31. Innovation systems and development: history, theory and challenges

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INTRODUCTION

When the first edition of Lundvall (2010) was published in 1992, only a handful of scholars and policy-makers were familiar with the concept of a 'national innovation system'. Over a period of 20 years there has been a rapid and wide diffusion of the concept. The concept is now widely used in research in different disciplines and in all countries policy-makers link the concept to growth, development and competitiveness.[1]

In this chapter I 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 (Innovation, Knowledge and Economic Dynamics) Group in Aalborg. Often policy-makers and scholars have applied a narrow understanding of the concept, and this gives rise to so-called 'innovation paradoxes' which leave significant elements of innovation-based economic performance unexplained.

I will argue that only with a broad definition of the national innovation system encompassing individual, organizational and interorganizational learning is it possible to establish the link from innovation to economic development. A double focus is needed where attention is given not only to the science infrastructure, but also to institutions and organizations that support competence-building in labour markets, education and the working life. This is especially important in relation to developing countries and in the current era of the 'globalising learning economy' (Archibugi and Lundvall 2001; Lundvall et al. 2009).

The chapter first takes a brief look at the origins of the national system of innovation (NSI) concept before covering the general background of the history of innovation research.[2] It confronts the theoretical foundations of the concept with standard economics, before going on to define analytical challenges. It then relates the concept to economic development, inequality and sustainability. The chapter ends with my conclusions.

[1] Google scholar gives more than 2 million hits for 'innovation system' while Google gives close to 5 million.

[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 spheres.

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A CONCEPT WITH ROOTS FAR BACK IN HISTORY

Milestones in the Development of the Innovation-System Concept

At 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 United States (US) scholars, had compared technology policy and institutions in the high-technology field in the US with Japan and Europe (Nelson 1984). The Science Policy Research Unit (SPRU) at Sussex University pursued several studies comparing industrial development in Germany and the United Kingdom (UK) covering, for instance, differences in the management of innovation, work practices and engineering education.

The idea of a national system of innovation was also immanent in the research programme pursued by the IKE Group at Aalborg University, of which I was a member.[3] 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'.

The first use of the concept national innovation system is to the best of my knowledge to be found in a working paper by Christopher Freeman written for an OECD working group and it refers to Friedrich List's reference to the national production system as a predecessor to the concept (Freeman 1982; Freeman 2004).When Freeman collaborated with Nelson and Lundvall in the Institute for International Assistance and Solidarity (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). The concept was consolidated when three major edited volumes on the subject came out in the 1990s (Lundvall 1992; Nelson 1993; Edquist 1997).[4]

The innovation system concept may be regarded as a practical tool for designing innovation policy. But it may also be seen as an analytical focusing device and as a synthesis of analytical results produced by scholars working on innovation. In this section I 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 (Smith 1904 [1776]). It is especially interesting to note that he identifies and distinguishes two different modes of innovation (see Box 31.1).

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[3] 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, e.g., Freeman 1981).

[4] For an overview of the current status and prospects of innovation research see Fagerberg et al. (2013).

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BOX 31.1 ADAM SMITH ON MODES OF INNOVATION AND LEARNING

Adam Smith (1904 [1776], 8) on the learning by doing, using and interacting (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.

Adam Smith (1904 [1776], 9) on the science, technology and innovation (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 anything, but to observe everything; and who, upon that account, are often capable of combining together the powers of the most distant and dissimilar objects.

The first mode is experience-based, and in the chapter 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 I will argue that this distinction is fundamental when it comes to analysing modern innovation systems and when it comes to designing management strategy as well as public policy.[5]

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 (List 1841). 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

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

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'the accumulation of all discoveries, inventions, improvements, perfections and exertions of all generations which have lived before us' (Freeman 1995a, 6).

Karl Marx on Technological Progress

The historical parts of *Das Kapital* (Marx 1967) 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 organizational 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.[6]

Marx is a pioneer also when it comes to emphasizing the importance of both '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 science and technology in relation to the economy are very advanced for his time (Rosenberg 1976).

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.[7] In his *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 come 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 research and development (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'.

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.[8] It is true that he defines the opening of new markets as one kind of innovation. But, in general,

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[6] For a historical analysis of how match and mismatch is reflected in economic performance of national systems, see Freeman (1995b).

[7] Verspagen and Werker (2003) are interesting in showing which scholars define themselves as 'neo-Schumpeterians'.

[8] 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, xiv).

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consumers and users are assumed to be ready to absorb whatever new innovations are 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 by 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).

Christopher Freeman as the Father of Modern Innovation Theory

Christopher Freeman played a key role in stimulating these new theoretical developments, especially in Europe.[9] In the early 1980s, his lectures to PhD 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. His founding of the SPRU at Sussex University in 1966 was a major step toward giving innovation studies a more permanent institutional foundation.

One important reference in his lectures at the beginning of the 1980s was to the Sappho (Scientific Activity Predictor from Patterns with Heuristic Origins) study organized at SPRU (Rothwell 1972, 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.[10]

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 introducing the concept of the 'national system of innovation' (Freeman 1982, 2004).

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

[10] 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 mobilize resources in critical phases of the innovation process.

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The Flourishing 1980s

The 1980s was a period when innovation research became 'emancipated' and more ambitious, including 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 et al. 1990). Christopher Freeman and Soete analysed employment issues in relation to technical innovation (Freeman and Soete 1987). Giovanni Dosi established his hypothesis on shifts in technological paradigms (Dosi 1984).

In the US, 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.

These different efforts merged into two different major projects. One was a major book project led by a team consisting of Dosi, Freeman, Nelson, Silverberg and Soete (Dosi et al. 1988). The other major project took place in the policy realm and was organized by the Directorate for Science Technology and Industry at the Organisation for Economic Co-operation and Development (OECD). The Technology Economy Programme (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 organizations, 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 Conceptualization 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 not only seen 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 explaining competitiveness, economic growth and development. In the next section I compare the NSI perspective with the basic assumptions of standard economics.

Many recent contributions to innovation systems have different and 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. Other contributions, emanating from international economic organizations analysing national growth performance, combine the system perspective with elements of neoclassical economics. Some even utilize

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production-function techniques based upon standard economics assumptions, including agents acting on the basis of rational expectations.

NATIONAL INNOVATION SYSTEM AS ANALYTICAL FOCUSING DEVICE

The innovation system framework is in direct competition with standard economics when it comes to giving advice to policy-makers. In this section I will present the core theoretical ideas behind the innovation system perspective and confront them with those of standard economics. The main conclusion is that the neglect in standard economics of the diversity of agents and of learning as competence-building is a major weakness that makes the approach inadequate when it comes to understanding innovation and dynamic economic performance.

Theoretical Elements Entering Into the Innovation System Concept

As indicated above, the national innovation system approach is grounded in empirical findings through the 1970s and 1980s, many of which emanated from scholars connected to the 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 show how different sectors interact 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).

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 invest in 'social capital'. When it is realized that actual markets are mixed with organizational elements, this 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 et al. (1988) and in Nelson (1993).[11]

Evolutionary economics constitutes a general theoretical framework for the analysis of innovation systems. It is a key assumption in evolutionary economics that agents and organizational 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

[11] Today we would add to this micro-foundation the nation-specific characteristics of work organization and learning at the workplace. This will be addressed below.

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follows I will assume that evolution in terms of what people and organizations know and in terms of how they learn is especially important for the dynamic performance of the national innovation system.

Knowledge and Learning

At the very beginning of Lundvall (2010) it is stated that 'the most fundamental resource in the modern economy is knowledge and, accordingly, the most important process is learning'. But when this proposition was coined (in 1992) 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 and the learning economy have created a more satisfactory theoretical foundation for the understanding of innovation systems by developing the analysis of different forms of knowledge and different modes of learning (see, e.g., 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 et al. 2002). Lundvall and Johnson (1994) introduced a distinction between 'know what', 'know why', 'know how' and 'know who' that has proved to be useful in understanding knowledge creation and learning in innovation systems. These distinctions are especially helpful when it comes to contrast the theoretical micro foundations of innovation systems with those of standard economics.

If neoclassical models include learning, it is either understood 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' to be reflected in productivity growth. 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 into knowledge-based networks (know-who) is abstracted from in order to keep the analysis simple. 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 of the exaggerated focus on allocation as opposed to knowledge creation and growth. Table 31.1 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

Table 31.1 The two-dimensional shift in perspective

	Allocation	Innovation
Choice-making	Standard neoclassical	Project management
Learning	Austrian economics	Innovation systems

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connected well-defined (but possibly risky) alternative outcomes, and the focus of the analysis is on the allocation of scarce resources. As illustrated by Table 31.1, the emphasis is different in the innovation system approach.

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, here we are concerned with how different institutional set-ups affect the creation of new resources. While standard economics analyses 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 – changes in the economic process.

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 neoclassical economics that theory should be both general and abstract sometimes takes Occam's razor too far, leading to negligence of the concrete and historical. But the most important weakness of neoclassical 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, neoclassical 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 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.

Standard Economics Favours a 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 to

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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 concerns 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.[12] 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 of '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.

CHALLENGES FOR INNOVATION SYSTEM RESEARCH

The Weak Correlation between the Strength of the Science Base and Economic Performance

Over the last century there has been a focus on the 'European paradox', referring to the assumed fact that Europe is strong in science but weak in innovation and economic growth.[13] Similar paradoxes have been argued to exist at the national level 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, 29).[14] This indicates that what is registered is not so much a paradox as a systematic weakness in the theoretical analysis and the indicators upon which it is built.

I 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 a limited positive impact upon innovation and economic growth. One important challenge for innovation system research is to develop the analysis of innovation systems so that it takes into account experience-based learning and interaction with users.

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

[13] This debate has triggered strong efforts to link universities to firms in Europe, sometimes going as far as seeing the ideal university as an 'innovation factory'. Dosi et al. (2006) raise doubts about the empirical basis for the paradox; they argue that Europe is not especially strong in science.

[14] 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, 29).

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Table 31.2 The probability that firms develop a new product or a new service

Variables	Odds-ratio estimate (1)	Coefficient estimate (2)	Odds-ratio estimate (3)	Coefficient estimate (4)
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
N	*692*	*692*	*692*	*692*

Note: ** = significant at the 0.01 level; * = significant at the 0.05 level.

Source: Based on Jensen et al. (2007).

This can be illustrated by data on innovation performance at the firm level; see Table 31.2. 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 of STI and DUI learning (Jensen et al. 2007).

Table 31.2 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 (Jensen et al. 2007). Sector, size and form of ownership were used as control variables, but the focus was upon a variable indicating the mode of innovation in the firm. Firms that make only weak efforts to support science-based and experience-based learning are used as the benchmark (odds ratio =1), 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 31.2 show that firms that combine the two modes are much more prone to innovate than the rest (see column 1). It shows that the effect also remains strong after introducing control variables related to size and sector (see column 3). Columns 2 and 4 show that the differences between modes are significant both with (column 4) and without (column 2) control variables.

As indicators of strong science-based learning were used the R&D expenditure, the presence of employees with an academic degree in natural science or technology, and the collaboration with scientists in universities or other science organizations. Indicators of experience-based learning were the use of certain organizational practices normally

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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.

Firms that only made weak efforts to support science-based and experience-based learning were taken as the 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 31.2 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.

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 analysing the barriers and opportunities for economic development in poor countries, another challenge for innovation system research (Arocena and Sutz 2000; Cassiolato et al. 2003).

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).

Firms as Sites for Employee Learning

To understand how learning takes place within organizations as well as in the interaction between organizations is a key to understanding how systems of innovation work. While it is important to study national characteristics in terms of organizations that pursue R&D, it is equally important to study to what degree firms in different national systems give employees access to competence-building in connection with ongoing economic activities.

Lorenz and Valeyre (2006) show that there are dramatic differences between Europe's national systems in terms of how and how much the average employee learns at their workplace. The majority of workers in the Netherlands, Denmark and Sweden are engaged in 'discretionary learning', where they combine learning through problem-solving with a certain autonomy in their work situation. This contrasts with countries such as Greece, Portugal and Spain, where Taylorist types of work with much more limited opportunities for learning and with very little autonomy are much more frequent. The distinction between discretionary learning, lean production and Taylorism refers to

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Table 31.3 National differences in organizational models (% of employees by organizational class)

	Discretionary learning	Lean production learning	Taylorist organization	Simple organization
North				
The 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
Luxemburg	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).

different degrees of worker autonomy, and it may be argued that the three forms represent different levels of quality of working life.

Table 31.3 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 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 under lean production is more than 40 per cent in the UK, it is less than 20 per cent in Germany. The micro-foundation of national systems of innovation differs not only because of levels of income but also because of other systemic features.

In a follow-up to the analysis of these national patterns of workplace learning they have been combined with innovation indicators. The analysis shows 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). See Figure 31.1, which shows the

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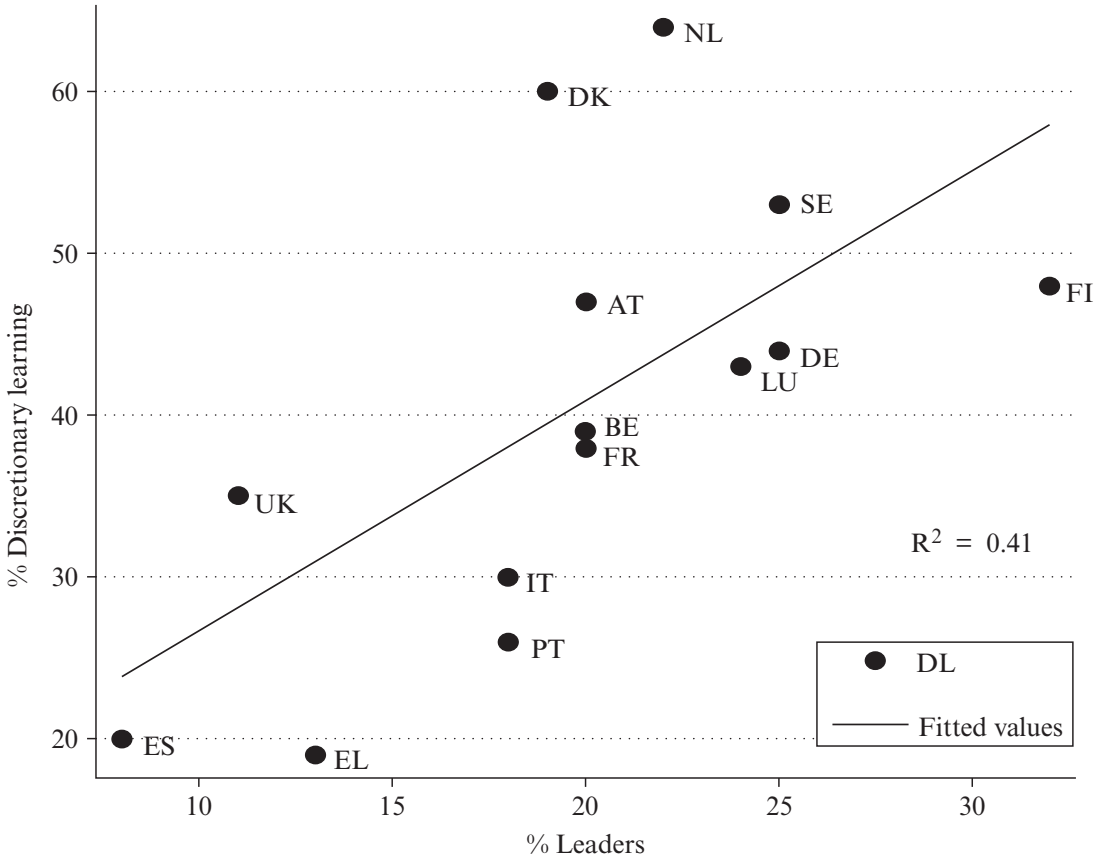

Figure 31.1 Discretional learning and leading innovators

proportion of 'lead innovators' among firms and the share of workers engaged in discretionary learning (Arundel et al. 2007).

Figure 31.1 shows that there is a tendency for countries hosting lead innovators to have a bigger share of workers engaged in the discretionay learning mode. The analysis indicates that 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 difficult to change than, for instance, R&D intensity, but it is also more fundamental and more deeply rooted in the industrial history of the country.

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).

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Most of the studies of national systems treat the innovation system as an *ex post* concept. Often 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 et al. 2003; Lundvall et al. 2006).

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 globalization and national and local systems need to be further researched. It is important to know more about how globalization processes affect the possibilities to build and support national and local systems of innovation in developing countries (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 mining and agriculture. Activities contributing to competence-building need to be taken into account, and narrow perspectives that focus only on the STI mode should be avoided.[15] These topics are reflected in the research agenda of the global research network on innovation systems and development: Globelics (see Box 31.2).

[15] Several authors analysing the situation of less-developed countries have been critical of the use of the concept of the 'national innovation system' and have preferred to work with concepts such as 'national technological systems' (Lall and Pietrobelli 2003) or 'national learning systems' (Mathews 2001; Viotti 2002). To some degree I see their alternative conceptual proposals as reactions to the use of narrowly defined innovation systems with a focus on STI-based 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).

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BOX 31.2 THE GLOBELICS EXPERIENCE

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

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 metropoles in the North. Several major research projects with global scope use Globelics as their host – the Catch-Up project coordinated by Richard Nelson, the BRICS Project (Brazil, Russia, India, China, South Africa) coordinated by Jose Cassiolato, and the Unidev project (Development Education in Theory and Practice) coordinated by Claes Brundenius.

One major long-term positive effect is that young scholars from all parts of the world, sometimes working in isolation and under difficult conditions, gain 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 with each other on both a scientific and a social basis.

CONCLUSIONS

In this chapter I went back to the origin of the concept of the national innovation system. I have argued that the original versions as developed by Christopher Freeman and the Aalborg group are more adequate tools when it comes to linking 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 linking 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 organizational boundaries. Third, there is a need to understand and develop indicators of how and to what degree workplaces function as learning sites in different national systems. Fourth, a promising research strategy is to link organizational learning, mobility of people and network formation. Networks will always involve interaction between people, and the specific career will have an impact on how and with whom agents interact.

Today, as compared to the original 1992 approach, I 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.

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