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Innovation systems and capabilities

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Abstract

This paper contains a critical analysis of the concept *national innovation system*. This much favored concept both in innovation analysis and innovation policy contains an inherent vagueness, and is in need of clarification and specification.

The paper presents an overview of the national innovation systems literature, and makes some proposals for improvements in the conceptual apparatus developed so far.

Keywords: National innovation systems; Innovation Policy; Innovation Theory

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Innovation systems and capabilities

Introduction

Understanding technical change and innovation is crucial for understanding the dynamics of 'knowledge-based economies' and 'learning economies'. Differences in innovation performance and the related institutional setting particular to a country partly explain variations in economic performance. In modern innovation theory, strategic behaviour and alliances of firms, as well as interaction and knowledge exchange among firms, research institutes, universities and other institutions, are at the heart of the innovation process. Innovation and upgrading of productive capacity is a dynamic social process that evolves most successfully in a network in which intensive interaction takes place between those 'producing' and those 'purchasing and using knowledge.

Innovation is a complex social phenomenon. The process through which innovations emerge, does not follow a linear path, it is characterised by complicate feedback mechanisms and interactive relations (Kline and Rosenberg (1986)) involving science, technology, learning, production, institutions, organisations, policy makers and demand (Edquist (1999)). *National Innovation Systems* (NISs) is the most frequently used approach of the last decade for understanding the complex relations that make up the innovation process. Analysis of NISs for different countries have described the participating institutions and organisations and their networks of interrelations (Lundvall (1992), Nelson (1993)).

The innovation systems literature is a relatively new and evolving field; moreover it is, as noted above, one with strong connections to other theories and fields of study, both historically and in contemporary research. However, systems theories often return us to long-standing debates in economic theory. These may be to do with the importance of national policy frameworks in economic development or of institutional conditions (where the very extensive institutional economics literature remains important). More generally, they also reflect Marx' broad conceptions of the economy as a social process. Marx is in fact one of the few important theorists to attempt to combine a theory of technological change with a theory of economic development. Historical roots of the concept of national innovation systems can be found in the writings of Friedrich List (List (1841)) and his outline of national systems of political economy, as well as in the early institutional school developed towards the end of the 19th century. In contrast to marginalist, later neoclassical, theories of economic interaction based on individualistic utility, this school emphasised the role of institutional and social contexts in shaping economic conditions and interaction (Veblen (1898), Hamilton (1919)). Such concerns are shared by a wide range of approaches to social and economic action, institutional and neocorporatist approaches (see f.i. Hodgson (1988) and Hollingsworth and Boyer (1997)) and Marxist (as Sayer (1995)) approaches, as well as the Regulation school (Boyer and Saillard (1995)) and the

sociological inclined 'embedding' and wider literatures on economic sociology (see f.i. Swelser and Swedberg (1994)).

The approach to innovation systems share several aspects with these approaches and must be seen as a member of many-sided efforts in a range of social sciences to dynamics in capitalist economies. In particular a discontent with the reduction of social dynamics to rational and self-interested atomistic agents is shared. This implies that understanding the shaping of economic behaviour and its determinants by necessity must consider a wider social framework than the restricted economic system of anonymous, 'arm's length' relations mediated through ideal or 'perfect' markets. In this wider social context, the dichotomous pair of markets and hierarchies coexist with other coordinating mechanisms, as bi- and multilateral relations such as networks, that shape and are themselves shaped by the social system of production. Typically in such approaches the social system of production encompasses corporate structures, horizontal and vertical relations of firms, employer-employee relations, financial markets, as well as norms, rules, laws and cultural aspects etc. (Hollingsworth and Boyer 1997). A contention in these literatures is that these social institutions are integrated into characteristic social configurations, being linked up to produce a cohesive system that reflects the underlying 'capitalist logic', either directly in a functionally determined sense (Habermas (1975)) or indirectly with social institutions being the result of an evolutionary process at the micro-level (as in Nelson and Winter (1982)). One essential point here, and one point among many which provide important links to the concept of innovation systems, is that such approaches emphasise that the social production system, shaping and shaped by coordination mechanisms, provides codes of communication and conduct of actors, as well as incentives/disincentives. They provide actors with vocabularies, norms and values, and with world views.

In this perspective the concept of innovation system is seen as one particular aspect of these wide-ranging approaches. The focus of the concept is restricted to 'innovative behaviour', to changes in economic behaviour that has inter-firm repercussions. One implicit perspective in the framework outlined above is made explicit in, the role of generation, dissemination and inter-agent accessibility of 'technological' knowledge as a basic determinant of economic innovation behaviour.

The objective of introducing the term is to catch the main determining factors of innovative behaviour, based on an argument that innovation shows features that are denoted 'systemic'. In that sense the term is intended to capture the main features of the 'innovation universes' of firms and industries. The sections below will briefly outline the two main lines that have been used to describe *innovation systems*. We argue that the richest of these is more appropriate for the kinds of analysis the term purports to enable. This line, being described as a 'cognitive approach to innovation systems', is a conceptualisation that is close to the RISE basis. In the last section we will briefly describe some policy implications of such innovation system based approaches.

With innovation being systemic; i.e. multifunctional and inter-organisational, innovation systems are ultimately interwoven with industrial dynamics, inti-

mately linked as these systems are to the relations between innovating firms and their environment. At the same time their structure and functionalities are affected by initiatives beyond the commercial objectives of firms. Policy measures like R&D or diffusion programmes, and establishment of technology service institutions may have permanent impact on the structure of these innovation systems.

Innovation systems

Since its inception about 10 years ago[1], the concept of 'national innovation systems' has gained wide popularity in both research on innovation and technical change and in innovation and technology policies. The OECD Technology/Economy Programme, a major effort to synthesise 'systemic' approaches to innovation and technical change into a resource base for innovation policy formulation in member countries, proved a significant vehicle for diffusing the term. The concept of national innovation systems was used in the TEP programme as a main backbone for mediating and making sense of the broad array of insights on technological change and economic growth, OECD (1991a), (1992). It was used to call attention to characteristic features of why and how firms innovate, and to the need of broadening attention of technology and innovation policies in enhancing national technological opportunities and capabilities, to 'technology in a changing world'.

The first major books surveying the NIS concept were published in 1992 and 1993: one edited by Richard Nelson includes case studies of fifteen NISs divided into 'large high-income', 'smaller high-income' and 'lower-income' countries (Nelson (1993)). The surveys were conducted mostly by resident researchers and they did not explicitly adopt any formal theory of 'systems', when they all made reference to the concept it was in the form of a unifying theme or perspective on national structures of innovation. The second one, edited by Bengt-Åke Lundvall, complements Nelson's book (Lundvall (1992)). In it Lundvall and his collaborators introduce the NIS concept by relating it to new understanding of interactive learning and innovation.

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[1] Chris Freeman, though the first to use the concept of national innovation systems, or equivalently national systems of innovation, (Freeman (1987)), credits Bengt-Åke Lundvall as the originator of the concept, see Freeman 1995. As is evident from Lundvall's contribution in Dosi et al (1988) the term for him grew out of a terminology of national production systems, evidently akin to the regulationist production system concept and attempts to generalise the analysis of user-producer relations in the Danish dairy industry, cf. Lundvall 1985 and Andersen and Lundvall 1988. The 'system of innovation' was here introduced as the 'system of innovative learning and searching', a central underlying aspect of the system of production in terms of generating endogenous institutional change. Richard Nelson was the third contributor to the NIS section in Dosi etal and progenitor of the term. He dates the birth of the concept to the three authors "more or less independently [using] the term and the basic conception" in the preparation of this volume.

Key elements of the NIS analytical framework such as 'innovation', 'system', 'national' and 'institution' have been interpreted differently by various researchers. However the notion of NIS is still conceptually vague (Edquist (1997)). Freeman (1987) originally defined NIS as the "network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies". The Japanese NIS is described with four elements; MITI, company R&D, education and training and industrial conglomerates. The Nelson volume is vague in terms of providing explicit definitions of NIS; the implicit use of the NIS term varies between the 14 contributions.

Lundvall (1992) provides a definition of NIS that emphasises non-organisational elements explicitly. After providing a first preliminary definition pointing to "elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge", an analytical definition is provided. NIS "includes all parts and aspects of the economic structure and the institutional set-up affecting learning as well as searching and exploring". This definition must "be kept open and flexible regarding which sub-systems should be included and which processes should be studied", though he notes that "the production system, the marketing system and the system of finance" are important sub-systems.

One of many secondary descriptions is provided by Metcalfe (1995). He describes NIS as "that set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artefacts which define new technologies". This deifinition runs in a vein very similar to the Freeman definition.

We will not review the literature on innovation systems in full here, insightful contributions to an overview are given in Freeman (1995), Edquist (1997) and Smith (1998). We will briefly outline the two main lines of approach to national innovation systems, arguing that one of these are more adapted to the analytical purposes of RISE. Following a brief discussion of two issues, to what extent are NISs *national* and what are innovation *systems*, we will follow the preferred approach to innovation systems in some more detail to address the analytical core of the concept; systemic dimensions of interactive learning. At the end of the chapter we outline a few main policy messages of approaches to systemic innovation.

From the outset it was clear that there were basically two different intakes to the concept, reflecting the broad distinction between *wide* or *narrow* interpretations of innovation systems (see Lundvall (1992)). These two intakes has given rise to the noted variations in the use of the term,

- an organisational approach, describing a national innovation system in terms of formal organisations and public institutions, such as public and semi-public technology service institutions, R&D labs, funding agencies and public arrangements and institutions as patent regulation. The per-

spective here is more strongly linked to the perspective of policy makers than to analytical purposes,

- what we here denote as a cognitive approach, where the concept of innovation systems is interpreted rather more strongly as a analytical concept for approaching innovation dynamics, see f.i. Edquist (1997) and Hauknes (1999).

The approach of Richard Nelson, see Nelson (1993), is based on what is in many ways a traditional institutional, or rather organisational, approach. This approach focuses the institutional infrastructure of (usually) national S&T systems, in the form of public or para-public knowledge generating institutions and public programmes and initiatives towards technical change. Lundvall's approach is a broader conceptualisation of innovation systems, focusing interactive learning as a general complementary aspect of economic interaction. As such it encompasses both the structure of economic interactions, the exchange relations, and the social and institutional structure within and around these 'economising' relations. Nelson's approach is closer in spirit to the ideas that have been prevalent in S&T policy formulation for several decades, see his contribution to the Dosi etal volume, Nelson 1988. Lundvall's capability-based, or cognitive, approach to innovation systems (Lundvall (1992a)) is wider and allows a more general analysis of provision of 'infrastructure services' in a situation of structural change.

That is, from the start it was evident that there were essentially two different approaches. One was based on economy-wide features of corporate behaviour, policy and support processes and the other was based on the evolution of specialization and its associated patterns of interaction and learning. In a sense though different, they were not incompatible. The point is that the two variants relate to different purposes and serve different uses. In fact, this was evidently noted by Lundvall himself early on, the innovation system concept was used for policy purposes, the analytical perspective was interactive learning and innovation. The analytical objective was to "contribute to a theoretical understanding of interactive learning and innovation", while 'national systems of innovation' was a derived concept, "useful when it comes to inspire public policies" (Lundvall (1992b)).

Three insights have facilitated diffusion of the innovation system concept. First, innovation is a basic characteristic of market systems, with innovation a main explicant of dynamic, endogenous evolution of market systems. Secondly, the role of technological information in market systems implies that innovation involves all the different ways firms acquire information about opportunities and how they are utilised for commercial purposes. Innovation is multi-functional. Thirdly, it is a multi-organisational phenomenon; from the vantage point of an innovating firm, innovation is shaped by interactions between this firm and multiple other organisations. This includes linkages to its various suppliers, competitors, and customers, professional networks and environments and technological infrastructures.

These three general factors, innovation as a dynamic process involving mutual and multi-functional interactions with a varied, and organisationally structured,

environment, have contributed significantly to the immense popularity of the term. This is not the least due to the immediate potency it suggests for policy formulation. Catching the systemic, inter-dependent character of innovation and technical change (Soete and Arundel (1993)), the term proposes to encapsulate determinants of 'created' comparative advantages. At the same time, in these same points lie the main weaknesses of the term; conceptually it is vague, seemingly all-encompassing, without the ability of providing differentiating ability to function as the 'focussing device' suggested by Lundvall (Lundvall (1992b)). This vagueness suggests that the term is slippery. While the Nelson approach conventionally interpreted allows us to talk of *the* (national) innovation system, the Lundvall approach is a concept that is much closer to specificities of individual firms.

Innovation *Systems*?

The conception of innovation *systems* reflects wide-ranging analysis and arguments that have emerged over the last decades addressing innovation dynamics and attempts to understand main features of the formation of innovation capabilities. Characterising the literature on innovation dynamics and economic change, there is today a substantial literature that may be characterised as 'systems' approaches. 'Systems' approaches to innovation are founded on one of the most persistent themes in innovation studies, namely that innovation by firms cannot be understood purely in terms of independent decision-making at the level of the firm. Rather, innovation involves complex interactions between a firm and its environment. Inter-firm linkages are far more than arms-length market relationships - rather, they often involve sustained quasi-cooperative relationships which shape learning and technology creation. But even broader factors shape the behaviour of firms: social and cultural contexts, institutional and organisational frameworks, infrastructures. Systems theories involve a very strong overall hypothesis, which is that diversity in macroeconomic performance can be traced to underlying system differences (Smith 1998).

It is clear that the systems aspect is a difficult and ill-defined notion. This is reflected in the many uses of systems notions in social sciences, ranging from Kenneth Boulding's anything-but-chaos to closed deterministic systems. The use of the term usually reflects some notions about internal relations between constituents at lower levels, the existence of system-level cohesive dynamics emerging from micro-agents activities and at least partial autonomy on the perceived 'system' level when embedded in a wider (social) system, often supplemented by arguments of non-linear feedback mechanisms at microlevel. These elements are well-known arguments in the innovation systems literature.

Innovation systems are *social* systems because they are made up with social agents and actants. They constitute sets of habits, practices and rules of social actors participating in them. Social systems are, for their nature, *dynamic* and *open* to external interaction (Lundvall (1992)). As these systems are influenced irreversibly by external factors and as the system 'logic' is locality specific, systems are *path-dependent* (Hollingsworth (1997)). Innovation systems are strongly contingent on local socio-economic history.

For the innovation system to be sustained as a social system, they must have a degree of internal coherence, higher than the degree of coherence between the system and the outer world. In principle, the 'broad' interactive learning based approach ensures that innovation systems have a degree of internal cohesion, and hence that the 'most important' determinants of innovation are included in the system.

Firm-level studies of interdependence between producers and users of technology have emphasised sustained user-producer interactions in technology creation, facilitated by industrial specialization and common cultural and policy environments. In this approach user-producer interaction around different culturally-supported modes of learning creates different complexes or clusters of technological capability which - taken as a whole - defined the *differentia specifica* of the national system. This is in effect an evolutionary approach, looking at the co-development of learning processes and competitive specialization. Interaction between the different agents involved in the innovation process is important for successful innovation (Morgan (1997); Lagendijk and Charles (1999)); firms never innovate in isolation (DeBresson (1996)). Networks of innovation are the rule rather than the exception, and most innovative activity involves multiple actors (OECD (1999)). To successfully innovate, companies are becoming more dependent on complementary knowledge and know-how in companies and institutions other than their own. Contrary to the 'heroic Schumpeterian entrepreneur' innovation is not the activity of a single company, but rather an active search process to tap new sources of knowledge and technology and apply them to products and production processes. A firm's competitiveness is increasingly more dependent upon its ability to apply new knowledge and technology to products and production processes.

At the same time, the rate of specialisation is rising. Companies are developing strategies to cope with their increasing dependency on their environment. For example, more flexible organisation structures and the integration of various elements in the production chain through strategic alliances, joint ventures and consortia. The division of labour between dissimilar and complementary firms is based on the strategic choice that firms have to make between internalising knowledge or sharing information with external actors. The main goal of most strategic alliances has been to gain access to new and complementary knowledge and to speed up the learning process. There has been a shift by firms towards dis-internalising activities along and between value chains and towards specialisation in those activities that require resources and capabilities, in which firms already have, or can easily acquire, a competitive advantage. In the literature, the concept of 'alliance capitalism' (Dunning, 1997) is used to indicate this new stage in the development of modern economic systems: the co-existence of competition, sharpened by globalisation and liberalisation, with an increasing number of network relations and strategic alliances.

Such arguments for *systems* of innovation are evidently a shared basis for a wide range of system approaches, that in a broad sense are mutually complementary. In addition to the innovation system approaches a la Lundvall, Nelson and Freeman, Smith (1998) points to related approaches

- from the history of technology, technology systems in the sense of Thomas Hughes,
- from 'science and technology studies', such as Bell and Callon (1994)
- the Regulation school,
- industrial cluster approaches, as Porter (1990),
- technological systems as in the sense of Carlsson (1995).

Cognitive innovation systems

Since innovation and learning are social processes, embedded in a wider set of social action, an economic system and a wider social system may become nearly indistinguishable when dynamic changes in the system of economic agents are considered. In terms of its social extension the innovation system may encompass the 'whole social system'; systems like the economic system, consisting of economic agents involved in 'economising' exchange based on present endowments and technological data, are more restricted subsets of the innovation system. What distinguishes innovation systems is the particular focus; innovation processes as generators of change in the economic system, and their repercussions in terms of social changes, *mediated through* the economic system. Lundvall starts his argument from two general facts about modern economies, a highly specialised vertical division of labour and 'anthropological constancy' of innovation; the general presence of innovation processes, everywhere and at all times. A highly-developed economic division of labour implies directly that a substantial amount of innovations will be addressed towards users that are distinguished from innovators, they will be product innovations. Hence needs arise for extended bi-directional information flows, going beyond the information transmitted through the price mechanism. How this changes the structure of market relations is best illustrated by Lundvall's analysis of user-producer links. Where market relations may be described as anonymous 'arm's length', that is where the individualities of related agents play a minor role, these individualities will also play a minor role in the formation of producer's interpretations of user expectations and requirements. All, or most, information exchange between users and producers will be closely tied to exchange of price information. Lundvall claims that in general innovation will be the exception on such markets, "it is obvious that product innovations would be rare and accidental" (Lundvall (1992a)).

Even without accepting this, it is clear that the nature of innovation changes as information exchange increasingly involve exchange of information beyond price information, exchange of what is traditionally termed 'technical' (that is non-price) information. Most prominent in integrated user-producer links involving production of complex capital goods, it is necessary for both the producer and the user to have access to more specific information of user needs and product characteristics and the matching of the two. These needs for exchanges of qualitative information implies that user-producer links structures the economic environment of firms. This leads to the description of the related markets as *organised* markets, as opposed to the structureless character of 'arm's length' markets. The requirement for such exchanges leads to co-operation, to the importance of trust and of a common language, a common protocol or code for information. These factors involve substantial investments from the firms, and hence this provides

stabilising mechanisms. The acquired information is not direct input into productive activities, it forms a necessary basis for shaping of capabilities, the use of which further enriches the acquired information. This provides a further stabilising factor for the organised market. Once developed an organised market will tend to persist. The structures shape what firms learn and do, and hence innovation.

The need for both price and technical information, being ever-present, hence leads to markets characterised by organisational modes of interaction that are neither 'arm's length' markets, nor organised hierarchies, to 'organised' markets. User-producer links form a significant constitutive force, though not the only one, for interactive learning in innovation systems. From the perspective of the individual firm, links to various organisations that contribute to formation of production and innovation capabilities contribute structuring the business environment of the firm. The innovation system in the Lundvall sense thus emerges as a perspective of describing this structured environment of individual firms. Such market environment structures would be pronounced when commercial and technological uncertainties are large, as when the 'environment' of an industry is perceived by the actors to be turbulent or where asset-specificities are important. Managing complex environments also enhance the value of specialisation, or 'division of knowledge'.

It is evident that the nexus of innovation system is the individual firm, the organisation that makes the decision to implement the innovation. This raises three issues that we will discuss very briefly; (1) the concept of innovation, (2) the underpinnings of innovation behaviour, and (3) the systemic dimensions of the concept.

The implied concept of innovation of these arguments is wide, generally speaking it may be denoted as changes in economic behaviour. This is evidently including, but wider than product and process innovations discussed in most survey-based innovation studies. It reflects the wider challenges and opportunities economic agents are faced with, beyond more or less arbitrary limits set by observers of innovation.

Secondly, innovation is developing new capabilities or new combinations, and transforming them into economic behaviour at the level of individual firms. Hence continual changes of (economic) behaviour imply antecedent and subsequent firm-based learning; learning is a vital process underlying innovation systems. This suggests that organisational effort will be directed towards those measures that enable appropriation of what is perceived as important informational inputs (as well as the necessary redundancy in such inputs) and institutionalisation of information 'broker' or 'filter' functions. A substantial part of this will thus be efforts to internalise and control informational requirements of importance to organisational development.

Thirdly, innovation systems in the 'cognitive' sense we discuss here may be described in a particular or in a general sense. We may describe it referring to a particular firm, a particular incident, or to a particular category of innovation processes. Or we may describe innovation systems from the angle of certain

technologies, industries or geographical areas. The appropriate angle is determined by the purposes of the analysis. What different approaches have in common is that they attempt to incorporate social and institutional structures wherein innovation is generated. The systems are presented as structural models of the social environment of techno-economic adaptations shaping innovation trajectories and paradigms. Innovation systems attempt to model the site and environment of interactive learning and innovation; they are analytical concepts or models, representing attempts to endogenise 'ordinary' determinants of learning and innovation.

Shapes of innovation systems

The systemic approaches to endogenous innovation thus emphasise three points;

- requisite information exchange between economic agents involve exchange of both price and technological information,
- the need for exchange of technological information leads to a structuring of capability shaping business environments of firms, to organised business environments, involving i.a. user-producer links as a substantial feature,
- the qualitative information exchange involves both information needs that are specific to the individual market relations and the agents involved in them, and generic, i.e. applicable in a wider context.

This distinction between specific and generic information in terms of applicability, goes far beyond the distinction between private and public information that is allowable within a framework of price-mediated information exchange. The scope of this information also goes beyond the scope of the latter. It involves a wider set of techno-economic information/knowledge and the related capabilities it contributes to the formation of. If we turn to Schumpeter and neo-Schumpeterian literature, three factors are usually identified as the central determinants,

- the existence of and ability to utilise *technological opportunities*,
- *market conditions and opportunities*, as well as
- the *appropriability conditions* for categories of innovations, contingent on technological, market and governance conditions.

The perceptions of these conditions and opportunities and changes in them are regarded as determining factors of industrial development through the firm's utilisation of and adaptation to these conditions, by changing its behaviour, its 'ways of doing things'. With a resource-based perspective on the firm (see Penrose (1995), Fransman (1995)), these conditions shape innovation through shaping firms' learning processes and subsequent capabilities. Adapting Carlsson and Eliasson's scheme for classifying such techno-economic capabilities (Carlsson and Eliasson (1995); economic competencies in their terminology), we may distinguish five dimensions to these capabilities. In describing such techno-economic capabilities as the ability to generate, identify, expand and exploit business opportunities, we identify five types of capabilities,

- selective or *strategic* capabilities,
- *organisational* or integrative and co-ordinating capabilities,
- technical or *functional* capabilities,
- capabilities and understanding of *market* and *demand* characteristics, and
- the ability to *learn*, to absorb, transform and reflect on acquired information and experiences, integrating and cutting through all of these.

We have added a separate category of market and demand capabilities to Carlsson and Eliasson's original list, since we regard these competencies as distinct from the selective or strategic capabilities in which these competencies seem to be included in the original scheme. An illustrative example of market competencies is Thomas Levitt's reflection that quarter-inch drill bits are sold in millions, "not because people want quarter-inch drill bits, but because they want quarter-inch holes. People don't buy products, they buy expectations of future benefits" (Levitt (1969), as cited in Quinn (1992)). A crucial dimension to these market competencies is the knowledge of their benefits, i.e., the services rendered by the products, the identification of the services that are decisive in determining demand and how demand patterns are changed by shifting emphasis on existing and new benefits. In addition knowledge of regulatory frameworks, socio-cultural attitudes, as well as the wider structure of governance may have a formative role on innovations. Knowledge about such conditions and of their likely future changes may be vital for successful innovation. Furthermore, if this is correct, capabilities to influence these conditions will be important.

These areas of capabilities differ in character and in intra-organisational distribution, and have often been focused selectively in different approaches to competencies. While the innovation literatures mainly focus functional capabilities, management literatures have a stronger focus towards organisational and strategic capabilities. Nevertheless, our contention is that all these types are complementary, it is the integration between these that forms the basis for 'economic action' and the changes in these we identify as innovations. What all these capabilities[2] have in common is the centrality of

- the interaction between internal and external repositories of competencies,
- these capabilities (see f.i. Cohen et al (1996)) being constituted partly in routines, heuristics and skills, and

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[2] As part of the OECD/CSTP project on national innovation systems led by the TIP working group, a set of six groups of 'innovative capacities' of innovative firms has been identified on the basis of surveys of recent innovation literatures. With each group comprising a set of more specific capacities, the Phase 1 report of the Innovative firm focus group (Arthur D Little 1998) groups innovation capacities in

- managing the competency base
- vision and strategy
- creativity and idea management
- intelligence
- organisation and process
- culture and climate

- that they have tacit dimensions.

These linkage and format characteristics together with the five-tier aspects of techno-economic capabilities suggest basic structural features of the structured business environment of firms, and hence of their innovation systems. With this general approach to innovation systems we may essentially regain the more specific approaches to 'national innovation systems', and notably what we denoted the Nelson institutional approach as features of these firm specific innovation systems that are common for a group of firms or productive activities. This denomination of common features thus may allow us to speak of innovation systems for these groups of firms or activities. In the last resort we may restrict attention to organisations or institutions that are involved in or intended to be involved in most firms' innovation systems f.i. in a functional or geographical delimited region. Note that there is a shift of emphasis and often of focus when innovation systems are interpreted in this regional or national institutional sense.

One of the main reasons for focussing institutional innovation systems is its use as a basis for analysing the general scope of innovation policies. The establishment and development of a institutional system of capability generating and dissemination is perceived as a main mode of policy response to objectives of enhancing innovation capabilities in regional or national enterprises. We prefer to stay with the fruitful understanding of 'cognitive' innovation systems and to retain the notion of technological infrastructures outlined later for the often policy motivated institutional infrastructures.

Policy messages of systemic innovation

From a broad-brushed review of systemic innovation approaches we may draw some general policy implications that go substantially beyond the implications of the Arrow-Nelson rationale, see chapter 3, and which include some of the consequences of a system failure approach.

- The existence of high levels of uncertainty remains a fundamental problem in technology creation, and a basic reason for under-provision of R&D. There is therefore still an important role for the public sector in funding high-risk projects in companies.
- The long-term strategic 'vision' of firms can often be limited, and strategic long-term research is frequently under-performed by firms. There is a role for the public sector in encouraging and supporting such longer-term competence and knowledge building and related actions in companies and supporting institutions.
- The existence of diversity and variation, at both industry and firm levels, means that 'neutral' policies for support are not generally appropriate. This has two dimensions. First, when firms differ sharply, then a neutral policy will not affect all firms equally, but will in effect be a form of selective policy. Secondly, it is necessary to be selective when adaptation is necessary.
- When firms seek to solve innovation-related problems, they must frequently look outside the boundaries of the firm for solutions: the technology infrastructure is particularly important, and must continue to rely on public-

sector support. However this infrastructure must be responsive to the needs of company users.

- Because of the constrained nature of firm-level knowledge bases, there are strong externalities and spillovers from public provision of intangible inputs. This remains a primary reason for support.
- How can and do firms cope with discontinuous technological change, meaning primarily the emergence of radical new technologies which change the main forms of technological competence which they require? What is the role of the public sector in supporting firms during periods of radical, generic technology change?
- What is the role of public support in which key forms of knowledge are produced via interaction between different types of institutions? How does the idea that economic performance results from the operation of an overall 'innovation system' (rather than just from the operation of single firms), affect the role of the public sector?
- How do policies other than intended innovation policy (such as macroeconomic policy, competition policy, monetary policy, education policy etc) shape innovation performance?

This perspective on industrial competitiveness poses a number of challenges for business and government policy. Within the enterprise, the challenges are to identify and sustain the investment in the types of organisational integration that are currently required, and that will be required in the future, to confront the innovative capabilities of global competitors. Increasingly, however, an enterprise acting on its own is incapable of putting in place all of the elements of the innovative enterprise. This is particularly the case when large-scale processes of technological change are underway, as at the present time.

Innovation and competitive advantage often demands a more collective involvement at the level of the regional industrial sectors or even the national economy. The regional sector can provide constituent enterprises with common financial, managerial, technology and marketing resources that each of these enterprises would not be able to acquire on its own. The national economy structures the educational and financial systems to provide enterprises with the human and financial resources that form the foundations for an innovative enterprise strategy. Public policies concerning taxation, income distribution, social welfare and economic development can encourage enterprises to invest for the future rather than live off the past.

Unfortunately, in the world of public-policy making, the most articulate and consistent perspective on the operation and performance of the economy ignores the *process* of innovation. This shortcoming derives from an overwhelming adherence of policy makers to a theory that contends that the most efficient economy is one in which market relations among participants dominate. This theory stresses financial mobility rather than financial commitment, and individual action for short-term gain rather than organisational integration for long-term change.

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STEP gruppen

STEP-gruppen ble etablert i 1991 for å forsyne beslutningstakere med forskning knyttet til alle sider ved innovasjon og teknologisk endring, med særlig vekt på forholdet mellom innovasjon, økonomisk vekst og de samfunnsmessige omgivelser. Basis for gruppens arbeid er erkjennelsen av at utviklingen innen vitenskap og teknologi er fundamental for økonomisk vekst. Det gjenstår likevel mange uløste problemer omkring hvordan prosessen med vitenskapelig og teknologisk endring forløper, og hvordan denne prosessen får samfunnsmessige og økonomiske konsekvenser. Forståelse av denne prosessen er av stor betydning for utformingen og iverksettelsen av forsknings-, teknologi- og innovasjonspolitikken. Forskningen i STEP-gruppen er derfor sentrert omkring historiske, økonomiske, sosiologiske og organisatoriske spørsmål som er relevante for de brede feltene innovasjonspolitikk og økonomisk vekst.

The STEP-group was established in 1991 to support policy-makers with research on all aspects of innovation and technological change, with particular emphasis on the relationships between innovation, economic growth and the social context. The basis of the group's work is the recognition that science, technology and innovation are fundamental to economic growth; yet there remain many unresolved problems about how the processes of scientific and technological change actually occur, and about how they have social and economic impacts. Resolving such problems is central to the formation and implementation of science, technology and innovation policy. The research of the STEP group centres on historical, economic, social and organisational issues relevant for broad fields of innovation policy and economic growth.