaining innovation and how innovation affects economic performance'. I hereby refer back to the intention behind the original version of the NSI-concept.

1.10 The Disko project as illustration

When I returned to academia from OECD 1995 I was invited to organise a project on The Danish Innovation System in Comparative Perspective – the so-called Disko-project (Lundvall 2002).[8] The project was organised largely according to the principles laid out above. In the project the research team (more than 15 scholars working together for more than three years) worked in four 'modules':

Module 1: The firm – product competition, competence building, organisation, innovative activities

Module 2: Inter-firm relationships and interaction with the knowledge infrastructure in the context of product innovation

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 that had an impact on product innovations in Danish firms. The empirical material gathered in 1996 included a major survey with 2000 firms in the final data

[8] The DISKO-project was successful in different respects. 4-5 Ph.D.-dissertation were based on the data sets gathered in the project and the project ended with a policy document worked out by the authority that contracted the project. This document had a major impact on the long term strategy of the social democratic government (a government that did not last long after the strategy had been launched). Even so, I would not argue that DISKO represents the only or best way to study innovation systems. Under all circumstances I would recommend to combine it with a historical analysis of the role of the state, the creation and evolution of institutions, the international specialization and the co-evolution of major sectors – primary, secondary and tertiary. Without such historical perspective it is difficult to understand the current features of the NSI.

set as well as register data for those firms. One of the most important results was that characteristics that are associated with 'learning organisations' – interdivisional teams, job rotation, autonomy in work and investment in training – seemed to have a major impact on innovation. Organisational forms promoting learning seem to be overlapping with the forms that promote innovation.

In a more recent analysis on the basis of a new data set gathered year 2000 according to the same principles we have made an attempt to get more insight in how different modes of innovation affect innovation performance. We have defined two different modes of innovation. On the one hand there are innovation strategies (STI-mode of innovation) that give main emphasis to promoting R&D and creating access to explicit codified knowledge. On the other hand there are innovation strategies (DUI-mode of innovation) that are mainly based on learning by doing, using and interaction. 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, Johnson, Lorenz and Lundvall 2004).

Table 1: 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	1.446	0.3689	1.5059	0.2198
DUI Cluster	2.389	0.8707	10.5767	0.0011
DUI/STI Cluster	4.374	1.4756	32.6970	<.0001
Business services	1.508	0.4105	1.3580	0.2439
Construction	0.435	-0.8314	5.7116	0.0169
Manufacturing (high tech)	1.777	0.5752	3.6585	0.0558
Manufacturing (low tech)	1.366	0.3122	1.3540	0.2446
Other services	0.635	-0.4545	1.1418	0.2853
100 and more employees	1.860	0.6204	6.6516	0.0099
50-99 employees	0.956	-0.0447	0.0382	0.8449
Danish group	0.664	-0.4090	2.1723	0.1405
Single firm	0.392	-0.9356	11.2917	0.0008
Customised product	1.636	0.4924	5.3128	0.0212

Using latent class analysis we established four clusters of firms and we found that the firms that combined the two modes were much more active in terms of product innovation than the ones that were weak in both modes (used as benchmark in Table 1). Another interesting result was that those with a predominantly experience based learning mode were more innovative than those with a

predominantly science-based mode of learning. These results are interesting because they indicate that the way firms organise themselves internally and the way they position themselves in networks have a major impact on their innovation activities. A major implication is that getting more insight in how the organisational patterns differ across national systems is of fundamental importance.

A weakness with module 1 was that it proved difficult to establish comparative data internationally The data for Denmark where we combined survey with register data could not be mobilised from other countries. Recent work by Lorenz and Valeyre is highly relevant in this context.

Their research is based on the results of the third European survey on Working Conditions undertaken by the European Foundation for the Improvement of Living and Working Conditions. The survey was carried out in each of the 15 member states of the European Union in March 2000. The analysis of forms of work organisation is based on the responses of the 8081 salaried employees working in establishments with at least 10 persons in both industry and services, but excluding agriculture and fishing; public administration and social security; education; health and social work; and private domestic employees.

Using factor analysis on the responses on working life and work organisation the authors construct four clusters:

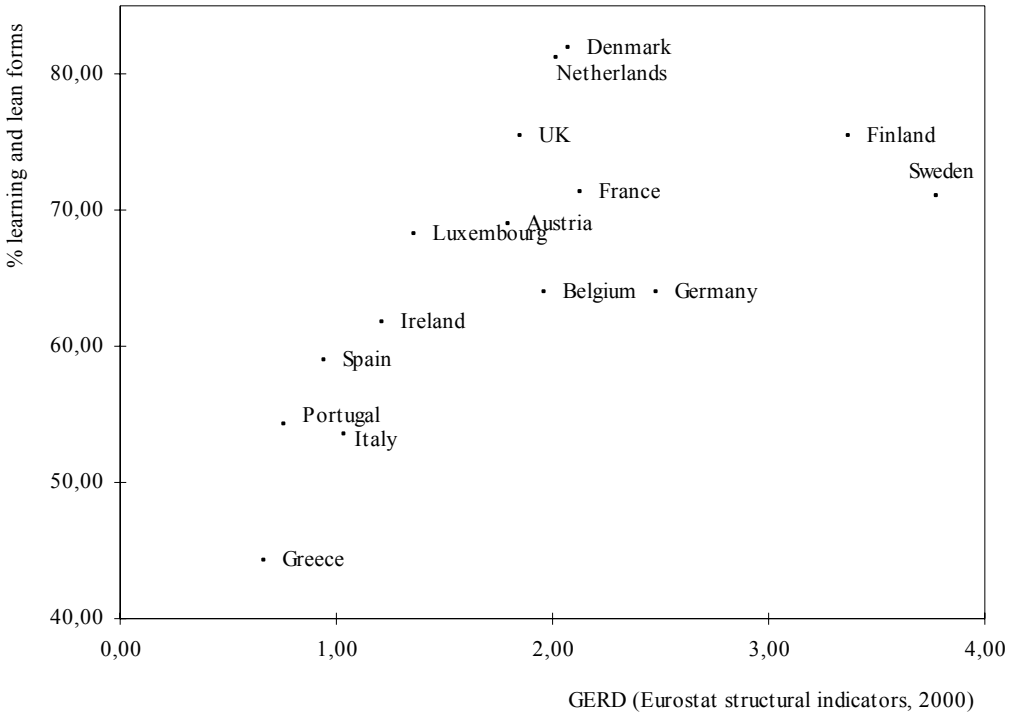
- Discretionary learning model (frequent learning and a high degree of autonomy)
- Lean production (Some learning, modern management techniques and a low degree of autonomy)
- Taylorism (Little learning and very low degree of autonomy)
- Traditional organisation (Little learning and some autonomy)

The analysis demonstrates that the form of work organisation, including the access to learning in working life, is very different in different parts of Europe. After correcting for sector and job position significant differences remain between Netherlands, Austria and the Nordic Countries where there is an overrepresentation of discretionary learning, the UK, Ireland and Spain where there is a strong presence of lean production and southern Europe where Taylorism and traditional organisations are overrepresented.

Diagram 2 shows, not surprisingly, a positive correlation between the combined importance of the learning and lean models and a standard measure of a nation's innovative effort, gross expenditures on research and development as a percent of GDP (GERD).

Close inspection of Figure 1, however, suggests that the positive correlations identified can be explained by the presence of the 4 southern European nations. If we restrict our attention to the Nordic and central and western European nations, which on average have much higher R&D expenditures, there is no obvious relation between the variables. An interesting interpretation would be that the STI-mode of learning plays a more important role in countries such as Sweden and Finland while the DUI-mode is more developed in countries such as Netherlands and Denmark.

Diagram 2: The frequency of learning organisations and the R&D-intensity in 15 European economies.



I would propose that more systematic international comparisons of how firms organise themselves differently in the context of innovation and learning in different national systems is a major task for innovation system analysis. It is more difficult to capture such differences than it is to map the national technological infrastructure and to describe the most recent tendencies in STI-policy. But it is necessary in order to understand the micro-foundation of national systems of innovation. A realistic understanding of the micro-foundation may than be used to consider what kind of incentives that might work in the economy (cf. implications for medicine of microbiology and genetic engineering).

Interfirm interaction

In the original version of the national system of innovation concept we referred to the interrelationships between organisations, especially user-producer relationships, as the micro-foundation. Today I would argue that we should aim at an analysis that links together the internal organisation 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.

While the analysis at the firm level covered firms in all parts of the private sector with the exception of agriculture most of the specific analysis of inter-firm relationships covered only manufacturing firms. The most important results have been reported in the Ph.D.-thesis by Anker Lund Vinding (Vinding 2002) and in a recent book on product innovation, interactive learning and economic performance (Christensen and Lundvall 2004).

Vinding confirms most of the hypotheses on the importance of interactive learning in the context of product innovation that were behind the original work on innovation systems (Lundvall 1992).

Firms do interact with other firms when they develop new products and there are long term relationships to many of the partners. Domestic interaction is more frequent than international interaction (but the international relations are referred to as more important).

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..

Comparing the pattern of interaction between firms and knowledge institutions also indicated international differences. Here Denmark appeared to be the single country where firms were the least involved in an interaction with universities. To some degree we ascribed this result to the small size of firms and to the fact that technological institutes were substituting for universities.

Vinding made an interesting further analysis showing that for SMEs operating in traditional sector the contact to universities and the presence of academic personnel in the firm made a major difference for their innovative capabilities. His results indicate that stimulating the STI-mode has a strong effect on innovation especially in low technology sectors.

Inter-sectoral knowledge flows in an input-output perspective

The most important results from this module have been reported in Ina Drejers Ph.D.-thesis (Drejer 2000). To track how different forms of knowledge – emanating from R&D and formal education - is produced and move from one sector to another is one useful way to get an over all picture of the innovation system as a whole. Comparing different states over time gives a an understanding of what structural change means in the knowledge based economy.

Among interesting results coming out of this module was the insight that business services now has become a kind of strategic sector playing a role similar to the role played historically by the sector producing machinery in the industrial economy. Again 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 organise 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 organisations.

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 organisations – the fear of falling in between jobs is less than in other countries.

The history of capital accumulation with co-operative ownership and foundations as owners of major firms has resulted in a limited presence of big finance (A.P. Møller is an exception), low concentration of production and a weakly developed capital market. This has forced firms to engage in industrial networks while the high frequency of small firms limit the interaction with universities.

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'.

Summing up
The most important result of the DISKO-project were:

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

As far as it was possible to pursue international comparisons we found important differences in the microstructure 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*'.

II. Is 'national innovation system' a theoretical concept?

It may be argued that, since it takes on different meanings in different contexts, the NIS-concept is not a theoretical concept. Especially the broader definition may be criticized since it might give the impression that anything can be included and nothing excluded in the definition. In parts of natural science such as physics and mathematics it is seen as crucial for scientific progress to agree on strict definitions and on a common terminology with as general applicability as possible. Some scholars in social science, especially economists, believe that the long term objective is to transform social science into something that equates natural science in these respects and thereby getting rid what they regard as loose description.

A more realistic and fertile approach for social sciences might be to combine the aim for more general, more valid and more reliable knowledge about causalities with the insight that social science, by definition, must remain historical – as we shall see this is a point on which Schumpeter certainly would agree. In such an endeavour 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.

Actually, one of the reasons why policy makers have found the NIS-concept useful is that it combines a specific perspective on the economy with a certain flexibility in terms of what parts of the economy should be include in the analysis. From a policy maker's point of view it is important that the innovation system concept can be connected to economic growth and economic development. As already indicated, the components of the economy related to innovation with the dominant impact upon economic growth and development differ over time and in space. To develop 'a general theory' of innovation systems that abstracts from time and space might therefore undermine the utility of the concept both as an analytical tool and as a policy tool.

II.1 Theory and history

The OECD-paper by Freeman from the beginning of the eighties (1982, p. 15) actually takes on this issue. He 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

If we follow the Norwegian sociologist Lars Mjøset (Mjøset 2001; Mjøset 2002), we can go even further along these lines 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' 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.

Mjøset ends up arguing that 'grounded theory' produced on the basis of case studies and especially comparisons between specific cases is the most realistic ambition of social science. The more ambitious goal of transforming social science into mature science where 'general laws' are systematically tested in experiments only leads to frustration and disappointment. It is interesting to note that Schumpeter in his very last academic contribution recommended scholars to give first priority to case studies in order to promote the understanding of the impact of the organization of the firm on industrial dynamics (Andersson 1994).

II.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 feed backs 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 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 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 data bases 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 in Dosi (1988) and in Nelson (1993).[9]

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).

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.

II.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.

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.

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[9] But before establishing this apparently deductive and theoretical construct I was involved in a series of case studies that helped me to see different patterns that could be generalized. For instance we found that a Swedish producer of dairy equipment was willing to take annual losses in its Danish subsidiary because it gave access 'to the most demanding and advanced users in the world'. This example supported the idea of interactive learning and it could not easily be reduced to transaction cost concepts – if anything we had found an example of 'interaction benefit'. More generally it is my impression that most interesting analytical contributions in the field of innovation studies have their roots in what might be called 'paradigmatic cases'. General hypotheses pursued by an author will often reflect insights gained in a specific concrete project taking place at a crucial point in the career. Schumpeter and the railways would certainly be one example.

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.[10] 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.

II.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. Diagram 3 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 the following table.

The table illustrates that learning as well as innovation, in principle, can be analyzed in analytical frameworks closer to the mainstream neoclassical 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.[11]

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[10] The empirical results based on Danish surveys reported in Lundvall (2002) are incompatible with a neo-classical world. They show that firms engage in innovation and organisation when the competition intensifies and they also show that there are big differences between good and bad organisational practises among firms operating in the same sectors.

[11] 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.

Diagram 3: Four different perspectives in economic analysis

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

Austrian economics (Hayek and Kirzner) has the focus on allocation of scarce resources in common with neoclassical economics. But Hayek presents the market as a dynamic learning process where the allocation of scarce commodities are 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 side-effect 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 processes may be seen as a process of joint production where one output is innovation and the other a change in the competence of the involved agents.

II.5 A further remark on abstraction

This obviously implies a more complex theory than the one behind standard neoclassical production models. In these models it is assumed that technology comes as manna from heaven to be entered into the book of blueprints. It is also assumed that all agents have equal access to the books of blueprints and are equally competent in utilizing them.

But the underlying theory of innovation systems is not ‘less theoretical’. Basically this theory is about how skilful but imperfect agents and organizations with a capability to enhance their competence do so in an interaction with other agents and how this is reflected in innovation processes and outcomes.

Neither is the most important problem with the 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. 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 of time there are patterns of collaboration and communication that shape the innovation system but, of course, the system is also evolving in a process of creative destruction of knowledge and relationships.

Box 4: Economic theory in the light of innovation system analysis

I see several fields of standard economic theory that could benefit from the analytical approach inherent in the concept of innovation system. New growth theory, new trade theory and the new regional economics all have moved toward recognising that knowledge and learning matters for economic performance. There are several other fields where we might envisage 'new theory'.

The first is to develop *a theory of the firm* that takes into account that firms are more or less oriented toward dynamic competition depending on the context in which they operate. In a static context the *allocation* of given resources may become the major concern of management. In a context characterised by incremental change the focus will move toward *adaptation* and flexibility. If there are ample technological opportunities and unexploited internal capabilities Penrosian strategies of *growth* will be an important concern and if the knowledge base of the activities are changing there will be a need to focus on learning and *competence building*. Profit seeking firms will mix these strategies differently depending on context – including sector and national context.

Second, an important Schumpeterian issue is how resources – including financial resources are allocated to processes of innovation. This may refer to *venture capital and entrepreneurship* where there are important differences between for instance the US and Europe (O'Sullivan 2005). But it is also important to understand what takes place inside the borders of firms in this respect - both multidivisional and single firms. The explicit investment in R&D is one way to stimulate innovation (in the STI-mode). Without some degree of slack inside the organisation it would be difficult to mobilise the necessary resources to create something new (in the DUI-mode). Corporate governance differs across national systems and may have a major effect on to what degree time and other resources are accessible for innovation.

Third a rethinking of markets is necessary since markets for new products must be seen as organised markets. The vertical division of labour and the limits of the firm will reflect not only production and transaction costs but also attempts to harvest benefits from interactive learning. Vertical integration may leave users and producers in a situation where the diversity of experiences that they may draw upon is reduced and thereby their capacity to develop product innovations may be hampered.

Fourth, it has long been recognised that competition is a factor that affects innovation in a somewhat complex way. The pressure to engage in change may come from competition in product markets while successful innovations would ease the pressure at least temporarily. Cut-throat competition may result in a situation with too little slack and therefore get in the way for innovation. Richardson has made several interesting contributions to understand competition in sectors where there are rich technological opportunities.

In a context of rapid change and knowledge-based competition we need to rethink some of the most basic concept in economics: The firm, the market and competition.

III. National System of Innovation as economic development tool

III.1 Introduction

In the earlier sections of this paper we have argued for a definition of the national innovation system where there is a core of firms that organise innovation in-house and interact with each other and with the knowledge infrastructure in the process. We have also argued that human resources, organisational forms and social capital (wetware, orgware and socware) are crucial for the process and especially for the impact of technical innovation on economic performance. Finally we have pointed out that this core is embedded in a broader national socio-economic setting (education systems, labour markets, financial markets and welfare regimes).

On the basis of empirical analysis we demonstrated that innovation may be the outcome of two different but complementary modes of innovation – the STI-mode and the DUI-mode. We also demonstrated that the forms that the constellations of human resources, organisational forms and social capital that support innovation are overlapping with those that promote adaptation and

learning. We summarised these observations in the concept national systems of innovation and competence building.

In this last section of the paper we will try to demonstrate that the application of this broad innovation system concept on economic development may be useful but also that doing so makes more visible some general weaknesses of the concept and gives strong incentives to develop it further. In the development context it becomes clear that we need to understand better the formation of as well as the openness of national systems. We also need a better understanding of the role of power relationships as well as the broader institutional context supporting competence building.

III.2 Common roots

The history and development of the concept of 'national system of innovation' indicates that it can be useful for analyzing 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 '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).

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 national system of innovation 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.

III.3 New Tendencies in development thinking

Under all circumstances the approach needs to be adapted to the specific needs of developing countries. One way to do this is to look at three recent tendencies in development thinking through the focussing devices presented in the first parts of this paper.

First, there is an increasing focus on capabilities rather than resource endowments as the main instruments and values in development. This tendency can be exemplified by work by Amartya Sen. Second, you can observe a new focus on knowledge as the perhaps most crucial resource driving development. This can be illustrated by several recent reports from the World Bank. Third, there is a tendency to underline the primary importance of institutions as the 'root causes' of development dwarfing the importance of all other factors such as geography and policies. The IMF has recently underlined this view.

The three tendencies are interesting since each of them represents a broadening of the more narrow economic views on economic development and they can find a place in the national system of innovation and competence building as defined in this paper. At the same time I will argue that they underestimate the importance of learning and especially DUI-learning (Lundvall and Johnson, 1994; Archibugi and Lundvall (eds) , 2000).

III.4 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 under nourishment, diseases and premature mortality. It also includes the freedoms of being literate, able to participate in public life and in political processes, having 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

A similar 'omission' seems to be common also in approaches, with 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[i]. 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 analyze 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.

Learning processes form the preconditions for innovation. Technological capabilities of firms, for example, develop over time as a result, of both firm specific learning and different kinds of interaction, co-operative as well as competitive, between firms and other organizations. Capability building involves interactive learning by individuals and organizations taking part in processes of innovation of different kinds.

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 co-exist with their environment it contributes directly to human wellbeing. Furthermore, to be able to participate in learning and innovation at the work place may be seen as 'a good thing' contributing to a feeling of belonging and significance.

When we say that the learning capability is missing from the capability based approach it is, admittedly, not entirely true. The importance of R&D capacity (which may be regarded as a kind of learning capability) for development is widely recognized. It is also true that the capability-based approach, like most other approaches, emphasizes the importance of education and training. Inadequate schooling and vocational training are widely considered to be main barriers for development in large part of the South.

What is missing, however, in the capability based approach, as well as more generally in development theory, is a focus on learning capabilities related to the DUI-mode of innovation; the many different kinds of learning, which are going on in society, i.e. in rural areas, villages, firms and organizations in the public sector as well as the private. Only a part of this takes place in the formal education system or in the research system. What needs to be understood is how and to which extent individuals, communities, firms and organizations are geared to learning and innovation, either by themselves or in interaction with others. Is there a 'learning culture'? Is there an adequate institutional underpinning of learning?

III.5 Institutions and development

There is a new tendency of focusing on institutions as perhaps the most important development factor. This tendency is interesting and useful and it is compatible with the version of the innovation system approach presented in this paper One may wonder, however, if the relatively narrow spectrum of institutions, which have been in focus, really can explain so much of the development

In recent publications IMF emphasizes the importance of institutions for growth. Sometimes institutions are even referred to as 'root causes' of economic development (Acemoglu, 2003). The power acknowledged to institutions is quite impressive. IMF (2003) for example concludes that if the quality of institutions in sub-Saharan Africa were to 'improve to the levels in developing Asia', per capita income would rise by 80 per cent and if its institutions 'rose to world average levels' the

average per capita economic growth rates would become 2 per cent higher. The question of how to close these 'institutional gaps' (Johnson and Lundvall 1992) is not discussed very much by the IMF, however. IMF focuses on a narrow range of market supporting institutions related to the security of property rights, good governance and measures to restrict corruption.

We are not arguing here that well functioning markets are not important for development, far from it. Neither do we deny the importance of uncorrupted civil servants and efficient regulation procedures in the economy. There is evidence that entrepreneurship and innovation in many developing countries are severely hampered by red tape and slow and costly regulation. Often the business regulation is a legacy of colonialism rather then of the present needs of country in question (World Bank, 2003b). The point, however, is that the crucial question of how institutions may support learning and innovation is not raised (except for the role of the formal school system, which belongs to the 'established' growth factors). The impact on learning and innovation of, for example, labor market institutions, financial institutions, economic policy regimes and a host of norms supporting (or undermining) a learning culture need to be analyzed.

III.6 Innovation systems and development.

As a way of summarizing these critical observations on some new tendencies in development thinking one might say that even if both institutions and knowledge seem to be moving to the centre of the stage the question of how they interact and co-evolve shaping learning and innovation and driving the process of development is not explicitly raised.

It seems to us that 'national systems of innovation and competence building' may be useful in this context. Such a broad definition of national systems of innovation – taking into account not only the core but also the setting in which it is embedded - fits well with both the new focus on capabilities and the focus on institutions since it implies that a broad spectrum of socially based inter-linked capabilities is necessary for efficient innovation processes or for well performing innovation systems. The concept of innovation systems may, thus, be a tool for understanding the relations between different kinds of capabilities and between the constitutive and instrumental aspects of capabilities in developing countries. The viewpoint taken here is that improving learning and innovation capabilities is not only a question of more resources for education and research (more and better schools and universities, etc.) but also of shaping and reshaping a broad set of institutions in order to support interactive learning broadly in many parts of society including the individual families, communities, firms and organizations.

III.7 Weaknesses in the Innovation Systems Approach.

Above, when discussing the diffusion of the systems of innovation approach pointed out a number of its weaknesses. It 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 need 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 need 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 even 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 world-wide this perspective may be to too naïve. Within developing economies 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 globalisation and national and local systems need to be further researched. It is important to know more about how globalisation 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 is an important key 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 seems also clear, however, that its focus on the complementarity of production based tacit knowledge and science based knowledge is a useful correction to narrow perspectives that focus only on the STI-mode.

III.8 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 study 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 Africa 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 and 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.

It is certainly easier in developing countries to map and analyse what goes on in the public sphere and in the technological infrastructure. 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 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 as important as more glamorous policy initiatives on knowledge transfer. Studying 'good practise' 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.

To take into account how 'the wider setting' affects what is going on at the core of the system may be especially important when the object of analysis is a less developed national system of innovation and competence building. The lack of infrastructure may take the form of irregularities in transport and in access to electricity and water. But the shared values in society and the power structure may constitute as important barriers to competence building. When this is the case such barriers may best be detected by interviewing agents that engage in change, upgrade their skills and try to create new economic activities. To break down such barriers is not a techno-economic project – it can only take place through social processes within the developing countries. But, even so it is necessary to include them in the analysis in order to avoid engaging in projects that are doomed to fail.

IV. 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 organisations 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 organisations 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 microstructure and changes in the wider setting may be necessary 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 is not a luxury but necessary and basic processes, which have to be parallel to and interact with poverty alleviation.

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 mobilisation 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 'social innovations' brought about by social movements might be necessary to overcome the stalemate.

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Addendum on Activities at the Core of the System

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Introduction

In the paper I define a core of the innovation system as encompassing firms, their interrelationships and their relationships to the knowledge infrastructure. In this addendum I discuss what kind of activities that take place in that core.

How firms contribute to innovation at the system's level

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 competing firms 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 feed back 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 over all innovation process as the pioneer firms.*

The late followers and late users may not contribute directly to the over all 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 over all 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. Feed back 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.

In any specific national economy the distribution of firms over the three groups will differ between sectors. In Denmark there are pioneer firms in a few sectors such as windmill technology (Vestas) and pharmaceuticals (Novo) but in most sectors there are no pioneer firms. The over all performance of the economy will depend primarily on the competence of early and late followers and users. Therefore all firms should be seen as important elements in the core of the innovation system. The implicit assumption behind much of innovation policy that pioneers play the key role in the national system is not helpful.

The knowledge infrastructure

There is overlap between the population of firms and the knowledge infrastructure. Some firms are specialised in producing, handling and selling knowledge (KIBS). Other parts of the knowledge infrastructure are semi-public or part of the public sector (universities, schools, training institutes, laboratories, standardisation institutes and technological service). Diversity in the knowledge infrastructure is crucial for the performance of the national innovation system. Standardising the units and giving too much responsibility to one type of units makes the system more vulnerable.

Firms may link up and communicate with the different parts of the knowledge infrastructure through different media (market, organised 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 interaction 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 and with evolving new pervasive technologies.

We have pointed out that interaction and communication is a 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 and body-body contact* ("full mounty"). 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.

To intervene successfully in innovation processes there is a need to understand how different modes of learning and communication complement each other as well as how the tension between them is resolved. *Therefore the most fundamental task for innovation system research is to understand learning and knowledge in these dimensions*. This obviously calls for interdisciplinary efforts. Sociologists, anthropologists, psychologists and philosophers are among those who know much more about such processes than economists do.

What pioneer firms do when they innovate

The radical innovation new to the world is normally based upon *a fresh idea* that might be 'a new combination'. The most basic and first step is the idea. The idea may spring out of the firms's research and development effort out of everyday practice within the organisation or it may be picked up from outside. Only a minority of ideas popping up will become serious candidates for becoming radical innovations.

Each idea may be seen as a potential 'project'. Many potentially good ideas will die long before they become a project. Firms that want to remain pioneers need to develop mechanisms for selection of ideas as well as for transforming ideas into innovations. They also need to have mechanisms stopping hopeless projects. This has to do with establishing project groups.

Running from start to end is a process of 'diplomacy' where the project group tries to gain acceptance for the project. The other process that runs from start to end is the process of design. Design is about giving the idea a material form (hard-ware) or just giving it a formal structure (soft-ware). Design will typically refer both to production and distribution. The product needs to be shaped in such a way that it can be produced at reasonable costs. It also needs to be designed in such a way that there is an effective demand for it.

Project groups and project leaders are crucial for transforming ideas into new products and processes. The project leader may have the double role of being chief diplomat and chief co-ordinator of the design process. The capability project group leaders are critical for the success of the project. Setting up routines – and challenging them – that work when it comes to select ideas, select members of project groups and select the chief diplomat and the chief designer is the key to successful innovation management. Screening aiming at closing down unsuccessful projects is as important as screening aiming at mobilising resources for potentially successful ones.

At the end of the process prototypes will be used as new process equipment or be offered in markets for external users. Establishing routines aiming at what is going on in the early stages of implementation and use is crucial and organising feed-back from the production department as well as from early internal and external users makes it possible to adjust the original prototype and make it more attractive.

Activities at the core of the national system of innovation

One *activity* resulting in new ideas is basically *interaction between people*. It typically involves *doing things together* as well as *communication and learning*. New ideas feed upon diversity. New combinations come about by individuals with a mixed background and by groups of people with different experiences. 'Brain-storming' my take place in the head of one person and some individuals (inventive minds) get more brainstorms than others. New combinations may also come about by bringing together people with different background. The outcome may be both a new idea and learning among the agents involved. This kind of idea-production I would refer to as *part of the DUI-mode of innovation.*

In some fields, such as pharmaceuticals and aviation, firms will engage in a systematic search for new ideas. This will reflect mapping of earlier attempts to develop new combinations – using experimental design, information technology and simulation techniques. Here the *activity* resulting in new ideas is *doing research.* It typically involves *mapping what is already known, experimenting with new combinations and testing alternative ideas*. A key to success is to register and codify what is going on so that you do not have to make the same mistake more than once. To determine what is a promising idea will typically take both scientific and commercial expertise. This kind of idea-production I would refer to as *part of the STI-mode of innovation.*

While search for new ideas through research will be highly specialised and aim at digging deeper into a narrow field, interactive learning will feed upon short-circuits across fields. The combination of digging deeper and bringing together knowledge harvested at distant fields might be typical for processes where new ideas become radical innovations.

The systematic search for new ideas is certainly part of the innovation system. The organisations engaged in producing new ideas may belong to the knowledge infrastructure and be more or less distant (in social and technical terms) from those firms that use the ideas to design innovations and they may be more or less creative. These characteristics have to do with the form of organisation, culture, incentive systems, specialisation and network positioning.

The two modes of production of ideas may co-exist and co-evolve within the same firm and probably the most creative firms succeed in retaining both modes. Highly specialised researchers may be taken out of their standard function and work in different environments than laboratories for a period and practical inventors and workers may be given formal training so that they can communicate their needs and ideas with laboratories.

Diplomacy and design

In most cases there is a long way to go from idea to prototype and from prototype to normal scale production. Many things can go wrong in this process and the key to success is as already mentioned well-functioning project groups and project leaders.

During the design process there is a definite need to communicate among agents with diverse background. The role of the project group is to bring in experiences from production and sales divisions and to let those be reflected in the new design. The role of the project group leader is to orchestrate this process and through diplomacy to mobilise the necessary resources for bringing the project forward.

The most important activities in the design process are *communication, co-operation and interactive learning.* Individuals belonging to different communities, speaking different languages have to communicate and share their experiences and contribute to a common project. To coach this process is a difficult task. A common corporate culture/vision may help if people within the organisation are really committed to it.

Another important activity in the design process leading to the proto-type may be *research*. The design of a drug involves research all along the design process including systematic tests on animals and patients. Designing a new machine may involve elements of research to solve specific problems. Again this will involve communication with experts from other parts of the organisation.

Inter-organisational interaction with early users

As pointed out above the early users who are customers to the innovating firm play an important role in the innovation system. They act as external test laboratories. Their experiences with the new product/process will involve discovering and sometimes solving problems. Building channels for feed-back of experiences to the innovating firm is important for the success of the innovation.

Having several early users operating under different circumstances is especially useful since it gives a more diverse source of learning for the innovating firm. This is one reason why vertical integration might not take place in spite of small numbers, uncertainty and information impactedness. The benefits from diverse sources of learning over an organised market may make ‘outsourcing’ preferable to ‘insourcing’.

I have written in some detail about the different activities that take place across an organised market (Lundvall 1985; Christensen and Lundvall 2004). It involves monitoring, co-operation and exchange of experiences. Different media may be used – ICT-based communication, flying prototypes and exchange of personnel. Basically the central activity is communication across organisational borders using either direct human to human contact or computers as medium.

Summary on the activities at the core

The central activities in the core of the innovation system and in the process from idea, to design and to user feed-back basically involves two types of activities. One is human interaction and the other is systematic search (research). The first involves the creation of new ideas and design as well as different forms of learning based upon doing, using, and interacting. The second also involves the creation (or locating and finding) of new ideas and design as well as solving specific problems.

An alternative to Edquists 10 activities could in this light result in what is presented in Box A:

Box A: Summarising the national innovation system – the core with its activities and characteristics as well as the wider setting, outcomes and public policy*

Central activities in the core

11. Searching and researching – STI (1)
12. Human Interaction and learning – DUI (4 and 6)
13. Interaction between firms and the knowledge infrastructure – STI and/or DUI.

Central characteristics of the core

14. Organisational forms (5)
15. Institutional framework (7)
16. Production structure

Wider setting

17. Market for labour
18. Market for finance (9)
19. Welfare regime

Outcomes

20. New products (2)
21. Competence building (3)
22. Impact on growth and development

Dimensions of government intervention

23. Promoting STI- or DUI-mode of innovation
24. Promoting Pioneers or Followers
25. Promoting High technology or Low technology sectors

* Numbers in parenthesis refer to Edquists scheme in the main paper.

I would see learning through research and learning through human and organisational interaction as the central activities at the core of the innovation system. *Important for how these activities take place and with what outcomes are* organisational forms, institutional framework and the production structure. *The processes and the organisational forms will reflect* the wider setting in terms of the national welfare regime and the markets for labour and finance. Outcomes *of the system may be* innovation and competence building and in the last instance economic growth and development.

Governments may try to intervene in order to promote the DUI- or the STI-mode of innovation, pioneers or followers and firms from high technology sectors or firms from low technology sectors. One reason why it is important to insist on a broad definition of the innovation system is that the 'innovation' as a concept leads the attention of theoreticians as well as practicians toward respectively STI, Pioneers and High technology sectors while the performance of most national economies – as it reflects innovation activities – is highly dependent on DUI, Followers and Low Technology sectors.

[i] Several of the latest World Developmet Reports from the World bank have focused on knowledge. For example the 1998/99 report states that: "This World Development Report proposes that we look at problem of developmet in a new way – from the perspective of knowledge"