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3. National innovation systems

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1 INTRODUCTION

The concept national systems of innovation (NSI) was made explicit in a number of contributions in the second half of the 1980s.[1] In B.-Å. Lundvall's *Product Innovation and User-Producer Interaction* (1985), it still appears as 'the innovative capability of national production systems'. C. Freeman's *Technology Policy and Economic Performance: Lessons from Japan* (1987) was the first major publication where the concept was explicitly used. The collaboration between Freeman, Nelson and Lundvall in the International Federation of Institutes for Advanced Study (IFIAS) project on technology and economic theory (Freeman 1998; Nelson 1998; Lundvall 1998) was crucial for the development of the concept. So far there have been three major books on the subject: B-Å. Lundvall (1992), *National Systems of Innovation: Towards a theory of innovation and interactive learning*; R. Nelson (1993), *National Innovation Systems: A Comparative Analysis*; and C. Edquist (1997), *Systems of Innovation*.

Innovation systems research has evolved along three dimensions: geographical scale, technology and sector. Often researchers take one dimension as their starting point, and either disregard the other dimensions, or conflate the sectoral with the national (compare sectors between nations), conflate sectors with technologies (compare technological paradigms), or conflate nations and technologies (compare specialization patterns between countries). Only a few researchers combine these three dimensions successfully. Most innovation systems research is defined on a geographical scale. Whereas initially the national level was predominant (Freeman 1987; Nelson 1993; Barré 1996), later research introduced the regional and even the local level (Illeris and Jakobsen 1990; Bergman *et al.* 1991; Grabher 1991; Saxenian 1991; Storper and Harrison 1992; Tödtling 1994; Cooke *et al.* 1997). Paradoxically the 'new regionalism' evolved in tandem with research on globalization and internationalization.

The seminal research of Pavitt (1984) concentrates more on the interaction of innovative firm behaviour and features of technologies (functions, qualities, sources) and pursues the development of a sectoral taxonomy of technological development. The geographical dimension is absent in his work. The work of Breschi and Malerba (1997) combines the national, sectoral and technological dimension very nicely, although their theoretical reasoning is technology biased. Examples of studies that concentrate on the analysis of technological development as such are Sahal (1985), Tushman and Anderson (1986), Henderson and Clark (1990), Achilladelis *et al.* (1990), and Lawless and Anderson (1996). Technological dynamics are explored in terms of variation in design specifications, form, size of systems and standardization. Mostly sectoral and competitive forces are the dominant drivers, whereas the institutional environment is often the impeding factor for technological change or exogenous shocks pushing inventors and innovators in new directions.

2 SOME DEFINITIONS

In a number of reviews on systems of innovation approaches by Edquist (1997), McKelvey (1991), Freeman and Soete (1997) and Nelson (1998) we found several definitions of NSIs. As many others have already concluded, there is considerable variation in the definition. Edquist (1997) notes that the literature is conceptually diffuse, and that NSI literature is not theory based. He contends that it is a conceptual framework and provides a basis for the formulation of conjectures, for example, that various factors, like institutions or learning, are important for technological innovation. On the one hand the issue of innovation systems turns out to be a new field of research where novel combinations of economic growth theory, international trade theory, evolutionary theory, economics of organization, organizational sociology, regional sciences and institutional approaches emerge. On the other hand many of the researchers doing NSI research are very much policy oriented, and in general are not interested in conceptual clarification or theoretical explanation. In tandem, the variety of disciplines involved in NSI research, and the policy orientedness of the research, cause the low level of theoretical development and the *ad hoc* character of much NSI research. Table 3.1 summarizes the various definitions.

3 FUNCTIONS, ORGANIZATIONS AND LINKAGES IN A NATIONAL SYSTEM OF INNOVATION

Galli and Teubal (1997) add to the rather general definitions of national innovation systems a dynamic view on NSIs, as well as a description of the functions of NSIs and linkages between the building blocks. Before World War II, NSIs developed within a relatively well-defined sectoral or subsystem

Table 3.1 What are national systems of innovation?

Author	Definition of NSI, building blocks, empirical focus, role of institutions
Porter (1985)	Not possible to analyse general differences, only specific, successful industries in a country. Definition: the environment supporting innovative activities in companies, i.e., competition in the home market, supporting industrial structure etc. Empirical focus: comparison of industries. Role of institutions: stresses the role of government, networks.
Freeman (1987)	A new, radical technology promotes social and institutional innovation on a national scale. Otherwise innovation may be incremental and technological. Definition: 'the network of institutions in the public and private sectors whose activities and interactions initiate, modify and diffuse new technologies' (1987: 1). Empirical focus: comparison of nations based on their innovations and adjustments in social institutions. Role of institutions: Freeman talks about 'the network of institutions' in his definition.
Lundvall (1992)	Definition: an NSI includes all parts and aspects of the economic structure and the institutional set-up affecting learning as well as searching and exploring – the production system, the marketing system and the system of finance present themselves as subsystems in which learning takes place (1992: 12). The national system refers to the national economy, but there is stress on the importance of linkages and on interaction within development blocks. The relevant institutions and industrial structures form the national system of innovation. Empirical focus: the historical development of institutions and production structures in different countries. Role of institutions: the institutional set-up in tandem with the economic structure determines learning.
Nelson (1993)	Definition: refers to the national economy. Differences in industrial structure (such as the needs of industry for science and technology and whether technology is public or private) and differences in the organization of institutions (especially the R&D system) explain how national systems of innovation differ.

Continued overleaf

Table 3.1 Continued

Author	Definition of NSI, building blocks, empirical focus, role of institutions
	Empirical focus: current institutional differences between nations. Role of institutions: essential.
Florida (1995)	Definition: implies separate elements nurturing innovation and their relations. The basic elements are: 1) a manufacturing infrastructure, 2) a human infrastructure, 3) a physical and communications infrastructure, 4) a capital allocation system and financial market. The relationships between the elements in a system of innovation are the linkages that can be specified in terms of flows of knowledge and information, flows of investment funding, flows of authority and other arrangements such as networks, clubs, and partnerships. Role of institutions: unclear
Freeman and Soete (1997)	Definition: pertains to the many interactions within a country between various institutions dealing with science and technology as well as with higher education, innovation and technology diffusion in the much broader sense. Empirical focus: differences in the national systems of innovation. Role of institutions: essential.

Source: McKelvey (1991) and Edquist (1997)

configuration schematically based on three R&D performing sectors (business sector, public sector and universities), with relatively weak linkages among them, and a fourth basic infrastructural subsystem (bureau of standards, patent office, and so on). Every organization within a building block predominantly performed a specific role or function. For universities it was higher education and basic research; for government labs, mission-oriented research; for business firms, applied research and technological development. Table 3.2 describes different types of NSI organization. Nowadays it is necessary to distinguish between function and organization, as the latter tend to play increasingly multiple roles. A useful distinction is between hard functions, requiring hard organizations (that is, equipped with laboratories and performing R&D), and soft functions, which may be operated within soft organizations (that is, without laboratories and not performing R&D) and involve catalytic and interface roles only (see Table 3.4).

Table 3.2 NSI organizations

Bodies	Agents/organizational fields
Political bodies	Ministries, national councils for science and technology
Bureaucratic bodies	Public agencies and offices implementing innovation policies
Regulatory bodies	For standards, norms, and certification
Social bodies	Academies and professional associations
Educational bodies	Universities and schools
Knowledge-oriented bodies without economic goals	Government laboratories in the area of defence or health, or non-profit organizations without economic goals, e.g., a technical centre or experimental stations of an industrial association
Profit-oriented firms	Including R&D companies, joint ventures, consortia
Bridging bodies	Connect the science and technology realm to the industry: innovation centres, chambers of commerce, industrial associations, industrial liaison units of universities

Source: North (1994: 360)

Table 3.3 Institutions structuring innovation processes

Formal	Patent laws, formal criteria for allocating resources to science, peer review procedures, technical standards and norms, etc.
Informal	Norms of behaviour (professional norms), conventions, codes of conduct, etc.

Source: Galli and Teubal (1997: 346)

Several linkages connect the various players and subsystems. Galli and Teubal (1997: 347) distinguish three types of linkages:

1. Market transactions, which involve backward and forward linkages as well as horizontal linkages.
2. Unilateral flows of funds, skills and knowledge (embodied and disembodied) within an NSI as well as externally, between organizations and others located in other countries or NSIs.
3. Interactions, such as user-supplier networks.

Table 3.4 Hard and soft functions of NSIs

Hard functions and related organizations include:

R&D, involving universities and public (governmental, local, mixed) and non-profit organizations;

Supply of scientific and technical services to third parties (business sector and public administration) by industrial firms, technological centres, technical service companies, universities, governmental laboratories and *ad hoc* organizations.

Soft functions and related organizations include the following:

Diffusion of information, knowledge and technology towards economic and public operators acting at the interface between knowledge suppliers and users; such bridging institutions include various forms of innovation centres and liaison units at universities and public labs, etc.;

Policy making by government offices, technology assessment offices, academies, universities, *ad hoc* fora, national committees and councils, etc.;

Design and implementation of institutions concerning patents, laws, standards, certifications, regulations, etc.; these functions are usually performed by public or intermediate organizations;

Diffusion/divulgation of scientific culture through science museums, science centres, etc.;

Professional co-ordination through academies, professional associations, etc.

Source: Galli and Teubal (1997: 346–7)

These linkages are to a certain level facilitated and enabled by, or embedded in, a wide variety of institutional arrangements, for example, laws, norms, and traditions (see Table 3.3); regulations; policy-induced incentives and disincentives; specific allocation and decision-making mechanisms within formal institutions; alliances; cooperation agreements; exchanges; and so on. Interaction between science and technology operators may take place in a variety of spaces and dimensions. Their context can be related to geography, technology or industry. Besides the economic exchange between agents, government policy is a major enabling factor in the generation of linkage mechanisms.

4 MAJOR TRENDS WITHIN THE VARIOUS NSI BLOCKS

The universities represent the cornerstone for an NSI's absorptive and generative capacity and the quality of the national knowledge base, because they provide higher education and performing basic research. Emerging major trends are (Galli and Teubal 1997):

1. Growing links with application have increasingly blurred the borderline between science and technology in frontier areas of research, and the need for interdisciplinary approaches in complex problem solving, which causes the growth of multidisciplinary research;
2. A focus on generic technologies, which are either lacking in industrial R&D and have to be reinforced, or because industrial R&D is already ahead (mechatronics) and universities have to catch up;
3. A stronger university-industry interaction as a means of focusing and aligning basic research with industrial knowledge demand (in the Netherlands, Innovation Oriented Research Programs of the Dutch Ministry of Economic Affairs (IOPs) are examples);
4. The (re-)establishment of interface units, enhancing the possibilities for the business sector to access the internal capacity, skills and know-how of university laboratories, thus reducing transaction costs of technology transfer;
5. The establishment of joint research/technology development organizations. In the Netherlands there is an increasing outsourcing of industrial R&D to universities.

In short, universities move to other types of research and organize it differently.

The public sector contains three major kinds of R&D organizations:

1. The mission-oriented bodies and agencies that supply the required scientific and technical support for ministries and other national or regional authorities (national health institutes, space agencies, environmental institutes, and so on).
2. Basic or general bodies like the Centre National de la Recherche Scientifique in France, TNO (Organization for Tuegepart Natuurwetenschappelijk Onderzoek, Applied Scientific Research) in the Netherlands, the Max Planck Institutes in Germany, the CNR (Consiglio Nazionale delle Ricerche) in Italy, and so on).
3. Publicly owned companies, which generally operate in such sectors as oil, gas, minerals, utilities, railways or telecommunications. They often play critical roles in NSIs, because of the relatively high share of country R&D performed in the laboratories of these companies as well as their role in defining technical standards for a vast number of supplying firms.

This public part of NSIs is undergoing strong restructuring in most countries and is adopting a new role in supplying scientific and instrumental capabilities to the business sector and much stronger market orientedness. Budget cuts, in particular, forced many R&D agencies to look for new roles. Most R&D agencies tend to organize *ad hoc* structures dedicated to the promotion and commercialization of their know-how.

The third NSI block – the business sector – is based on enterprises and their laboratories. Many firms are considering the option of decentralizing R&D to division or even business unit level, aiming at a better alignment of R&D with the actual businesses and operations of firms. The linear R&D approach – from basic science to application – is abandoned and firms shift to an iterative and integrative R&D organization. There is special emphasis on integration of invention, design, development, engineering, production and commercialization roles. External interaction with suppliers and buyers is intensified in specific sectors. Commodity manufacturers (steel, metals, plastics, fibres, paper, functional chemicals, cement, and so on) supply their customers with know-how on the utilization of their products. These services strengthen ties with customers. System companies (automobiles, consumer electronics) assembling components or subsystems play a critical role in updating and maintaining the technological level and production quality of their suppliers. The almost infinite number of technological options, and the monitoring capacity needed to know about them, invoked the spread of engineering, consulting and information service companies. Also corporate R&D budgets show worldwide decline. This is caused by new technology strategies that avoid uncertain outcomes of investments in corporate R&D. The bypass for this uncertainty is to buy firms with a complementary knowledge portfolio, or to form strategic R&D alliances and joint ventures.

The major trends in all three sectors can be summarized with on the one hand a growing connectivity within and between the building blocks, and on the other hand a stronger alignment of knowledge generation and knowledge demand. The buzzword that comes up is 'interfacing'.

5 THE DEVELOPMENT OF THE NSI[2]

The logic linking industry formation and technological dynamics to a system of innovation containing networks of multiple stakeholders can be schematized in the following way (Nelson, 1998). An important development that almost invariably occurs as a new industry develops is that the people in it become conscious that there is a new industry, and that it has collective interests and needs. Industry or trade associations form, which may be active in the process of standard setting. More generally, they give the industry a position in the broader network of institutions and stakeholders governing the conduct of companies within the whole industry of a country. When a new industrial population emerges, collective interests and needs are developed on the basis of common activities and events like fairs and exhibitions where businessmen meet each other. The recognition and definition of common interests is often translated into the foundation of trade or industry associations, new labour unions and new professions. These give an industry recognized organizations that can lobby on its behalf for regulation to its liking, for protection from outside the group, for public support programmes, education and so on. If the technology on which the industry is based has novel characteristics, new professions, new technical societies and new technical journals tend to spring up.

Dependent on the novelty of the technology as well as its source (industry or university), the ties between industry and universities are strengthened. Nelson and Rosenberg (1993) claim that basic scientific research, without pursuing application, has in several cases led to major technological paradigm shifts. (Maxwell's electromagnetism, an exercise in pure science, led to radio; Carnot developed thermodynamics because of his interest in what was going on in steam engines.) Quite often with the emergence of new technologies there is very little relevant scientific understanding of it. However, the appearance of that new technology then induces scientific research to understand it, and lay the basis for subsequent development. The result may be the creation of a new scientific field related to it (metallurgy developed to understand better the properties of steel; computer science developed out of the advent of the modern computer; chemical and electrical engineering rose up as fields of teaching and research because of intensive industry lobbying following the technological advances that launched the industries). The appearance and development of these technology-oriented sciences tend to tie industries to universities, which provide both people trained in the relevant fields, and research findings which enable the technology to advance further.

If firms have recognized the innovation possibilities of a specific technology, they want to protect their future opportunities legally. This requires new, amended or extended intellectual property rights to be sorted out (for example, in biotechnology and the software industry). Hughes (1987) has shown the wide range of legal and regulatory matters that had to be decided before electrical power could go forward strongly.

So far we have discussed new industries, but what about mature industries? How is a mature industry affected by radical new developments (for example the advent of the transistor and later integrated circuit technology on a mature electronics industry which had been based on vacuum tubes; the advent of biotechnology on the mature pharmaceuticals)? Often the issue is specified in terms of who adopts the new technology: large incumbent firms, or new (sometimes small, sometimes large) entrants. The proposition advanced by the literature is Schumpeterian: it depends on the level of creative destruction caused by the new technology. If the deployment of the new technology demands radically new understanding, competencies and skills incumbents have to be able to switch, which incurs high costs. If incumbent firms do not switch over to it, new firms will tend to enter the industry, causing an increasing failure rate among the incumbents (Tushman and Anderson 1986; Tushman and Romanelli 1985; Hannan and Freeman 1989; Henderson and Clark 1990).

The institutional dimension of the effects of new technology on mature industries pertains to the question whether the larger set of institutions is able to adapt, or whether their conservatism makes it difficult for established firms to shift away from old practices, or for new firms to enter or to take over (Lazonick's example (see Lazonick 1991) of the broad organization of work and training labour shows that this supported 19th century British industry, whereas it became a handicap in the 20th century). Perez (1983) and Freeman (1991) contend that to be effective with new technologies a nation requires a set of institutions compatible with and supportive of them. The ones suitable for an earlier techno-economic paradigm may be quite inappropriate for a new one. While Britain lagged, Germany and the USA had or quickly adapted institutions that could support the rising chemical and electrical industries that were the basic poles in the era from 1910 to 1960 or so. Perez and Freeman showed that the period since 1970 has seen the rise of 'information technologies' as the new basis of effectiveness, and argues that effective accommodation requires a very different set of institutions from those required in an earlier era. Japan they see as coming closest to having them. Shifts in techno-economic paradigms demand institutional learning and adaptation (Johnson 1992).

6 THE RESEARCH AGENDA

McKelvey (1991: 136–7) infers from her review of NSI approaches that there is no one adequate theory for NSI. The theoretical challenge is to relate entities at various levels and to different but inter-conditioning processes. Freeman and Soete (1997) specify this assertion through their contention that a clear understanding of national systemic interactions requires an essential theoretical bridge enabling the analysis of the bridge between macro and micro aspects of innovation processes and technological change. Lundvall (1998: 416) stresses that there is a strong need for a more systematic theoretical underpinning of the NSI concept. He considers the evolutionary framework a useful starting point, because of its emphasis on qualitative change and on the creation of diversity, allowing for an integration of aspects of learning and innovation. From an evolutionary point of view NSIs may be regarded as offering distinct regimes of diversity creation, selection and reproduction. The institutional set-up plays a key role in this respect as a selection environment in which specific technologies, firms and agents fit while others do not. Lundvall (1998) also warns against some of the pitfalls of the evolutionary approach, particularly the biological analogies. No institutional set-up is given by nature; it demands human actors and social action. The key to further development of the NSI concept is to understand better the role of knowledge in the economy. To understand what is happening to the creation, distribution and use of knowledge (including the spatial dimension of learning) is fundamental for understanding the role of innovation systems. Nelson's basic point (see Nelson 1998) is that new technologies are often not well accommodated by prevailing institutional structures, and require institutional reform if they are to develop effectively. Yet Nelson is quite sceptical as to the modelling of institutional analysis. Nelson's future research directions derived from these reflections suggest that the support structure should be included. But how? Nelson raised this issue for two reasons: one is that it is not clear exactly how various institutions ought to be represented. What activities do they perform? How do they affect the behaviour and performance of firms in the industry? The second reason is that it is unclear how the 'evolutionary process' works which forms new academic disciplines or blocks old ones, or the ways in which new laws are created or old laws are modified.

In our view there are two important theoretical gaps in the NSI literature: it puts institutions at the centre of the analysis without unpacking institutional arguments, and it disregards the tension between the systems approach and the role of agency, and firm behaviour. The systems imagery of the innovation systems literature suggests natural boundaries as well as certain coherence between the subsystems. This indicates one of the problems with the 'systems approach' namely the risk of getting caught in a functionalist and determinist universe where it is impossible to locate the sources of change. Firms are conceived as puppets on institutional strings. We conceive of NSI research as typically multi-level research in which interactions between different variables (firm-specific, sectoral/technological and macroeconomic and institutional) are considered a key issue. Accordingly, given the embeddedness of the innovation process in a seamless web of social forces that enable and constrain the innovative behaviour of firms, this calls for very sophisticated research, both from a theoretical and methodological point of view.

This yields several research agendas. First, an institutional approach has to be developed that allows for a broader set of institutions than only the science and technology supporting institutions. Mostly, NSI researchers apply a narrow definition of institutions relevant for innovative capacity, and definitions are conceptually diffuse.

A possible direction might be the socio-cognitive approach developed by Garud and Rappa (1994), which links the macro and the micro level by specific processes. They analyse how reciprocal interactions between beliefs and evaluation routines in the behaviour of members of technological communities affect the form and function of a new technology (cochlear implants). The interactions give rise to two processes. One is a process of inversion at the micro level of individual cognition wherein evaluation routines designed to judge specific artifacts begin reinforcing researchers' beliefs. The other is a process of institutionalization at the macro level of shared cognition. By institutionalization, Garud and Rappa mean the development of a common set of evaluation routines that can be applied to all technological paths.

Second, a behavioural approach has to be developed that explains how innovative firm behaviour and institutions affect each other reciprocally. The mechanisms explaining the relations between institutional arrangements and firm behaviour have to be specified and extended. Most NSI literature concentrates especially on connectivity and capabilities. Old exchange theory could do a wonderful job here, as well as modern network theory. Yet, in the literature such a theory that accounts for this connectivity is absent (see the sections on interactive learning and networks). Furthermore, the so-called legitimization and reputation processes (Rao 1994), which link firm behaviour to institutional contexts, and function as sources of attraction between actors are seldom taken into account in the NSI literature.

The systems- and resource-based perspective, which is the intellectual basis of the NSI approach as well of evolutionary theory, has overlooked the institutional process of legitimization. To date, the resource-based view has emphasized issues such as efficiency and types of rents earned with diverging strategies, thereby isolating social and organizational mechanisms from a broader social and institutional background, and tracing capabilities to luck and organizational learning. It would be very illuminating to study how institutional dynamics underlie the creation of technical criteria, but also how beliefs, routines and artifacts in iterative evaluation processes add to the legitimacy of artifacts. The research may pertain to the way in which innovative performance of firms generates status orderings and creates favourable reputations, and accordingly legitimizes their behaviour. In this view, technology strategies of firms are a mixed bag of institutional, technological, market and social arguments. In this view also, institutions are tool kits or menus from which CEOs choose options, rather than a unified whole, which pushes actors in prespecified directions; entrepreneurs thus become skilled users of institutional tool kits rather than cultural dopes. In technology policies, innovation reputations could be used in order to benchmark the firms that submit proposals for technology subsidies. Also in starting R&D collaborations, firms' innovation reputations might give them a co-operative advantage. Finally, firms' innovation reputations may perform a vital function in technology brokering and partner search carried out by bridging institutions like, for example, innovation centres, liaison agencies or transfer agencies.

To avoid the determinism and functionalism of the systems approach, institutional impacts on firm behaviour must be qualified in terms of the room for strategic choices left to firms. Scott (1991) distinguishes several types of connections between institutional environments and organizational structures (including organizational and strategic behaviour):

1. The imposition of organizational structure: this means that that there are environmental agents that are sufficiently powerful to impose structural forms on subordinate organizational units. Nation states do this when mandating by law changes in existing organizational forms or when creating a new class of administrative agencies. Corporations do this when acquiring new companies or reorganizing existing divisions. So the mechanisms at stake are hierarchical relations between organizations in an organizational field, with no room for strategic choice for the subordinate organization. Here one can think of direct government regulation, for instance the Federal Communications Commission's 1949 mandatory choice of the CBS colour television standard.
2. The authorization of organizational structure: the feature that distinguishes this mode from the case of imposition is that the subordinate unit is not compelled to conform but voluntarily seeks out the attentions and approval of the authorizing agent. On the one hand this process is based on mechanisms of persuasion in which the authorizing agents explicate the benefits of the organizational adaptations. Here one can think of certification, for example by the International Standards Organization, and accreditation. On the other hand firms may seek accreditation by public agencies. Especially in the field of testing and calibration of equipment this is important.
3. The inducement of organizational structure: when organizational fields do not contain agents having power and/or authority to impose their own structural definitions on local organizational forms, they may provide strong inducements for organizations to conform to their wishes. Relatively weak nation states – like the US – are able to obtain authority

over funding decisions, without direct influence over programmatic decisions. Inducement strategies are often applied in industrial and technology policies, to create structural changes in innovative behaviour by providing financial incentives to organizations that are willing to conform to the agent's eligibility conditions to receive funds in the form of grants, contracts, tax benefits and so forth, or reimbursement for work performed. The recipient organization must provide detailed evidence concerning continuing structural or procedural conformity to requirements – accounts of who performed the work, how the work was performed and so on – in the form of periodic reports.

4. The acquisition of organizational structure: this involves the deliberate choosing of structural models by organizational actors.

These four processes connecting institutional environments to organizational structure clarify how the strength of institutional environments varies and diminishes the opportunities for strategic choice of individual firms. NSIs in different countries could be compared with respect to the prevalence of these processes. The institutional drag hypothesis predicts that institutions through their inertia and rigidity retard the dynamics of technical change (Johnson 1992). Institutions are regarded as inflexible and institutional change is supposed to be lagging behind technical change. This creates mismatch problems, which often hamper the full realization of the productive potential of new technologies. However, institutions also enable innovation, search and learning activities. Different ways of organizing cooperation, co-makership, R&D collaboration and so on are important representations of the utilization of the social capital that is available in societies.

Another research agenda could be: 1) whether one could specify the mechanisms explaining the constraining and enabling features of the institutional set-ups of NSIs on the innovative performance of organizations, and 2) to determine the extent to which certain types of NSI support radical innovations and techno-economic change, and which types of NSI primarily support incrementalism and technological development. Finally, the problem of change of NSIs across countries needs further analysis. Which countries have a fast evolving NSI? Galli and Teubal (1997: 350–52) bring up the issue of the modelling of the transition of old closed NSIs with little interaction and sectoral support systems, to open NSIs, with a lot of interaction between the building blocks, oriented toward knowledge demand and supported by interfacing units. We think that it is important to add to this the identification and specification of systems aspects which one wants to study: feedback loops, law of requisite variety, input levels, utilization of inputs, throughput mechanisms. Is this transition of NSIs associated with patterns of specialization or performance differences?

NOTES

1. This passage is taken from Lundvall (1998).
2. This paragraph is adapted from Nelson (1998).

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