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**Innovation System Research
Where it came from and where it might go**

By

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1. Introduction

When the first edition of Lundvall (1992) and of Nelson (1993), the concept ‘national innovation system’ was known only by a handful of scholars and policy makers. Over a period of 15 years there has been a rapid and wide diffusion of the concept. Giving ‘Google’ the text strings ‘national innovation system(s)’ and ‘national system(s) of innovation’ you end up with almost 1.000.000 references. Going through the references you find that most of them are recent and that many of them are related to innovation policy efforts at the national level while others refer to new contributions in social science.

Using Google Scholar (May 2007) we find that more than 2000 scientific publications have referred respectively to the different editions of Lundvall (2002) and Nelson (1993). Economists, business economists, economic historians, sociologists, political scientists and especially economic geographers have utilized the concept to explain and understand phenomena related to innovation and competence building.¹

In this paper we argue that during the process of diffusion there has been a *distortion* of the concept as compared to the original versions as developed by Christopher Freeman and the IKE-group in Aalborg. Often policy makers and scholars have applied a narrow understanding of the concept and this has gives rise to so-called ‘innovation paradoxes’ which leave significant elements of innovation-based economic performance unexplained. Such a bias is reflected in studies of innovation that focus on science-based innovation and on the *formal* technological infrastructure and in policies aiming almost exclusively at stimulating R&D efforts in high-technology sectors.

Without a broad definition of the national innovation system encompassing individual, organizational and inter-organizational learning, it is impossible to establish the link

¹ In economic geography the diffusion of the innovation system perspective has, together with the industrial district and industrial clusters approaches, contributed to the construction of a ‘new economic geography’ that has changed the way geographical location and agglomeration is explained (Maskell and Malmberg 1997; Cooke 2001; Clark, Feldman and Gertler 2000).

from innovation to economic growth. A double focus is needed where attention is given not only to the science infrastructure, but also to institutions/organisations that support *competence building* in labour markets, education and working life. This is especially important in the current era of the *globalizing learning economy* (Lundvall and Johnson 1994; Lundvall and Borràs 1998; Archibugi and Lundvall 2001).

We see one major reason for this distortion in the uncomfortable co-existence in international organisations such as OECD and the EC of the innovation system approach and the much more narrow understanding of innovation emanating from standard economics (Eparvier 2005). Evolutionary processes of learning where agents are transformed and become more diverse in terms of what they know and what they know how to do are not reconcilable with the rational ‘representative agents’ that populate the neoclassical world (Dosi 1999). Actually, we regard the neglect of ‘learning as competence-building’ as the principal weakness of standard economics and the narrow definitions of innovation systems as reflecting a negative spill-over from this misdirected abstraction.

Both Mode 2 knowledge production (Gibbons et al 1994) and the Triple Helix approach focus on science and the role of universities in innovation. When they present themselves or are applied by policy makers, not as analysing a subsystem within, but as full-blown alternatives to the innovation system approach (Etzkowitz and Leydesdorff 1995; Etzkowitz and Leydesdorff 2000), these approaches contribute to the distortion. These perspectives capture processes linking science and technology to innovation – below we refer to this as *STI-learning*. The fact that science and codified knowledge become increasingly important for more and more firms in different industries – including so-called low-technology ones – *does not imply that experience-based learning and tacit knowledge have become less important* for innovation. To bring innovations, including science-based innovations, to the market organisational learning, industrial networks as well as employee participation and competence building are more important than ever. We refer to these processes as *DUI-learning*.

Section 2 takes a brief look at how the NSI-concept came about and developed on the general background of the history of innovation research.² Section 3 confronts the theoretical foundations of the concept with standard economics; section 4 defines analytical challenges. Section 5 relates the concept to economic development, inequality and sustainability. The chapter ends with the concluding section 6. As mentioned, the literature on innovation systems has grown exponentially over the last 15 years and what follows does not aim at a full and fair survey of the literature. The issues raised and the sources cited reflect my own priorities.

2. A concept with roots far back in history

Milestones in the development of the innovation system concept

Basic ideas behind the concept 'national systems of innovation' go back to Friedrich List (List 1841).³ 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 infrastructure such as networks for transportation of people and commodities (Freeman 1995a). To the best of my knowledge, the first written contribution that used the concept 'national system of innovation' was the unpublished paper by Christopher Freeman from 1982 that he produced for the OECD expert group on Science, Technology and

² Several authors have presented overviews of the innovation system literature and made attempts to classify different approaches. An early contribution is McKelvey (1991). More recent ones are Balzat and Hanusch (2004) and Sharif (2006). The latter's contribution builds upon a combination of literature survey and interviews with key persons who were involved in coining the concept. An interesting critical contribution is Miettinen (2002). Miettinen points to the problematic and vague character of the concept as it is transferred back and forth between the academic and the public policy sphere.

³ Reinert (2003) argues that many of the ideas go further back to a succession of scholars belonging to 'the other Cannon' starting with Antonio Serra. De Liso (2006) argues that Charles Babbage may be seen as another ancestor for the innovation system concept.

Competitiveness (Freeman 1982, p. 18).⁴ Here he takes Friedrich List as one central point of reference.

Box 1: Regional, sectoral, technological and corporate systems

Over the last decade several new concepts representing the systemic perspective on innovation have been developed. The literature on 'regional systems of innovation' has grown rapidly since the middle of the 1990s (Cooke 1996; Maskell and Malmberg 1997). Bo Carlsson with colleagues from Sweden developed the concept 'technological systems' in the beginning of the 1990s (Carlsson and Stankiewicz 1991). While Franco Malerba with colleagues from Italy developed the concept of 'sectoral systems of innovation' (Breschi and Malerba 1997). Ove Granstrand has proposed the corporate innovation system as perspective. Some of the crucial ideas inherent in the innovation system concept such as vertical interaction and innovation as an interactive process are central also in the literature on industrial clusters by Porter and colleagues.

Of these different perspectives the regional system approach is the one that resembles most original versions of the national system of innovation. It has in common with the NSI-approach that it uses the fact that some knowledge is local and tacit to explain that innovation systems are localised. Also, both approaches attempt to explain economic performance of geographical entities. The corporate system perspective may also have economic performance at focus at the level of the single enterprise.

The other perspectives aim at explaining the innovation process in relation to specific technologies and sectors. The analysis of technological systems has been especially useful in analysing how new technologies emerge. The sectoral system approach is unique among the different approaches in not defining as analytical object a vertically integrated system. The approach may be seen as the outcome of a cross fertilisation between industrial and innovation economics.

In the beginning of the 1980s, the idea of a national system of innovation was immanent in the work of several economists studying innovation. Richard R. Nelson together with other US scholars had compared technology policy and institutions in the high technology field in the US with Japan and Europe (Nelson 1984). SPRU at Sussex University pursued several studies comparing industrial development in Germany and the UK covering for instance differences in the management of innovation, work practices and engineering education.

⁴ The paper was published for the first time more than 20 years later in the journal *Industrial and Corporate Change* (Freeman 2004).

The idea of a national system of innovation was immanent also in the research program pursued by the IKE-group at Aalborg University.⁵ In several working papers and publications from the first half of the 1980s we referred to 'the innovative capability of the national system of production'. The handier 'innovation system' appears for the first time in Lundvall (1985) but without the adjective national. Again, it was Christopher Freeman who brought the modern version of the full concept 'national innovation system' into the literature. He did so in 1987 in his book on innovation and innovation policy in Japan (Freeman 1987).

When Freeman collaborated with Nelson and Lundvall in the IFIAS-project on technical change and economic theory the outcome was a book (Dosi et al. 1988) with a section with several chapters on 'national systems of innovation' (Freeman 1988; Lundvall 1988; Nelson 1988). After followed three major edited volumes on the subject (Lundvall 1992; Nelson 1993; Edquist 1997).⁶

The innovation system concept may be regarded as a practical tool for designing innovation policy. But it might also be seen as a synthesis of analytical results produced by scholars working on innovation. In this section we give a brief review of the history of innovation research with focus on how different generations of economists have contributed to the modern understanding of innovation systems.

Innovation research starting with Adam Smith

The idea that innovation matters for economic development is present in the work of the classical economists. Innovation plays an important role in the introduction to Adam Smith's classical work on the Wealth of Nations. It is especially interesting to note that he identifies and distinguishes *two different modes of innovation* (see Box 2 below).

⁵ The IKE-group had the privilege to interact with Christopher Freeman in several projects in this period and many of our ideas were shaped in a dialogue with him (see for instance Freeman 1981).

⁶ For an overview of the current status of innovation research see the new Oxford Handbook on Innovation (Fagerberg, Mowery and Nelson, 2005).

Box 2: Adam Smith on innovation and modes of learning

Adam Smith (1776: p. 8) on the DUI-mode of learning:

A great part of the machines made use of in those manufactures in which labour is most subdivided, were originally the inventions of common workmen, who, being each of them employed in some very simple operation, naturally turned their thoughts towards finding out easier and readier methods of performing it. Whoever has been much accustomed to visit such manufactures, must frequently have been shown very pretty machines, which were the inventions of such workmen, in order to facilitate and quicken their own particular part of the work. In the first fire-engines, a boy was constantly employed to open and shut alternately the communication between the boiler and the cylinder, according as the piston either ascended or descended. One of those boys, who loved to play with his companions, observed that, by tying a string from the handle of the valve which opened this communication, to another part of the machine, the valve would open and shut without his assistance, and leave him at liberty to divert himself with his play-fellows. One of the greatest improvements that has been made upon this machine, since it was first invented, was in this manner the discovery of a boy who wanted to save his own labour.

Adam Smith (1776: p. 9) on the STI-mode of learning:

All the improvements in machinery, however, have by no means been the inventions of those who had occasion to use the machines. Many improvements have been made by the ingenuity of the makers of the machines, when to make them became the business of a peculiar trade; and some by that of those who are called philosophers or men of speculation, whose trade it is not to do any thing, but to observe every thing; and who, upon that account, are often capable of combining together the powers of the most distant and dissimilar objects. In the progress of society, philosophy or speculation becomes, like every other employment, the principal or sole trade and occupation of a particular class of citizens. Like every other employment too, it is subdivided into a great number of different branches, each of which affords occupation to a peculiar tribe or class of philosophers; and this subdivision of employment in philosophy, as well as in every other business, improves dexterity, and saves time. Each individual becomes more expert in his own peculiar branch, more work is done upon the whole, and the quantity of science is considerably increased by it.

The first mode is experience-based and I will refer to it as the DUI-mode – learning by doing, using and interacting. The other mode refers to science-based research processes and I will refer to it as the STI-mode – science is seen as the first step toward technology and innovation. In this chapter we will argue that this distinction is fundamental when it comes to analyzing modern innovation systems and also when it comes to design management strategy as well as public policy.⁷

⁷ Adam Smith's major contribution was to link the evolving and increasingly more developed division of labour to the creation of wealth. In Lundvall (2006) I have tried to reformulate his theory, emphasizing

Friedrich List on the need for an active state to build innovation systems

While Adam Smith was propagating free trade and a liberal economy the German economist Friedrich List disagreed. He characterized Adam Smith's theory as 'cosmopolitan' and argued that if followed by other countries, it would just confirm and reinforce the dominance of the British Empire in the world economy (Reinert 1999).

He argued that for countries such as Germany, trying to 'catch up' with the leading economy, there was a need for government intervention. List presented a broad agenda for government in the building of infrastructure that could contribute to technical advance. It is interesting to note that he referred to 'mental capital' as the most important kind of capital. He argued that the wealth of nations more than anything else reflected *'the accumulation of all discoveries, inventions, improvements, perfections and exertions of all generations which have lived before us'* (Freeman 1995a, p. 6).

Karl Marx on technological progress

The historical parts of *Das Kapital* give deep insights in how new technologies shape the economy and society. The basic assumption in his historical analysis that new productive forces may get into conflict with 'production relations' is a useful guideline for how to study innovation systems. At the micro-level this corresponds to the fact that radically new technologies cannot flourish in firms 'locked in' into old organisational forms and competence sets. At the aggregate level it corresponds to the need to transform societal institutions, competences and organizations in order to reap the benefits of technological revolutions.⁸

Marx is a pioneer also when it comes to emphasize the importance both of 'science as a force of production' and 'technological competition' where firms need to engage in innovation in order to gain markets and reduce costs. Many of his insights on the role of

interactive learning in the context of vertical division of labour, so that it becomes more relevant for explaining innovation-based economic growth.

⁸ For a historical analysis of how match and mismatch is reflected in economic performance of national systems see Freeman (1995b). In (Lundvall 2002) I discuss the role of mismatches in the disappointing performance following 'the new economy' euphoria.

science and technology in relation to the economy are very advanced for his time (Rosenberg 1976).

Marshall's contribution

Marshall (Marshall 1919; Marshall 1920) is known as one of the founding fathers of modern neo-classical economics. He was also the one who introduced the concept 'the representative firm' – a concept that has contributed to the lack of understanding of economic development in modern neo-classical economics. But as documented by Metcalfe (2006) in a different reading Marshall may be seen as contributing not only to evolutionary understanding of industrial dynamics in general, but also to the idea of a national system of innovation (Metcalfe 2006: p.17). He links innovation to management competences, brings the wider institutional setting in terms of different types of research laboratories into the analysis and recognises that the overall system and mode of innovation may differ across national borders (ibid. p.19).

Marshall's focus on incremental innovation – rather than on the radical innovations as emphasized by Schumpeter – may be seen as an important inspiration for modern innovation research. As will be argued below, any attempt to link innovation to economic growth and development needs to capture radical and incremental innovation but also the on-going processes of imitation and learning (Arocena and Sutz 2000a).

As with Adam Smith it is possible to discern two types of mechanisms for the advancement of knowledge and technology and in the case of Marshall they are linked to two types of 'innovation systems'. One refers to industrial districts where the focus is on experience-based learning (DUI) and the other refers to the national system of research (STI).

Marshall is unique in being a potential source of inspiration both for mainstream and evolutionary economics. This reflects his ambition to develop a theory that explains fluctuations in supply and demand with a theory that explains economic development. His method to try to combine the short-term static analysis and the evolutionary development where innovation takes place and agents become more competent is to

introduce the distinction between short period, long period and secular period. Metcalfe argues that this should be seen primarily as an attempt to link order and change.

While the national innovation system approach assumes innovation to be a ubiquitous and on-going process, not to be relegated to 'the secular period', it also operates with a distinction between order and change. It assumes that for national economies there are systemic features in terms of economic structures and relationships as well as institutions that represent continuity and order and that form the environment for innovation processes where technical knowledge and the competence of individuals and organisations change.

Joseph Schumpeter as the grandfather of modern innovation theory

Joseph Schumpeter is generally seen as the founder of modern innovation research and many scholars who work on innovation would accept to be classified as Neo-Schumpeterian.⁹

In *Theory of economic development* (Schumpeter 1934) innovation is seen as the major mechanism behind economic dynamics. The dynamo of the system is the individual entrepreneur who introduces innovations in markets and creates new enterprises. After the pioneers follow imitators and gradually the profits created by the original wave of innovation are eroded.

In *Capitalism, Socialism and Democracy* (Schumpeter 1942) the innovation mechanism is quite different. Here the major source of innovation is not the brave individual entrepreneur but the big company with experts working together in R&D teams searching for new technological solutions. The distinction between the two ways to present the motor of innovation has led scholars to refer to *Schumpeter Mark I* and *Schumpeter Mark II*.

⁹ Verspagen and Werker (2003) is interesting in showing which scholars that define themselves as 'neo-Schumpeterians'.

We can use some of Schumpeter's ideas to inspire our analysis of innovation systems. First, we might note the important role of imitation. The overall performance of an innovation system will reflect not only the pioneers but also the capability of followers. Second, we might revise his analytical scheme and regard the total population of firms in a system as including both Mark I- and Mark II-firms. We may characterise specific national system as being more or less dominated by one type or the other.

But at one very important point Schumpeter's ideas deviate from the basic insights behind the innovation system concept. Schumpeter took an extreme position assuming *that the demand side would simply adjust to the supply side*.¹⁰ It is true that he defines the opening of new markets as one kind of innovation. But, in general, consumers and users are assumed to be ready to absorb whatever new innovations is brought to them by entrepreneurs or firms. Actually, it might be argued that the innovation system perspective came out of a criticism of Schumpeter's relative neglect of the demand side.

Schmookler (1966) opened the debate with taking almost the opposite view of Schumpeter. He used a host of empirical data on inventions as well as secondary sources to demonstrate that inventions and innovations tend to flourish in areas where demand is strong and growing. One important outcome of the ensuing debate was *a new perspective on innovation as reflecting the interplay between technology-push and demand-pull*. The critical debate of Schmookler's empirical results confirmed this new perspective (Mowery and Rosenberg 1979).

The Chain-Linked model, where both supply push and demand pull are analysed in relation to scientific knowledge, may be seen as one contribution to the new perspective (Kline and Rosenberg 1986). The perspective on innovation as a process of interaction between producers and users may be seen as a micro-dimension of this new perspective (Lundvall 1985).

¹⁰ Another point where Schumpeter's approach differs from the NSI-approach is his neglect of the importance of knowledge and learning for understanding the innovation process. Schumpeter's entrepreneurs are activists who bring new combinations to the market. How the new combinations come about is left in the dark (Witt 1993, p. xiv).

Christopher Freeman as the father of modern innovation theory

Christopher Freeman played a key role in stimulating these new theoretical developments, especially in Europe.¹¹ In the early 1980s, his lectures to Ph.D.-students were on Schumpeter Mark I and Mark II and on the controversy between Schumpeter and Schmookler regarding the role of supply and demand in the innovation process.¹² His founding of Science Policy Research Unit (SPRU) at Sussex University 1966 was a major step toward giving innovation studies a more permanent institutional foundation.

One important reference in his lectures in the beginning of the 1980s was to the *Sappho-study* organised at SPRU (Rothwell 1972; Rothwell 1977). This study was simple but original in design. The research team located a number of innovation pairs – ‘twins’ in terms of major characteristics – where one of the two was a success while the other was a failure. The two innovations were then compared in terms of characteristics of the ‘host’ organization. The most important result was that *interaction* within and between organizations came out as a prerequisite for success in innovation. Innovations that took place in firms where divisions operated without interaction with each other and firms that did not interact with suppliers, users and customers were less successful than the more interactive firms.¹³

Freeman pioneered the vision that innovation should be understood as an interactive process; not as a linear one where innovation automatically comes out of R&D efforts. As mentioned above, Freeman was also the pioneer when it came to introduce the concept of ‘national system of innovation’ (Freeman 1982/2004).

¹¹ In the US Richard R. Nelson and Nathan Rosenberg played the most important role in developing the theoretical, historical and empirical understanding of innovation.

¹² The IKE-group had the privilege to have him visiting as guest professor at Aalborg University for periods and there is little doubt that we all became his apprentices. He is not only an outstanding scholar but also a uniquely generous person.

¹³ Another characteristic of the successful innovations was that the project team leader in charge of developing the innovation had certain seniority and was able to mobilise resources in critical phases of the innovation process.

The flourishing 1980s

The 1980s was a period when innovation research became ‘emancipated’ and more ambitious also in confronting basic assumptions in standard economics. Important work took place in different areas both in Europe and in the US. Dosi, Pavitt and Soete made important contributions to the role of innovation in relation to foreign trade (Dosi, Pavitt and Soete 1990). Christopher Freeman and Soete analyzed employment issues in relation to technical innovation (Freeman and Soete 1987). Giovanni Dosi established his hypothesis on shifts in technological paradigms (Dosi 1984).

Box 3: Different perspectives on national systems

Scholars, comparing national systems in terms of how they differ in qualitative terms and in terms of how they perform, have developed and made use of different perspectives. The analysis of the *national competitive advantage* by Michael Porter borrowed some ideas from the innovation system tradition – especially the importance of domestic demand and domestic user for product innovation. But he also added unique ideas about the positive impact of domestic competition on innovation in specific sectors of clusters.

Whitley's analysis of *national business systems* offers important inspiration for the analysis of innovation systems (Whitley 1994). The basic idea that match and mismatch between different elements of the system affect performance and that it is possible to develop a typology of national systems are in line with Freeman's comparison between the Japanese and the Anglo-Saxon systems. But Whitley's analysis is broader and it introduces cultural and social dimensions in the analysis.

Similar intentions lie behind the concept Social Systems of innovation (Amable, Barré and Boyer 1997). Recent work on the micro-organisational basis for learning by Lorenz and Valeyre indicates that the systemic features distinguishing the taxonomic categories are rooted in different types of micro-organisational structures.

An early contribution not referring explicitly to 'system' may be found in the work of Sabato who as early as 1968 proposes that for S&T to help development processes a systemic view should be taken, proposing as a focusing device the figure of a triangle (famously known all over Latin America as the "Sabato triangle") with Government, Production and Academia in its vertex (Sabato and Botana 1968). It may be seen as a forerunner to the Triple Helix concept but the 'NSI' flavour of Sabato's approach is also unmistakable: for Sabato much more important than the strengths of each vertex were the strengths of the sides connecting the vertex: if the sides of the triangle are weak, each vertex sought to articulate outside the triangle (this leading to brain drain and to blind technology transfer).

In the US, the Nelson and Winter's evolutionary economic approach to economic growth signalled a more ambitious agenda for innovation research (Nelson and Winter 1982). Rosenberg and Kline presented the Chain-linked model (Kline and Rosenberg 1986). Freeman and Lundvall developed further ideas about innovation as an interactive process and innovation systems together with Richard Nelson.

Box 4: Does the innovation system have a function?

Edquist (2005) argues that the NSI-concept is diffuse and calls for making it more rigorous, systematic and 'theory-like' concept. This is always a legitimate concern but it is not obvious that the direction he recommends for the effort would bring us in this direction.

Edquist argues that the innovation system has 'as general function' to pursue innovation processes. His functionalist approach seems to emanate from a version of system theory as is practiced among engineers (Rickne 2000). *We would argue that social systems only have the functions that we assign to them.* If I were to assign a function to the national system of innovation I would be more specific than defining it as just 'pursuing innovation' and propose that the function is to contribute to economic performance on the basis of processes of creation and diffusion of knowledge. This corresponds to the normative focus of those who pioneered the NSI-concept.

Edquist lists ten *activities* (also referred to as 'functions' on p. 189) that should be studied in a systematic manner in terms of their respective 'causes and determinants'. The list encompasses quite disparate elements including for instance forms of knowledge creation and learning, organizational forms, market demand and public policy instruments.

The idea that studying separately each of the listed activities reminds somewhat of Edward Denison's attempt to reduce the growth residual through growth accounting. We can see the listing of a number of 'activities' as being potentially useful as establishing a checklist for managers and policy makers (Rickne 2000). It might also be helpful when comparing market with non-market economies (Liu and White 2001).

But in terms of theoretical understanding, it represents a step backwards since much of what we already know about the innovation process is neglected. For instance the distinction made between the three kinds of learning neglects that one of them (innovation) comes out of practising the other two (R&D and competence building) (Edquist op.cit., pp. 191-92). It is therefore not obvious how studying them separately would lead to more rigorous theory.

These different efforts merged in two different major projects. One was a major book project led by a team consisting of Dosi, Freeman, Nelson, Silverberg and Soete (1988). The other major project took place in the policy realm and was organized by the Directorate for Science Technology and Industry at OECD. Director Chabbal initiated the TEP-project and Francois Chesnais was the intellectual dynamo of the project. The TEP-report integrated many of the most advanced ideas developed among innovation scholars in the 1980s and it gave innovation policy as well as innovation studies a new kind of legitimacy in all OECD-countries (OECD 1992). The idea that innovation is an

interactive process and that it is useful to analyse ‘national innovation systems’ was spread to policy makers.

While the TEP-project gave legitimacy to the innovation system concept among policy makers it did not result in a clean break with the linear model where innovation is seen as emanating more or less automatically from science. In international organisations, as in national governments, the strong position of expertise based upon standard economics contributed to a narrow interpretation of the national system of innovation. Triple Helix and Mode 2 theories also tend to support a perspective where the DUI-mode of innovation is neglected.

Intentions behind the original conceptualisation of national systems of innovation

As we have seen, the innovation system perspective integrates principal results from innovation research. For several of the protagonists of the concept, including Freeman and myself, it was seen not only as a tool to explain innovation. It was also seen as constituting an alternative analytical framework and a challenge to standard economics when it comes to explain competitiveness, economic growth and development. In the next section we compare the NSI-perspective with the basic assumptions of standard economics.

Many recent contributions to innovation systems have different and in a sense more modest ambitions ‘to explain innovation’ by linking inputs in terms of investment in R&D to outputs in terms of patents or new products. They may emanate from scholars connected to technical universities and business schools and have as principal aim to give good advice to business managers or specialised government agencies. Other contributions, emanating from international economic organisations analysing national growth performance combine the system perspective with elements of neo-classical economics. Some even utilise production function techniques based upon standard economics assumption, including agents acting on the basis of rational expectations. In this post scriptum I will stick to the original ambitions when discussing how to study national systems of innovation.

3. National innovation system as analytical focusing device

The innovation system framework is in direct competition with standard economics when it comes to give advice to policy makers. In this section we will try to present the core theoretical ideas behind the innovation system perspective and confront them with those of standard economics. Our main conclusion is that the neglect in standard economics of ‘learning as competence building’ is a major weakness that makes it less relevant for understanding innovation and dynamic economic performance, especially in the current era of the learning economy.

Theoretical elements entering into the innovation system concept

As indicated in the first section the national innovation system approach is grounded on 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 feedbacks are crucial for the innovation performance of the firm while the Pavitt taxonomy helped to see how different sectors interact and fulfil different functions in the overall innovation process.

But, the concept also reflects deductive reasoning explaining the stylized facts observed in empirical studies. For instance, on reflection, it is obvious that product innovation could not thrive in an economy with ‘pure markets’ characterized by arm’s length and anonymous relationships between the innovating producer and the potential user (Lundvall 1985; Lund Vinding 2002; Christensen and Lundvall 2004).

Box 5: Is innovation system a theory?

Edquist has raised the question if innovation is ‘a theory’ and his response has been in the negative. In a sense it is obvious that ‘innovation system’ is a concept rather than ‘a general theory’. It is certainly true that it does not specify general laws of cause and effect. But nonetheless this way of putting the question may lead to misleading conclusions for how to proceed research and analytical work in relation to innovation systems.

One problem with posing and answering the question is that it is far from clear what should be meant with ‘theory’ in social science. As indicated in the earlier section, the innovation system perspective is built upon a series of coherent assumptions. It is also true that most of these assumptions are rooted in systematic empirical work and that they can be tested as well as rejected by further empirical work. Using the perspective helps to see, understand and control phenomena that could not be seen, understood or controlled without using this (or a similar) concept. In this sense it does what theory is expected to do: it helps to organize and focus the analysis, it helps to foresee what is going to happen, it helps to explain what has happened and it helps to give basis for rational action.

The fact that different scholars work with different delimitations of the components of the system and with different focus on elements and relationships does not make the concept less theoretical or scientific. In this paper I have argued in favour of a ‘broad definition of the NSI’. But this argument reflects a specific purpose – i.e. to link innovation to economic performance at the national level. It is equally legitimate to pursue the analysis with a more narrow perspective – such as the one implicit in the triple-helix approach – if, for instance, the purpose is to analyse international differences in the emergence of science-based technologies.

A more realistic and fertile approach for social science than the aim to develop general theory is to combine attempts to build general, valid and reliable knowledge about causalities with the insight that social science, by definition, always will remain historical. 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 (Mjøset 2001; Mjøset 2002). To develop a ‘general theory’ of innovation systems that abstracts from time and space would therefore undermine the utility of the concept both as an analytical tool and as a policy tool (Shin 2004).

The only solution to the paradox that product innovations are quite frequent in the market economy is that most markets are not ‘pure’; rather they are ‘organized’ and include a mix of trust, loyalty and power relationships. To establish these durable relationships it is necessary for the parties involved to invest in codes and channels of

information – and to build ‘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).¹⁴

Evolutionary economics constitutes a general theoretical framework for the analysis of innovation systems. It is a key assumption in evolutionary economics that agents and organisational routines differ and that *diversity* is fundamental for the dynamics of the system. Innovation creates novelty and diversity in the system, competition is a selection process that reduces diversity, while some routines are reproduced over time. In what follows we will assume that evolution in terms of what people and organisations know and in terms of how they learn is especially important for the dynamic performance of the national innovation system.

Knowledge and learning

In the very beginning of this volume we stated that ‘the most fundamental resource in the modern economy is knowledge and, accordingly, the most important process is learning.’ But at the time (1992) our use of the concepts of knowledge and learning were not at all well developed. Over the last 15 years the attempts to get a better understanding of the knowledge-based economy and the learning economy have created a more satisfactory theoretical foundation for the understanding of innovation systems (see for instance Lundvall and Johnson 1994; OECD 2000; Foray 2004; Amin and Cohendet 2004).

The understanding has been 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 (Johnson, Lorenz and Lundvall 2003). In Lundvall and Johnson (1994) we introduced a distinction between Know What, Know Why, Know How and

¹⁴ Today we would add to this micro-foundation the nation-specific characteristics of work organisation and learning at the workplace. This will be addressed in section 4 below.

Know Who that has proved to be useful in understanding knowledge creation and learning in innovation systems. These distinctions are especially helpful when it comes to contrast the theoretical micro foundations of innovation systems with those of standard economics.

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

The theory behind innovation systems

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

Table 1: The two-dimensional shift in perspective

	Allocation	Innovation
Choice making	Standard neoclassical	Project management
Learning	Austrian Economics	Innovation systems

The analysis of innovation systems is based upon a two-dimensional shift of focus toward the combination of innovation and learning. While standard economics is preoccupied with specifying the institutional set-up that results in an optimal allocation of existing resources we are concerned with how different institutional set-ups affect the creation of new resources. While standard economics analyse how agents make choices on the basis of given sets of information and competences, we are interested in how the knowledge – including both information about the world and know-how of agents – change in the economic process.

This double shift in perspective has implications for innovation policy. Just to take one example, a policy analysis of patent races where ‘winner takes it all’ will, as far as it neglects the learning and competence building that takes place during the race, end up with too restrictive conclusions regarding the role of government in stimulating R&D.

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

What has been said obviously implies a more complex theory than standard neoclassical economics where it is assumed that all agents have equal access to technologies and are equally competent in developing and utilizing them. But it would be wrong to conclude that the theory behind innovation systems is ‘less theoretical’.

Basically, the theory underlying innovation system analysis is about learning processes involving skilful but imperfectly rational agents and organizations. It assumes that organizations and agents have a capability to enhance their competence through searching and learning and that they do so in interaction with other agents and that this is reflected in innovation processes and outcomes in the form of innovations and new competences.

The methodological dictum within neo-classical economics that theory should be both general and abstract sometimes takes Occam’s razor to far leading to negligence of the concrete and historical. But the most important weakness of neo-classical theory is not that it is too abstract. *It is rather that it makes the wrong abstractions.* In a context where knowledge is the most important resource and learning the most important process neo-

classical theory tends to abstract from the very processes that make a difference in terms of the economic performance of firms and for the wealth of nations.

Processes of competence building and innovation are at the focal point in innovation system analysis. The focus is upon how enduring relationships and patterns of dependence and interaction are established, evolve and dissolve as time goes by. New competences are built while old ones are destroyed. At each point of time discernable patterns of collaboration and communication characterize the innovation system. But, of course, in the long term these patterns change in a process of creative destruction of knowledge and relationships. A crucial normative issue is how such patterns affect the creation of new resources and to what degree they support learning among agents.

Box 6: Different meanings of learning

As any everyday concept learning has several different connotations. In the literature on learning organizations it is often referred to as *adaptation*: as a process where agents when confronted with new circumstances register and internalize the change and adapt their behaviour accordingly.

In education we see learning also as a process of *competence-building*. We assume that new competences can be established through education and training and thereafter mobilized when coping with and mastering theoretical and practical problems.

In our analysis of innovation systems we see learning as referring both to adaptation and competence building. And we emphasize that competence building takes place on-the-job through learning by doing, learning by using and learning by interacting.¹⁵

Standard economics favours narrow interpretation of innovation systems

Standard economics tends to stick to the idea that only quantitative as opposed to qualitative concepts can be accepted as scientific (Georgescu Roegen 1971). One reason for the bias toward narrow interpretations of innovation systems is that it is much easier

¹⁵ In our empirical research on the performance of Danish firms we have found that there is substantial overlap between organizational characteristics that support adaptive capacities and those that support innovation and competence-building (Nielsen and Lundvall 1999; Lundvall 2002).

to develop quantitative analysis of R&D and patents, than it is to measure organizational forms and outcomes of organizational learning.

Standard economics will typically focus on potential market failure and on choices to be made between different alternative uses of scarce resources. In the context of innovation policy the concern will be, first, if public rates of return are higher than private rates and, second, if the rate of return of public money is higher in investing in R&D than it would be in other areas of public investment.¹⁶ The very idea that there might be organizational forms that are more efficient than the ones already in use cannot be reconciled with the basic analytical framework where it is assumed that agents, including firms, are equally rational and competent.

Standard economics will tend to see the market as the ‘natural’, if not optimal, framework of human interaction and economic transaction. This leads to biased conclusions when considering how to organize the economy (Nelson 2006). The concept ‘market failure’ reflects this bias since it indicates that other institutional set-ups should be considered only when it is obvious that the market cannot do the job.

4. Challenges for innovation system research

Causality in a systemic context

A major challenge for innovation system analysis is to avoid thinking in terms of mechanical models of causality and develop theory as well as analytical techniques that make it possible to study how different factors interact in a systemic context.

When studying national systems it is a specific challenge for statistical analysis that the ‘population’ is so small and heterogeneous. Some statistical procedures will as first approximation look for causality patterns that are general for the whole population – for all national systems of innovation. Such procedures are sometimes used in empirical analysis of determinants of economic growth. We believe that other methods are more

¹⁶ Within this narrow logic the neglect of learning effects from engaging in innovation will underestimate both the private and public rates of return.

useful when it comes to study national systems of innovation. Clustering procedures that result first in dividing the population into different ‘sub-species’ or ‘families’ with common characteristics (level of development, size, continental belonging etc.) and second in looking for patterns of interdependency for each of the different families and finally relating this to multidimensional indicators of economic performance.

It is for instance common to rank the US at the top of performance together with the small Nordic countries. But it is also well known that the US-system is fundamentally different from the small Nordic countries in terms of institutions and characteristics (population size, size of the public sector, degree of inequality, industrial structure and mode of innovation). Therefore, in spite of the fact that both categories belong to the same species, ‘national systems of innovation’, there is no reason to assume that the mechanism linking R&D effort to innovation and economic performance is the same in the two countries.

The idea that the aim of innovation research is to end up with general laws that can be applied equally in all national systems is mistaken. There are certain activities that can be linked to innovation and that link innovation to economic growth in all systems. But the mechanisms differ across different national systems. This is why theoretical work on national innovation systems cannot dispense from historical analysis.

Understanding knowledge and learning

One important challenge for innovation system analysis is to deepen the understanding of how different kinds of knowledge are created and used in the process of innovation. Some elements of knowledge are local and tacit, embodied in people and embedded in organizations. Other elements are global, explicit and can easily be transferred from one part of the world to another. Different sectors in the economy and in society make use of different mixes of local and global knowledge and in some areas, such as education and business consulting, it is especially difficult to codify the know-how that consultants and teachers make use of when they give advice and teach (OECD 2000).

To understand how learning takes place within organizations as well as in the interaction between organizations is a key to understand how systems of innovation work. While it is

important to study national characteristics in terms of organisations that pursue R&D, it is equally important to understand national characteristics in terms of how firms interact with customers and to what degree different firms give employees access to competence-building in connection with on-going economic activities.

The co-evolution of the division of labour, interaction and cooperation

As pointed out by Adam Smith, a fundamental process in economic development and economic growth is the deepening and extension of the division of labour. Specialization within and between organizations makes it possible to exploit scale economies and also to focus on competence building so that it can advance more rapidly.

As the horizontal and vertical division of labour evolves it contributes to *diversity* and diversity feeds innovation. But the growing specialisation also creates new barriers for communication and interaction. This is highly relevant because innovation is the outcome of combining knowledge located at different sites in a specialized innovation system. It is well documented that different departments (R&D, production, sales etc.) within a firm have difficulties to understand and communicate with each other. At the individual level, experts with different specialties have difficulties to interact and understand each other. The ease to communicate across such barriers in a national system with vertical disintegration between organizations is especially interesting because it is here product innovations are developed in an interaction between users and producers (Lundvall 2006).

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

Box 7: National patterns in Work Organisation¹⁷

Table 1 below originates from paper by Lorenz and Valeyre (2006). The four organisational models were constructed on the basis of factor analysis of responses to surveys addressed to employees in 15 European countries.

Table 1: National Differences in Organisational Models (percent of employees by organisational class)

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

Source : Lorenz and Valeyre (2006)

Table 1 shows that people working in different national systems of innovation and competence building *have very different access* to learning by doing. It also shows that at lower income levels the bigger proportion of the workforce that work in either simple or Taylorist organizations. The richer the country the more workers are employed in discretionary learning contexts. But it is also important to note that countries at similar income levels – Germany and the UK – have quite different distributions of workers between the four forms. While the proportion of workers operating in the lean production is more than

¹⁷ The data originate from a survey of workers in 15 European countries on working conditions gathered by the Dublin Institute for Working and Living conditions. Discretionary learning refers to work situations where workers say that they learn a lot and that they have some freedom to organise their own work. Lean production learning refers to work situations where workers learn but where there is little discretion left for the worker to organise his/her own activities. Taylorist organisation offers little learning and very little freedom for the worker while simple production gives more autonomy in solving simple tasks that offer little learning opportunities.

40% in the UK, it is less than 20% Germany. The micro foundation of national systems of innovation differs not only because of levels of income but also because of other systemic features.
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Firms as sites for employee learning

Innovation indicators reflect outputs such as number of patents or inputs that are easy to measure such as R&D expenditure. When it comes to indicators of knowledge there is a strong bias in favour of knowledge that is explicit. Investment in scientific knowledge is measured by surveys on R&D and innovation. The know-how built up through learning by doing, using and interacting is much more difficult to measure. Human capital measurements may register formal investment in education but what people learn at the workplace or as consumers is not easy to capture through standard measurements.

The absence of indicators makes the area less visible for policy makers and this contributes to a bias in innovation policy toward promoting STI- rather than DUI-activities (see Table 2 below).

In recent empirical work by Lorenz and Valeyre it has been shown that there are dramatic differences between Europe's national systems in terms of how and how much the average employee learns at his/her workplace (Lorenz and Valeyre 2006). While in Denmark a majority of workers are engaged in 'discretionary learning' where they combine learning through problem solving with a certain autonomy in their work situation, the majority of workers in countries such as Greece and Spain are engaged in taylorist type of work with much more limited opportunities for learning and with very little autonomy (See Box 7).

In a follow-up to the analysis of these national patterns of workplace learning they have been combined with innovation indicators. The analysis shows, first, that on average countries that make intensive use of discretionary learning are most prone to engage in 'endogenous innovation' (defined as innovations that emanate from in-house R&D efforts and result in products new to the market). But, second, it shows that strong economic performance may emanate from quite different combinations of innovation and learning modes. For instance Denmark is not very strong in endogenous innovation but very strong in discretionary learning while the opposite is true for another Nordic country, Finland (Arundel, Lorenz, Lundvall and Valeyre 2006).

The national differences in what people do and learn at their workplace is a major factor structuring the national innovation system and affecting its performance: It is certainly more fundamental and difficult to change than for instance R&D intensity. In countries such as Finland and Korea these favoured BERD-measures of ‘performance’ reflect the propensity to do research within one big corporation such as Nokia and Samsung. This contrasts with indicators of competence building in working life since these refer to how competence building takes place in all parts of the economy.

The weak correlation between strength of the science-base and economic performance

Over the last century there has been a certain focus on the European Paradox referring to the assumed fact that Europe is strong in science but weak in innovation and economic growth.¹⁸ Similar paradoxes have been argued to exist in countries such as The Netherlands, Finland and Sweden. In a recent OECD-report a *general result* is that for the countries included in the study it can be shown that those that ‘perform well’ in terms of STI-indicators do not perform well in terms of innovation (OECD 2005, p. 29).¹⁹ This indicates that what is registered is not so much a paradox as it is a systematic weakness in the theoretical analysis and the indicators upon which it is built.

We would argue that these apparent paradoxes emanate from a narrow understanding of the innovation process. They demonstrate that heavy investment in science in systems where organizational learning within and between firms is weakly developed and where there is a weak focus on user needs has only limited positive impact upon innovation and economic growth.

¹⁸ This debate has triggered strong efforts to link universities to firms in Europe sometimes going as far as seeing the ideal university as ‘innovation factory’. Dosi, Llerena and Sylos Labini (2006) raise doubts about the basic assumption behind the paradox that Europe is strong in Science.

¹⁹ After comparing the performance of six countries it is stated that ‘A striking feature is the apparent missing link between indicators A-E and the overall performance indicators in F. *This suggests that priorities and biases in the STI-policy system are weakly linked to general economic performance and policies.*’ (OECD 2005, p.29, italics by this author).

Table 2: The probability that firms develop a new product or a new service

<i>Variables</i>	Odds ratio estimate	Coefficient estimate	Odds ratio estimate	Coefficient estimate
STI Cluster	3.529	1.2611**	2.355	0.8564**
DUI Cluster	2.487	0.9109**	2.218	0.7967**
DUI/STI Cluster	7.843	2.0596**	5.064	1.6222**
Business services			1.433	0.3599
Construction			0.491	-0.7120*
Manuf. (high tech)			1.805	0.5905*
Manuf.(low and med. tech)			1.250	0.2229
Other services			0.747	-0.2923
100 and more employees			1.757	0.5635*
50-99 employees			0.862	-0.1481
Danish group			0.859	-0.1524
Single firm			0.521	-0.6526*
Customised product			1.378	0.3203
Pseudo R ²	0.1247	0.1247	0.1775	0.1775
<i>N</i>	692	692	692	692

** = significant at the .01 level

* = significant at the .05 level

This can be illustrated by data on innovation performance at the firm level – see table 2. In a series of recent papers based upon a unique combination of survey and register data for Danish firms we have demonstrated that firms that engage in R&D without establishing organizational forms that promote learning and neglect customer interaction are much less innovative than firms that are strong both in terms to STI- and DUI-learning (Jensen, Johnson, Lorenz and Lundvall 2007).²⁰

Table 2 refers to the outcome of an analysis of survey and register data for almost 700 Danish firms and it presents different variables related to the propensity to introduce new products or services. We use sector, size and form of ownership as control variables but the focus is upon a variable indicating *the mode of innovation* in the firm. We distinguish between firms that are strong in science-based learning, firms strong in organizational learning, firms that are strong in both respects and we use those firms that are weak in both respects as the benchmark category. To construct this variable we pursue a cluster analysis grouping the firms in the four categories.

As indicators of strong science-based learning we use the R&D expenditure, presence of employees with academic degree in natural science or technology and collaboration with scientists in universities or other science organizations. As indicator of experience-based learning we take the use of certain organizational practices normally connected with learning organizations such as ‘interdisciplinary workgroups’ and ‘integration of functions’ together with ‘closer interaction with customers’ – to signal learning by interacting and a focus on user needs.

We use firms that only make weak efforts to support science-based and experience-based learning as benchmark and the odds ratio estimate indicates how much higher the propensity to innovate is among firms strong in respectively one or both of the modes of learning. The results reported in table 2 show that firms that combine the two modes are much more prone to innovate than the rest. It shows that the effect remains strong also after introducing control variables related to size and sector.

²⁰ The data in table 2 are from Jensen, Johnson, Lorenz and Lundvall (2007).

Box 8: How to study national systems?

Our interest in utilizing the innovation system perspective is not purely academic. We use this concept as a focusing device in order to better understand how innovation affects economic development at the national level. Within this broad view many factors contribute to innovation and it might be seen as a problem that almost all aspects of society need to be brought in to explain the actual pattern of innovation. To structure the analysis it is useful to distinguish between the *core* of the innovation system and *the wider setting*. Both need to be included in the analysis since the aim is to link innovation to economic development.

Firms and the knowledge infrastructure constitute the core of the system. In principle we include all firms in the core since every firm has a potential for developing, absorbing or using new technology.

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

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

The analysis and results reported above point to the need to develop our understanding of how different forms of knowledge and different modes of innovation are combined in different national innovation systems. The analysis also explains why narrow definitions of national innovation systems that focus only upon science-based innovation are of little relevance for the economic performance of firms and national innovation systems. This is not least important when it comes to analyse the barriers and opportunities for economic development in poor countries, another challenge for innovation system research (Arocena and Sutz 2000b; Cassiolato, Lastres and Maciel 2003).

5. National systems of innovation and economic development

While the modern version of the concept of national systems of innovation was developed mainly in rich countries (Freeman 1982; Freeman and Lundvall 1988; Lundvall 1992; Nelson 1993; Edquist 1997) some of the most important elements 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 came from Myrdal (1968). Applying the systems of innovation approach to economic development brings into focus other research issues of general interest such as the need to understand how innovation relates to sustainable development, economic welfare and the role of government in commodifying knowledge.

Most chapters in this book treat the innovation system as an ex-post rather than as an ex-ante concept. The concept refers to relatively strong and diversified systems with well-developed institutional and infrastructural support of innovation activities. The perspective is one where innovation processes are evolutionary and path dependent and systems of innovation evolve over time in a largely unplanned manner. The system of innovation approach has not, to the same extent, been applied to system building. When applied to the South the focus needs to be shifted in the direction of system construction and system promotion – something that was central in List's ideas for catching up – and to the fact that public policy is a conscious activity that needs to stimulate and supplement the spontaneous development of systems of innovation (Muchie, Gammeltoft and Lundvall 2003; Lundvall, Interakummerd and Lauridsen 2006).

Box 9: A method to study national innovation systems

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

1. Firms play the most important role in the innovation system. Firms innovate in an interaction with other firms and with knowledge infrastructure.
2. Firms’ mode of innovation and learning reflects national education systems, labour markets, etc.
3. Firms belonging to different sectors contribute differently to innovation processes.

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

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

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

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

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

Another weakness of the system of innovation approach is that it is still lacking in its treatment of the power aspects of development. The focus on interactive learning – a process in which agents communicate and cooperate in the creation and utilization of new economically useful knowledge – may lead to an underestimation of the conflicts over income and power, connected to the innovation process. 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 global schemes to protect intellectual property this perspective gives a too rosy picture. Post-colonial and class privileges may

block learning possibilities and existing competences may be destroyed for political reasons related to the global 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 (Lastres and Cassiolato 2005). '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 is also clear that what is most relevant for developing economies is a broad definition of the NSI including not only low-tech industries but also primary sectors such as agriculture. Activities contributing to competence building needs to be taken into account and narrow perspectives that focus only on the STI-mode needs to be avoided.²¹

²¹ Several authors analysing the situation of less developed countries have been critical to the use of the concept 'national innovation system' and have preferred to work with concepts such as national technological systems (Lall and Pietrobelli 2003) or national learning systems (Matthews 2001; Viotti 2002). To some degree I see their alternative conceptual proposals as reactions to the use of narrowly defined innovation systems with focus on STI-learning. I strongly support the idea that understanding processes of experience based learning is a key to the understanding of the specificities of national innovation systems (see Lorenz and Lundvall 2006).

Box 10: Innovation Systems and Development Thinking

As pointed out in the text the SI literature builds upon conceptual pillars rooted in the development discussion. The role of technology was an important part of the post-war debate on development. Schumpeter's (1934) concept of development contributed with two central ideas for this debate. One was the positive effects of generating new products and new processes. The other was the disruptive character of development. These two notions shaped the subsequent contributions, with Prebisch's (1950), Singer's (1950) and Myrdal's (1958) analyses of the long-term deterioration of terms of trade for primary products and of the distribution of gains between developed and developing countries.

In Latin America, a number of development studies followed Prebisch, arguing about the central role played by technical change in explaining the evolution of the capitalism and in determining the historical process of hierarchy formation of regions and countries. Furtado (1964), for instance, established an express relation between economic development and technological change pointing out that the growth of an economy was based on the accumulation of knowledge and understood development within a systemic, historically determined, view.

Inspired by Schumpeter an important and influential literature about how firms in the developing world acquire and develop technological capabilities unfolded during the 1970s and 1980s. Key concepts were the notions of technological capabilities and learning. Several empirical studies have shown how less developed countries have managed to develop significant skills, which have led to 'efficient' production, at least in the short term. These studies focused mostly on the capabilities of producers, e.g. knowledge and skills required for production (Katz 1984; Dahlman et al. 1987)

In the same period (1970s and 1980s), in Latin America, authors inspired by the Latin American Structuralist School (LASA) literature, developed a number of firm-level studies where the second of Schumpeter's ideas – the disruptive character of development – was taken into account. This work was instrumental in showing, not only successful stories of technological up-grading, but also important limitations of the capabilities and learning approach to technology and development; precisely because this approach left behind key elements, such as the role of institutions, of the macroeconomic regime and of power conflicts.

In East Asian economies, empirical investigation of successful evolution of innovation systems also helped to link the innovation systems perspective to development analyses. For example, case studies of the textile and clothing and electronics industries in the Taiwan Province of China and the Republic of Korea confirmed that inter-firm linkages, including subcontracting arrangements, were crucial channels of technological learning, in some cases, even more important than direct channels such as foreign direct investment (San Gee and Kuo 1998; Ernst, Ganiatsos and Mytelka 1998).

Welfare and inequality in the context of innovation systems

A promising line of research is to link the perspective of Amartya Sen (1999) on welfare and inequality to the national system perspective. Sen presents a capability-based approach where development is seen as an expansion of the substantive freedoms that people enjoy. Substantive freedoms are defined as the capabilities people have to live the kind of lives they have reason to value. They include things like being able to avoid starvation and undernourishment, diseases and premature mortality. It also includes the freedoms of being literate, able to participate in public life and in political processes, having 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 in the learning economy is whether the setting gives access to and stimulates a renewal and upgrading of the competence of agents.

The learning capability is thus one of the most important of the human capabilities and it is conditioned by national institutions and forms of work organisation (see for instance Box 7 for the case of Europe). 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 well-being. 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.

On the sustainability of innovation systems

National Systems of Innovation may be regarded as a tool for analysing economic development and economic growth. It aims at explaining how systemic features and different institutional set-ups at the national level link innovation and learning processes to economic growth.

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

Diagram 3: Resources fundamental for economic growth – combining the tangible and reproducible dimensions

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

The diagram illustrates that economic growth is faced with a double challenge in terms of sustainability and that there is an immanent risk of undermining not only the material basis of material production (Segura-Bonilla 1999), but also the knowledge base. The creation of tangible capital may be threatened by a neglect of environmental sustainability. We will argue that the production and efficient use of intellectual capital is fundamentally depending upon social capital (Woolcock 1998). A development strategy that focuses only on production capital and intellectual capital is not sustainable.

This is equally true for developed as for developing economies. But in most developed economies there has been a long history of institution building that helps to cope with

sustainability (Russia is a case where there is imbalance between the level of technical development and institutions checking unsustainable development). Even if they are insufficient in many respects this kind of institutions are more developed than in the developing part of the world. A success in terms of economic growth in a less developed economy may therefore create extreme tension between growth and sustainability. Directing the efforts of the innovation system toward solving crises in ecological and social terms may be necessary in order to avoid real 'limits to growth'.

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

This perspective indicates a broader and more interdisciplinary approach to national innovation systems.

The role of the state and the commodification of knowledge

As explained, the modern version of the innovation system concept was developed in the middle of the 1980s. It is important to note that the early versions were *critical* both to mainstream economics and to the prevailing economic policy where weak competitiveness was seen as primarily reflecting high costs and especially high wage costs.

The wide diffusion of the concept among policy makers took place in the 1990s. At the beginning of the new millennium most OECD countries had adopted the concept to support the design of innovation policy. In order to understand the interpretation of the concept in policy circles it is important to take into account the ideological and political climate that reigned during this diffusion process.

Basically the 1990s was a period with strong emphasis on market regulation and on private property rights as ideal institutions – the break-down of the centrally planned

economies in Europe gave new impetus to neo-liberal strategies developed in the 1980s. This resulted in a certain degeneration of the concept. Analytical aspects of the concept that might lead to conclusions that went against the logic of markets and free trade were suppressed.

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

To make universities more open to society is a necessary process and expectations that the knowledge produced at universities should contribute to economic welfare are legitimate. But the current drive toward the market is driven by the lop-sided understanding of innovation as emanating almost solely from science and therefore it goes too far.

The long-term implications and costs of making scholars and universities profit-oriented seem to be neglected among the protagonists of university reforms in the Bayh-Dole spirit.²² Scholars who are stimulated to act strategically on their own behalf and on the behalf of their institution will certainly become less engaged in sharing their knowledge with others. Private companies might, in the short run, appreciate that universities become more profit-oriented but they will soon experience that the barriers around the knowledge accumulated will become higher and that access to the most relevant knowledge will become more difficult.

²² The Bayh Dole act implemented in the US in the 1980s gives stronger opportunities and incentives to universities to engage in patenting and protecting their knowledge. As documented by Mowery and Sampat (2004) the interpretation of the ‘success’ of this reform in Europe has been exaggerated.

It is even more intriguing to reflect on what awaits at the end of the current trajectory; at the point in time where the entrepreneurial university has become truly a business corporation operating in international markets. At that point we must expect that WTO restrain the current freedom of national governments to subsidize basic research taking place within universities by competition laws and trade regulations. How could it be argued that private firms (universities) that compete on global markets should be subsidized by national government? To establish controls that make it certain that government support only goes to basic research without affecting services sold internationally would open up for complex legal processes. If governments wanted to go on subsidizing basic research they might need to establish a new set of institutions.²³

Finally, there is a need to think about the implications for the role of universities of the fact that knowledge becomes more and more fundamental for the economy as for society as a whole. The historical role of universities has been an institution that ‘validates’ knowledge. It has been an institution that, while aiming at the full truth of matters, at least systematically tries to establish what ‘reasonably reliable knowledge’ is. This is also one reason why it has been an institution with a relative autonomy in relation to the state as well as in relation to economic interests. This function is even more important in a knowledge-based society.²⁴

As a kind of countervailing power to the colonizing tendency emanating from market-oriented innovation policy we see a need to develop a wider field of politics – *knowledge politics* – that covers all aspects of knowledge production and takes into account that the

²³ This scenario gains in realism by the fact that some major US universities would dominate ‘the level playing field’ and by fact that the US government would still be able to pursue basic research under headings such as health, military defence and space technology since these can be defined as being of strategic importance for its security.

²⁴ In order to explain this to economists who are eager to market orient universities it is useful to point to the relative autonomy of central banks. To make sure that we can trust the value of money it has been accepted that its main guardian is given a certain degree of autonomy. We need a similar guardian for knowledge and it is difficult to find another institution/organization that is better suited to be the central bank of knowledge than the university.

production of knowledge has much wider scope than just contributing to economic growth. This includes of course knowledge necessary for social and ecological sustainability but not only that. In rich societies it should be possible to afford culture, ethics and knowledge for its own sake, not only knowledge that promotes innovation and economic growth. This implies that there might be a need for establishing a new kind of ‘academy of science and knowledge’ that has as one of its dedicated tasks to set the limits for how far innovation policy may influence knowledge production and use.

Higher education, innovation and economic development

In the context of poor countries the idea of a relative autonomy for universities may appear as a luxury that cannot be afforded. In a recent paper (Lundvall 2007) I have made an attempt to link higher education to innovation and economic development.

In less developed countries as in rich countries the most important function of universities remains to train academic personnel and give them competences so that they can be absorbed in meaningful employment where they solve problems that are so complex that less-skilled workers would fail. Such problems will appear more frequently in economies where innovation is frequent (Nelson and Phelps 1965; Schultz 1975). Therefore the design of the university system needs to be seen as an integrated part of the formation of a national system of innovation.

The idea that universities should serve as direct sources for innovation through their ‘third mission’ and that this mission should involve the creation of markets for knowledge implicit in much of the triple-helix literature is problematic in poor as in rich countries (Arocena and Sutz. 2005). To establish a closer interaction with the rest of society is especially important in less developed countries where the distance between academia and real life is often very big. But rather than creating market-oriented universities, what is needed is educational reform including the wide introduction of problem-based learning as teaching method and, in general, a closer interaction between theory and practise.

Box 11: The Globelics experience

Globelics is a global research community combining scholars working on innovation studies with scholars working on development studies. It has been characterised as a network for ‘researchers without borders’ (www.globelics.org). The Globelics annual conferences take place in developing countries and the finance has been raised within the hosting country.

Besides the annual conferences, regional and national networks have been established in Asia, Latin America and China (see www.cicalics.org). Each year 40 Ph.D.-students, coming equally from Asia, Africa, Latin America and Europe, are invited to Globelics Academy in Lisbon where world-leading scholars in innovation studies for a 10 days period give lectures and methodological advice for their thesis work. A similar Cicalics Academy takes place in China every year with a majority of Chinese students and with international lecturers. New initiatives in Africa and India may soon result in similar activities in these areas.

The purpose of Globelics is to counterbalance the increasingly uneven global access to research networks. It gives scholars in less developed countries access to the most recent research and it opens up channels for publication of their work. It also makes it possible to share experiences among scholars from different parts of the developing world, by-passing the metropolises in the North. Several major research projects with global scope use Globelics as host – the Catch-Up project coordinated by Richard Nelson, The Brics-project co-ordinated by Jose Cassiolato and the Unidev project co-ordinated by Claes Brundenius.

Globelics has a scientific board with distinguished scholars such as Christopher Freeman and Richard Nelson and with leading scholars from the South. But basically Globelics is a self-organising global network. It draws its energy mainly from the fact that scholars from the North and the South find it highly rewarding to work together and learn from each other in a seriously committed but friendly atmosphere.

One major long term positive effect is that young scholars from all parts of the world, sometimes working in isolation and under difficult conditions, get inspiration and support in their effort to do good research on innovation. There is already a lively ‘Globelics community’ of young scholars who correspond regularly on both a scientific and a social basis.

Investment in higher education may not give substantial rates of return in a technologically stagnant economy. Since the alternative to invest in higher education is to remain in stagnation forever, our analysis needs to focus on two questions. First, how to design higher education in such a way that it helps to break the vicious circle of stagnation and stagnating demand for graduates? Second, how to design a general strategy for vitalising national innovation systems that includes investment in higher education as important element?

6. Conclusions

In this paper we went back to the origin of the concept of the national innovation system. We have argued that the original versions as developed by Christopher Freeman and the Aalborg-group are more adequate tools when it comes to link innovation to aggregate national economic performance than narrow versions that focus mainly on the science

base. In the current era there is a need both for strengthening the science base and for promoting experience-based learning. This is absolutely fundamental when it comes to link the analysis of national innovation systems to economic development.

This implies new directions for research on innovation systems. First, it is necessary to develop a better understanding and more efficient analytical techniques to study institutional 'complementarity' and 'mismatch' in innovation systems. Second, there is a need to deepen the understanding of the production, diffusion and use of knowledge. In this connection the focus should be on interactive learning processes and upon how 'social capital' evolves as a basis for interaction within and across organisational boundaries. Third, there is a need to understand and develop indicators of how and to what degree work places function as learning sites in different national systems. Fourth, a promising research strategy is to link organisational learning, mobility of people and network formation. Networks will always involve interaction between people and the specific career will have an impact on with whom and how agents interact.

Universities play an important role in the innovation system but the triple-helix perspective, with its neglect of DUI-mode of learning, may have led to exaggerated expectations of what can and should be expected from them. Universities need to be guaranteed a minimum autonomy in order to give long term contributions to knowledge creation and the idea that they should be completely subsumed to market forces and political control is incompatible with their role as guardians of what is 'reasonably reliable knowledge'. Their most important role in the national innovation system is not to be incubators for start-up firms or for patents, it remains the training of graduates for the labour market.

Today, as compared to the original 1992-approach, we would emphasize even more the importance of human resources. While one aspect of globalization is that codified knowledge moves quickly across borders, the most localized resource remains people, their tacit knowledge, their network relationships and their accumulated organizational experiences. Therefore all parts of the innovation system that contribute to competence building are becoming increasingly important for national performance.

Over the last decade there has developed a big lively and productive research community primarily studying industrial dynamics in the business sector and often the contributing scholars are employed at Business Schools or Technical Universities (compare for the annual Druid and the bi-annual Schumpeter conferences- www.druid.dk). There might be falling marginal return to this kind of research and seen from the point of view of the innovation system approach there are important issues not given sufficient attention. Five themes that have been touched upon in this post-script need to be further developed in future research:

- Implications of the NSI-approach for economic theory.
- NSI and economic development.
- NSI welfare states and inequality.
- Environmental sustainability of national innovation systems.
- Innovation in the public sector.

Most of these themes will require transdisciplinary efforts combining economics with management, sociology, political science and engineering.

References

- Amable, B., Barré, R. and Boyer, R. *et al.* (1997), *Les systèmes d'innovation à l'ère de la globalization*, Paris, Economica.
- Amin, A. and Cohendet, P. (2004), *Architectures of Knowledge: Firms, Capabilities and Communities*, Oxford, Oxford University Press.
- Andersen, E. S. and Lundvall, B.-Å. (1988), 'Small National Innovation Systems Facing Technological Revolutions: An Analytical Framework', in Freeman, C. and B.-Å. Lundvall (eds.), *Small Countries Facing the Technological Revolution*, London, Pinter Publishers, 9-36.
- Archibugi, D. and Lundvall, B.-Å. (eds.) (2001), *The globalising learning economy: Major socio-economic trends and European innovation policy*, Oxford, Oxford University Press.
- Arocena, Rodrigo and Judith Sutz (2000a), 'Looking at national systems of innovation from the south', *Industry and Innovation*, Vol.7, No.1, pp. 55-75.
- Arocena, Rodrigo and Judith Sutz (2000b), *Interactive Learning Spaces and Development Policies in Latin America*, DRUID working papers, No. 00-13.
- Arocena, R. and Sutz, J. (2005), 'Latin American universities: From an original revolution to an uncertain transition', *Higher Education*, vol. 50, pp. 573-592.

- Arundel, A., Lorenz, E., Lundvall, B.-Å. and Valeyre, A. (2006), 'The Organisation of Work and Innovative Performance: A Comparison of the EU-15', *DRUID Working Paper* no. 06-14, Aalborg University.
- Balzat, M. and Hanusch, H. (2004), 'Recent trends in the research on national systems of innovation', *Journal of Evolutionary Economics*, 14: 197-210.
- Breschi, S. and Malerba, F. (1997), 'Sectoral innovation systems', Edquist, C. (ed.), *Systems of innovation: Technologies, institutions and organizations*, London, Pinter Publishers.
- Carlsson, B. and Stankiewicz, R. (1991), 'On the Nature, Function and Composition of Technological Systems', *Journal of Evolutionary Economics*, Vol. 1, pp. 93-118.
- Cassiolato, J. E., Lastres, H. M. M and Maciel, M. L. (2003), *Systems of Innovation and Development*. Edward Elgar, Cheltenham, UK, 2003.
- Christensen, J. L. and Lundvall, B.-Å. (eds.) (2004), *Product Innovation, Interactive Learning and Economic Performance*, Amsterdam, Elsevier.
- Clark, G. L., Feldman, M. P. and Gertler, M. S. (2000), *The Oxford Handbook of Economic Geography*, Oxford, Oxford University Press.
- Cooke, P. (1996), *Regional Innovation Systems: An Evolutionary Approach*, London University Press, London.
- Cooke, P. (2001), Regional innovation systems, clusters and the knowledge economy. *Industrial and Corporate Change* 4 (10), pp. 945-974.
- Dahlman, C. J., Ross-Larson, B. and Westphal, L. E. (1987), 'Managing Technological Development: Lessons from the newly Industrialized Countries', *World Development*, Vol. 15, No. 6.
- De Liso, N. (2006), 'Charles Babbage, Technological change and the "national system of innovation"', *Journal of Institutional and Theoretical Economics*, Vol. 162, No. 3, pp.470-485.
- Dosi, G. (1984), *Technical change and economic performance*, London, Macmillan.
- Dosi, G. (1999), 'Some notes on national systems of innovation and production and their implication for economic analysis', in Archibugi, D., Howells, J. and Michie, J. (eds.), *Innovation policy in a global economy*, Cambridge, Cambridge University Press.
- Dosi, G., Freeman, C., Nelson, R.R., Silverberg, G. and Soete, L., (eds.) (1988), *Technology and economic theory*, London, Pinter Publishers.
- Dosi, G., Llerena, P. and Sylos Labini, M. (2006), 'Science-Technology-Industry link and the European paradox: Some notes on the dynamics of scientific and technological research in Europe', in Lorenz, E. and Lundvall, B.-Å. (eds.) (2006), *How Europe's economies learn*, Oxford, Oxford University Press, pp. 203-234.
- Dosi, G., Pavitt, K., Soete, L. (1990), *The economics of technical change and international trade*, Herfordshire, Harvester Wheatsheaf.
- Edquist, C. (ed.) (1997), *Systems of innovation: Technologies, institutions and organizations*, London, Pinter Publishers.
- Edquist, C. (2005), 'Systems of Innovation: Perspectives and Challenges', in Fagerberg, J., Mowery, D. and Nelson, R.R. (eds.), *The Oxford Handbook of Innovation*, Norfolk, Oxford University Press.
- Edquist, C. and Lundvall, B.-Å. (1993), 'Comparing the Danish and Swedish Systems of Innovation', Nelson, R.R. (ed.), *National Innovation Systems: A Comparative Analysis*, Oxford, Oxford University Press.

- Eparvier, P. (2005), 'Methods of evolutionism and rivalry with neoclassical analysis. The example of the National System of Innovation concept', *Journal of Economic Methodology*, vol.12, no. 4, pp. 563-579
- Etzkowitz, H. and Leydesdorff, L. (1995), 'The Triple Helix - University-Industry-Government Relations: A Laboratory for Knowledge-Based Economic Development', *EASST Review* 14(1), 14-19.
- Etzkowitz, H and L. Leydesdorff (2000), 'The dynamics of innovation: from National Systems and 'Mode 2' to Triple Helix of university-industry-government relations', *Research Policy*, Vol. 29, No. 2, pp. 109-123.
- Fagerberg, J., D. Mowery and R.R. Nelson (eds.) (2005), *The Oxford Handbook of Innovation*, Norfolk, Oxford University Press.
- Foray, D. (2004), *The Economics of Knowledge*, Cambridge, Mass., The MIT Press.
- Freeman, C. (ed) (1981), *Technological Innovation and National Economic Performance*, Aalborg, Aalborg University Press.
- Freeman, C. (1982), 'Technological infrastructure and international competitiveness', Draft paper submitted to the *OECD Ad hoc-group on Science, technology and competitiveness*, August 1982, mimeo.
- Freeman, C. (1987), *Technology policy and economic performance: Lessons from Japan*, London, Pinter Publishers.
- Freeman, C. (1988), 'Japan: A new National Innovation Systems?', in Dosi, G., Freeman, C., Nelson, R.R., Silverberg, G. and Soete, L.,(eds.), *Technology and economic theory*, London, Pinter Publishers.
- Freeman, C. (1995a), 'The National Innovation Systems in historical perspective', in *Cambridge Journal of Economics*, vol. 19, no. 1.
- Freeman, C., (1995b), 'History, co-evolution and economic growth', in IIASA Working Paper 95-76, Laxenburg, IIASA.
- Freeman, C. (2002). Innovation systems: City-state, national, continental and sub-national, Mimeo, Paper presented at the Montevideo conference, *Research Policy* 31 (2): 191-211.
- Freeman, C. (2004), 'Technological infrastructure and international competitiveness', *Industrial and Corporate Change*, Vol 13, No 3, pp 540-52.
- Freeman, C. and Soete, L. (eds.) (1987), *Technical change and full employment*, Oxford, Basil Blackwell.
- Freeman, C. and Lundvall, B.-Å. (eds.) (1988), *Small Countries Facing the Technological Revolution*, London: Pinter Publishers.
- Freeman, C. and Soete, L. (1997), *The Economics of Industrial Innovation*, Pinter, London.
- Furtado, C. (1964), *Development and Underdevelopment: A Structural View of the Problems of Developed and Underdeveloped Countries*, Berkeley, University of California Press.
- Georgescu-Roegen, N. (1971), *The entropy law and the economic process*, Harvard, Harvard University Press.
- Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Peter Scott, P., and Trow, M. (1994), *The new production of knowledge: the dynamics of science and research in contemporary societies* London: Sage.
- Granstrand, O. (2000), Corporate Innovation Systems A Comparative Study of Multi-Technology Corporations in Japan, Sweden and the USA, *Chalmers University of Technology*.
- Hirschman, Albert, O. (1958), *The Strategy of Economic Development*, Clinton: Yale University Press.

- Jensen, M. B., Johnson, B., Lorenz, E. and Lundvall, B.-Å. (2007), 'Forms of Knowledge and Modes of Innovation', forthcoming in *Research Policy*.
- Johnson, B. (1992), 'Institutional learning', in Lundvall, B.-Å. (ed.), *National Innovation Systems: Towards a Theory of Innovation and Interactive Learning*, London, Pinter Publishers.
- Johnson, B. and Lundvall, B.-Å. (2003), 'National Systems of Innovation and Economic Development', in Muchie, M., Gammeltoft, P. and B.-Å. Lundvall (eds), *Putting Africa First, The Making of African Innovation Systems*, Aalborg University Press.
- Katz, R. (1984), *Organizational Issues in the Introduction of new Technologies*, working paper, Alfred P. Sloan School of Management, Massachusetts Institute of Technology.
- Kline, S. J. and Rosenberg, N. (1986), 'An overview of innovation', in Landau, R. and Rosenberg, N. (eds.), *The positive sum game*, Washington D.C., National Academy Press.
- Lall, S. and Pietrobelli, C. (2003), 'Manufacturing in Sub-Saharan Africa and the Need of a National Technology System', in Muchie, M., Gammeltoft, P. and B.-Å. Lundvall (eds), *Putting Africa First, The Making of African Innovation Systems*, Aalborg, Aalborg University Press.
- Lastres, H. M. M. and Cassiolato, J. E. (2005), 'Innovation systems and local productive arrangements: new strategies to promote the generation, acquisition and diffusion of knowledge'. In *Innovation: Management, Policy & Practice*, Vol. 7, no 2.
- List, F. (1841): *Das Nationale System der Politischen Ökonomie*, Basel: Kyklos (translated and published under the title: *The National System of Political Economy* by Longmans, Green and Co., London 1841).
- Liu, X. and White, S. (2001), 'Comparing innovation systems: A framework and application to China's transitional context', *Research Policy*, Vol. 30, No 7, pp. 1091-114.
- Lorenz, E. and Lundvall, B.-Å. (eds.) (2006), *How Europe's economies learn*, Oxford, Oxford University Press.
- Lorenz, E. and Valeyre, A. (2006), 'Organizational forms and innovation performance: A comparison of the EU15', in Lorenz, E. and Lundvall, B.-Å. (eds.), *How Europe's Economies Learn*, Oxford, Oxford University Press, pp. 140-160.
- Lund Vinding, A. (2002), *Absorptive capacity and innovative performance: A human capital approach*, Ph.-D.-dissertation, Department of Business Studies, Aalborg University, Aalborg.
- Lundvall, B.-Å. (1985), *Product Innovation and User-Producer Interaction*, Aalborg, Aalborg University Press.
- Lundvall, B.-Å. (1988), 'Innovation as an interactive process: From user-producer interaction to the National Innovation Systems', in Dosi, G., Freeman, C., Nelson, R.R., Silverberg, G. and Soete, L.,(eds.), *Technology and economic theory*, London, Pinter Publishers.
- Lundvall, B.-Å. (ed.) (1992), *National Innovation Systems: Towards a Theory of Innovation and Interactive Learning*, London, Pinter Publishers.
- Lundvall, B.-Å. (2002), *Innovation, Growth and Social Cohesion: The Danish Model*, Cheltenham, Edward Elgar.
- Lundvall, B.-Å. (2006), 'Interactive learning, social capital and economic performance', Foray, D. and Kahin, B. (eds.), *Advancing Knowledge and the Knowledge Economy*, Harvard University Press, US.
- Lundvall, B.-Å. (2007), 'Higher Education, Innovation and Economic Development', Paper presented at the World Bank's *Regional Bank Conference on Development Economics*, Beijing, January 16-17, 2007.
- Lundvall, B.-Å. and Borrás, S., (1998), 'The Globalising Learning Economy – Implications for Innovation Policy', *The European Commission*, DG XII-TSER, Bruxelles.

- Lundvall, B.-Å. and Johnson, B. (1994), 'The learning economy', *Journal of Industry Studies*, Vol. 1, No. 2, December 1994, pp. 23-42.
- Lundvall, B.-Å., Johnson, B., and Lorenz, E. (2002), 'Why all this fuss about codified and tacit Knowledge?', *Industrial and Corporate Change*, No 2, pp. 245-62.
- Lundvall, B.-Å., Johnson, B., Andersen, E. and Dalum, B. (2002), 'National Systems of Production, Innovation and Competence-building', *Research Policy* 31 (2):213-231.
- Lundvall, B.-Å., Interakummerd, P. and Lauridsen J.V. (eds.) (2006), *Asia's innovation systems in transition*, London, Elgar.
- Marshall, A. (1919), *Industry and Trade: A Study of Industrial Technique and Business Organisation*, Macmillan, London.
- Marshall, A. (1920), *Principles of Economics*, Macmillan, London.
- Maskell, P. and Malmberg, A. (1997) Towards an explanation of regional specialization and industry agglomeration. *European Planning Studies*, 5: 1 pp. 25-41
- Mathews, J.A. (2001), 'National systems of economic learning: The case of technology diffusion management in East Asia', *International Journal of Technology Management*, 22 (5/6): 455-479.
- McKelvey, M. (1991), 'How do National Innovation Systems differ?: A critical analysis of Porter, Freeman, Lundvall and Nelson', in Hodgson, G. M. and Screpanti, E. (eds.), *Rethinking economics: Markets, technology and economic evolution*, Aldershot, Elgar Publishing House.
- Metcalf, J. S. (2006), 'Marshallian economics', paper presented at the International Schumpeter Society, 11th Conference, Sophia Antipolis 2006, June 21-24.
- Miettinen, R. (2002), *National Innovation System, Scientific Concept or Political Rhetoric*, Helsinki, Edita.
- Mjøset, L. (2001), 'Theory, understanding of in the Social Sciences', in N. J. Smalser and P. B. Bates (eds), *International Encyclopedia of the Social and Behavioral Sciences*, Pergamon/Elsevier, Amsterdam.
- Mjøset, L. (2002), 'An Essay on the Foundations of Comparative Historical Social Science', Working Paper No. 22, ARENA, Oslo.
- Mowery, D. and Rosenberg, N. (1979), 'The Influence of Market Demand upon Innovation: A Critical Review of Some recent Empirical Studies', *Research Policy*, Vol. 8, No. 2.
- Mowery, D. and Sampat, B. N. (2004), 'The Bayh-Dole Act of 1980 and University–Industry Technology Transfer: A Model for Other OECD Governments?', in *The Journal of Technology Transfer*, Vol. 30, No. 1-2.
- Muchie, M., Gammeltoft, P. and Lundvall, B.-Å. (eds.) (2003), *Putting Africa First: The Making of African Innovation Systems*, Aalborg, Aalborg University Press.
- Myrdal, G. (1958), *Economic Theory and Underdeveloped Regions*, Duckworth & Co.
- Myrdal, Gunnar (1968), *Asian Drama, An Inquiry into the Poverty of Nations*, New York: Penguin Books.
- Nelson, R. (1984), *High-technology policies – A five-nation comparison*, Washington, American Enterprise Institute.
- Nelson, R. R. (1988), 'Institutions supporting technical change in the United States', in Dosi, G., Freeman, C., Nelson, R.R., Silverberg, G. and Soete, L., (eds.), *Technology and economic theory*, London, Pinter Publishers.

- Nelson, R.R. (ed.) (1993), *National Innovation Systems: A Comparative Analysis*, Oxford, Oxford University Press.
- Nelson, R.R. (2006), 'What makes an economy productive and progressive? What are the needed institutions?', *Columbia University*.
- Nelson, R. R. and Phelps, E. S. (1965), 'Investments in Humans, Technology Diffusion and Economic Growth', in *The American Economic Review*, Vol. 56, No. 1/2.
- Nelson, R. R. and Winter, S. G. (1982), *An Evolutionary Theory of Economic Change*, Cambridge, Mass., The Belknap Press of Harvard University Press.
- Nielsen, P. and Lundvall, B.-Å. (1999), 'Competition and Transformation in the Learning Economy: The Danish Case', *Revue d'Economie Industrielle* 88, 67-90.
- OECD (1992), *Technology and the Economy – The Key Relationships*, Paris.
- OECD (2000), *Knowledge Management in the Learning Society*, Paris, OECD.
- OECD (2005), *Governance of Innovation Systems*, Volume 1: Synthesis Report, Paris, OECD
- Pavitt, K. (1984), 'Sectoral patterns of technical change: Towards a taxonomy', *Research Policy*, Vol. 13, pp. 343-73.
- Porter, M. (1990), *The competitive advantage of nations*, London, MacMillan.
- Prebisch, R. (1950), *The Economic Development of Latin America and its Principal Problems*, United Nations, Department of Economic Affairs, Economic Commission for Latin America.
- Reinert, E. (1999), 'The Role of the State in Economic Growth', *Journal of Economic Studies* 26 (4/5):268-326.
- Reinert, E. (2003), 'The Other Canon: The History of Renaissance Economics', *Evolutionary Economics and Income Inequality*, edited by E. Reinert. Northampton: Edward Elgar Publishing.
- Rickne, A. (2000), *New Technology-based Firms and Industrial Dynamics: Evidence from the Technological System of Biomaterials in Sweden, Ohio and Massachusetts*, Göteborg, Chalmers University of Technology.
- Rosenberg, N. (1976), *Perspectives on Technology*, Cambridge University Press, Cambridge.
- Rothwell, R. (1972), *Factors for Success in Industrial Innovations: Project SAPPHO – A Comparative Study of Success and Failure in Industrial Innovation*, Science Policy Research Unit, University of Sussex, Brighton.
- Rothwell, R. (1977), 'The characteristics of successful innovators and technically progressive firms', *R&D Management*, No 3, Vol. 7, pp. 191-206.
- Sabato, J. and Botan, N. (1968), 'La ciencia y la tecnologia en el desarrollo futuro de America Latina' Paper presented at *The World Order Models Conference*, Bellagio, Italy, September 25-30.
- San Gee and Kuo, W.-J. (1998), 'Export Success and Technological Capability: Textiles and Electronics in Taiwan, Province of China', in Ernst, D., Ganiatos, T. and Mytelka, L. (eds), *Technological Capabilities and Export Success in Asia*, Routledge, London.
- Schmookler, J. (1966), *Invention and Economic Growth*, Cambridge, MA, Harvard University Press,.
- Schultz, T. W. (1975), 'The Value of the Ability to Deal with Disequilibria', *Journal of Economic Literature*: 827-846.
- Schumpeter, J. A. (1934), *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interests and the Business Cycle*, London, Oxford University Press.

- Schumpeter, J. A. (1942), *Capitalism, Socialism and Democracy*, London, Unwin.
- Segura-Bonilla, O. (1999), 'Sustainable Systems of Innovation: The Forest Sector in Central America', *SUDESCA Research Paper No 24*, PhD dissertation, Department of Business Studies, Aalborg University.
- Sen, Amartya (1999), *Development as Freedom*, Oxford: Oxford University Press.
- Sharif, N. (2006), 'Emergence and development of the National Innovation Systems concept', *Research Policy*, Volume 35, No. 5, pp. 745-766.
- Shin, J.-S. (2004), 'Studies of National Innovation Systems – Which Way to Go?', Working Paper, *National University of Singapore*.
- Singer, W. H. (1950), 'U.S. Foreign Investment in Underdeveloped Areas – The Distribution of Gains between Investing and Borrowing Countries', in *The American Economic Review*.
- Smith, Adam (1776/1904), *An Inquiry into the Nature and Causes of the Wealth of Nations*, London: Methuen and Co., Ltd., ed. Edwin Cannan, 1904, 5th edition.
- Schmookler, J. (1966), *Invention and Economic Growth*, Harvard University Press.
- Stewart, Frances (1977), *Technology and Underdevelopment*, London: Macmillan.
- Viotti, E.B. (2002), 'National learning systems: A new approach to technological change in late industrialising countries and evidence from the cases of Brazil and Korea', *Technological Forecasting and Social Change*, 69 (7), pp. 653-680.
- Verspagen, B. and Werker, C. (2003), 'The invisible college of economics of innovation and technological change', *Estudios de Economia Aplicada*, Vol. 21, No. 3, 203-220.
- Whitley, R. (1994), 'Societies firms and markets: The social structuring of business systems', in Whitley, R. (ed.), *European business systems*, London, Sage Publications.
- Witt, U. (1993), *Evolutionary Economics*, Aldershot, Edward Elgar Publishers.
- Woolcock, M. (1998), 'Social capital and economic development: toward a theoretical synthesis and policy framework', *Theory and Society*, No. 2, Vol. 27, pp. 151-207.