

Dynamising National Innovation Systems



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ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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Publié en français sous le titre :
Dynamiser les systèmes nationaux d'innovation

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FOREWORD

Innovation through the creation, diffusion and use of knowledge has become a key driver of economic growth and provides part of the response to many new societal challenges. However, the determinants of innovation performance have changed in a globalising knowledge-based economy, partly as a result of recent developments in information and communication technologies. Innovation results from increasingly complex interactions at the local, national and world levels among individuals, firms and other knowledge institutions. Governments exert a strong influence on the innovation process through the financing and steering of public organisations that are directly involved in knowledge generation and diffusion (universities, public labs), and through the provision of financial and regulatory incentives to all actors of the innovation system. They need a sound conceptual framework and an empirical basis to assess how the contribution of public policy to national innovation performance could be improved.

Through a decade of academic research and policy analysis, the National Innovation Systems (NIS) approach has been developed to provide such framework and quantitative information. The OECD Committee for Scientific and Technological Policy, and its Working Party on Technology and Innovation Policy, have contributed to this development through the NIS project, conducted in two phases.

The first phase of the NIS project involved country case studies, the development of internationally comparable indicators and thematic analytical work by six Focus Groups, including one on clusters. Its results are reported in *Managing National Innovation Systems* (OECD, 1999) and in *Boosting Innovation: The Cluster Approach* (OECD, 1999). This work provided new evidence on the systemic nature of innovation, articulated a new rationale for technology policy and identified broad directions for the improvement of national policies.

The second and last phase of the NIS project was devoted to deepening the analysis on three themes: clusters; innovative firms and networks; and human resource mobility. The detailed results are reported in *Innovative Clusters*:

Drivers of National Innovation Systems (OECD, 2001), *Innovative Networks: Co-operation in National Innovation Systems* (OECD, 2001), and *Innovative People: Mobility of Skilled Personnel in National Innovation Systems* (OECD, 2001). The present publication summarises the findings of this last phase of the NIS project and derives the main policy implications.

It was prepared by Svend Remoe, in collaboration with Jean Guinet who managed the overall NIS project. It benefited from contributions and comments by the Working Party on Technology and Innovation Policy and by national experts involved in the three Focus Groups. The report is published on the responsibility of the Secretary-General of the OECD.

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SUMMARY

This report presents a synthesis of the main findings of the OECD project on National Innovation Systems. This project has spanned some seven years and three phases of project implementation. It was carried out under the auspices of the Committee for Scientific and Technological Policy (CSTP) and its working party on Technology and Innovation Policy (TIP). The synthesis covers the full project, but concentrates on the most recent outcomes. It is based mainly on the work of three Focus Groups which undertook analytical work on three areas in the last phase of the project: Clusters, innovative firms and networks, and human resource mobility. The Focus Groups have reported their work in a series of OECD proceedings published during the summer and fall of 2001.

The NIS approach rests on the interactive model of the innovation process that puts an emphasis on market and non-market knowledge transactions among firms, institutions and the human resources involved. Innovation performance depends on the scope and efficiency of such transactions, themselves influenced by framework conditions governing capital, products and labour markets and by institutional set ups and policy actions addressing market and systemic failures specific to knowledge transactions.

Knowledge flows are fostered through complementary interactions in the innovation systems. Evidence shows that clusters are powerful systems in this respect, combining strong market-based capital and disembodied technology flows and competition-based incentives for innovation, as well as propensities for collaboration and co-operation and long lasting networking that are efficient for transferring tacit knowledge. In general, the complementary interactions take different institutional forms. However, increased knowledge flows should not be seen as a substitute for the necessary growth in knowledge endowments such as investments in human capital or R&D. Dynamism arises from both growth and interactions.

Implementing the NIS framework implies a comprehensive perspective on policy design aiming at improving the overall configuration of the innovation system, notably as regards the reallocation of financial support to R&D,

incentives for collaboration among firms and between public and private institutions, and reduction of the regulatory obstacles that hinder mobility of human resources.

The implementation of the NIS framework should also be seen as a learning process that can lead to a reshaping of the policy making system itself. Three key areas for attention are highlighted: First, comprehensive policies need to be implemented in well-defined “policy spaces” to achieve best possible interactions between them and the best possible environment for innovators. Many countries currently reform their policy systems in this way. Policies should be co-ordinated through specific mechanisms, ranging from loose mutual information to strategic integration at the government level, or co-ordinated in a decentralised manner using for example regional bodies. Second, innovation governance should be as flexible as possible, building upon a division of labour between public and private sectors. In particular the regional level helps develop a more context-sensitive policy environment. Third, policy learning needs to be institutionalised, for example through dedicated evaluation schemes or learning mechanisms adapted to cycles or stages in the policy process.

Governments should use the NIS approach to learn about the intended and unintended consequences of their policies, and base implementation on political feasibility and consensus building.

PART I: INTRODUCTION

Background

The creation, diffusion and use of knowledge have become a vital ingredient in economic growth and change. The innovation-driven economy builds upon these processes. The rapid developments in information and communication technologies have contributed profoundly to the way knowledge is created and diffused and have influenced the innovation process itself to an exceptional extent. Policy makers are challenged on many fronts, from understanding how the current wave of technological change influences the economy and society at large, to designing novel approaches to policy making that can cope with these changes. To conduct research as well as develop policy, the National Innovation Systems approach (NIS) has grown in importance.

To further elaborate innovation policy from this perspective, the OECD Committee for Scientific and Technological Policy (CSTP), through its Working Party for Technology and Innovation Policy (TIP), embarked on the NIS project in 1994, using both general analytic approaches as well as selected focus groups of external researchers and consultants to underpin the growing need for empirical analysis. The last phase of the NIS project includes the work of three focus groups, on clusters, innovative firms and networks, and human resource mobility respectively (see the Annex on the NIS project and the work of the focus groups). A key aim is to develop substantiated recommendations for implementing the NIS framework in innovation policy.

This report is built upon all the phases of the NIS project. It seeks to pull together the main findings, including those of the Focus Groups. It attempts to take stock of our knowledge of the innovation process and how policy makers can develop strategies to improve the innovation and economic performance of their economies. A key aim of the report is to demonstrate how the NIS

framework is helpful for policy makers in adding value to a more conventional approach resting on sets of distinct policy measures.

Intermediary findings of the NIS project

The first phase of the NIS project was initiated in 1995 with the conceptual work on the distribution power of national innovation systems (David and Foray, 1995). The second phase, reported in *Managing National Innovation Systems* (OECD 1999a), was organised around a broad agenda of innovation policy issues and themes. These included a general analysis covering information concerning all OECD countries, both in terms of statistical indicators and country-wide reports, and work by six Focus Groups on selected issues of specific importance aimed at improving the empirical basis for innovation policy analysis. The main conclusions of this work were:

- The climate and conditions for innovation in OECD countries are changing through the concurrent influence of several trends, in particular *the growing importance of linkages between industry and the science base*, the increasing speed of scientific and technological change and more competitive markets that *force firms to innovate more often*, *the increasing need for firms to engage in networking and collaboration* to respond to a wider diversity and specialisation of knowledge, *the new and important role of technology-based start-ups* in the technology diffusion and commercialisation process, *and the growing interdependence between the innovation systems* of Member countries.
- The knowledge-based economy is not restricted to high-tech firms and industries. In fact, even though the end product of a value chain may not in itself be knowledge-intensive, the innovation process, including knowledge inputs from outside firms and institutions, may indeed be. This reinforces the need for innovation policy to focus on complex interactions between innovators and their partners.
- Innovation patterns are highly country- and even, to a large extent, cluster specific, depending on the individual country's economic specialisation and institutional set-up. The implication is that individual countries must find their own way in the innovation-driven economy, and that innovation policy needs to be based on national capacities for learning. A new role for governments is needed, to enable them to promote innovation by integrating technology and innovation policy within the general framework of economic policy.

This implies in particular a more horizontal approach in policy making combining the efforts of several policy areas in dedicated interventions.

The third and last phase of the project sought both to deepen the analysis on some areas of major importance, notably clusters, innovative firms and networks, and human resource mobility, as well as to provide a more precise understanding of how to implement the NIS approach. In addition to highlighting new dimensions to innovation policy the last phase of the project has attempted to draw broader lessons for the policy making process in an innovation driven economic environment.

The objective of this report

The NIS project has delivered a number of outputs, as analytical contributions on selected fields by Focus Groups, including four sets of proceedings over the past four years (OECD 1999b, OECD 2001a, OECD 2001b, OECD 2001c), as well as the above-mentioned synthesis report from the second phase. It has also provided a broad range of inputs to OECD projects such as *Technology, Productivity and Job Creation* (OECD 1998) and the OECD Growth Study (OECD 2001d). Hence, findings from the NIS project are broadly used and influence several policy areas aiming at improving the link between innovation and economic performance.

Along with a broad range of work carried out over the past 10-15 years the NIS project has provided solid evidence of the importance of knowledge interactions in the interactive innovation process and of the shortcomings of a pure market failure approach to innovation policy. Clusters have confirmed the key role of such interactions in innovation-led growth. Networking and collaboration are seen as essential enabling factors for knowledge sharing and exchange (including tacit knowledge embodied in human resources) in innovation systems. However, beyond the recognition of the importance of knowledge interactions and the system oriented developments in innovation policies to which they have given rise (OECD 2000c), there are still concerns in the policy making community that the NIS approach has too little operational value and is difficult to implement.

While the previous phase of the NIS project highlighted the need for a new role for governments, this report shows that the NIS approach can also provide a useful perspective to develop and implement a broad, comprehensive strategy for innovation policy. Therefore, the objective of this report is threefold:

- To present a synthesis of the main findings of the OECD NIS project, in particular the findings of the Focus Groups.
- To provide a better understanding of the role of governments in the innovation-driven economy of OECD countries.
- To provide operational guidance to policy makers on how the implementation of the NIS approach may add value to more conventional forms of policy making in the field of technology and innovation policy, and assist them to implement policies that create dynamic processes of innovation and growth.

PART II: INNOVATION THROUGH DYNAMIC SYSTEMS

Towards a dynamic, innovation-driven economy

Economic growth relies more on innovation than before. Recent evidence from OECD and other sources suggests that this trend is continuing (see *e.g.* OECD, 2000a). Managing innovation policy is becoming more complex and depends more on governments' ability to find a strategic approach to harness the innovative potential of their respective economies. Further, these economies become more inter-linked through the process of globalisation. The following major trends in the innovation-driven economy highlight both the relevance of the systems approach to innovation policy and the need to enhance its role as a platform for a government strategy:

Information and communication technology is becoming more important for innovation as more knowledge is codified and becomes transferable through ICT networks. Recent productivity increases in many countries, notably the United States in the second half of the 1990s, are to a great extent linked to the adoption of ICT in a variety of business processes.

Innovation reposes on economy-wide knowledge flows. Such flows have both market and non-market features, as exemplified by clusters and there are emerging markets for knowledge as outsourcing of R&D and service functions increases, and market mechanisms for knowledge commercialisation through increased patenting and licensing are becoming more important.

Human capital is becoming critical to innovation performance, and competition for and mobility of tacit knowledge is of increasing importance. Labour markets for highly skilled personnel are in many cases out of balance, leading to insufficient supply for many firms, in particular of ICT skills. The important differences in incentives and opportunities and consequent human capital flows have lifted the issue of international mobility onto the innovation policy agenda.

The ongoing process of globalisation provides incentives for firms to innovate and compete with greater degrees of specialisation and value added. But this process is mirrored by one of apparent contrast: Globalisation goes hand in hand with localisation, where the innovative processes themselves take place in geographical areas that are rich in linkages between actors in the innovation process. Regions grow in importance for innovation as they create geographical and place-specific conditions for proximity. The Silicon Valleys or Alleys of the world illustrate the broader phenomenon of location-specific innovation processes that are rich in flows of tacit knowledge and collaborative patterns in innovation.

The complexity and dynamism of the current innovation-driven economy do not call for a grand systems design in innovation policy, but challenge governments to explore new directions for innovation governance. One main conclusion from the previous phase of the NIS project was the need to cast innovation policy as a horizontal policy area. The dynamism itself requires governments to adapt and learn more profoundly than before.

The NIS approach: Managing knowledge, interactions and institutions

The NIS approach received a boost with the publication of the book *National Systems of Innovation* by Lundvall (1992). Based on observations that firms normally collaborated when innovating, the book presented an agenda for research and policy for much of the 1990s. The refocusing from a sequential to a systems oriented view of the innovation process was also a part of a reappraisal of the determinants of economic performance (Smith, 1995). Nelson (1993) contributed with a slightly different perspective, comparing different nations' institutional set-ups and their economic performance. Hence, institutional economics play a key role in the NIS approach (North, 1990). Recently the core agenda has been defined by an orientation to how knowledge is created, diffused and used in the economy, giving the NIS approach a close link to the knowledge-based economy. Over the years, the research agenda has deepened to focus on complex mechanisms promoting knowledge distribution, for example institutional diversity, sectoral innovation systems, economic and knowledge infrastructures and international linkages (see Edquist, 1997).

The policy implications of these developments have been profound, albeit difficult to operationalise and define. In general, the attention of policy makers moved away from an overall priority to fund the R&D input to the economy, with additions along the way to the market to enhance technology transfer. More attention was directed for example to encouraging collaboration and networking, stimulation of clusters, flows of knowledge into spin-offs and

industrial use, institutional change, entrepreneurship, and improved, market-oriented financial systems (see *i.a.* OECD, 1998; OECD, 2000c).

The contribution by David and Foray (1995) is of special interest in the present context. The OECD NIS project started in 1994 with their contribution on “accessing and expanding the scientific and technological knowledge base”, suggesting a programme of inquiry linked to the concept of an innovation system’s knowledge distribution power. This was used as an organising concept referring to the system’s ability to ensure timely access by innovators to the relevant stocks of knowledge. Countries with an efficient distribution-oriented system were expected to have a better innovation performance.

What are interactions?

A common perception of the NIS approach has been that it focuses on systemic failures rather than market failures. This perception has led to an “anti-market” bias, leaving the NIS approach difficult to apply for policy purposes. However, markets and market failures may be included more explicitly in the NIS approach on the grounds that any of the key institutional forms are essential for innovation and knowledge flows, and that policy makers need to make use of all of them, and indeed understand them and how they interact. In short, the knowledge distribution power of a given innovation system rests on either market and non-market institutions, or mechanisms.

The concept of interaction between innovators adopted in this report includes three basic ideas:

- Competition, which is the interactive process where the actors are rivals and which creates the incentives for innovation.
- Transaction, which is the process by which goods and services, including technology embodied and tacit knowledge are traded between economic actors.
- Networking, which is the process by which knowledge is transferred through collaboration, co-operation and long term network arrangements.

Providing dynamism in innovation systems

On a more general level, this points to a set of complex interactions and inter-dependencies in innovation systems that are highly relevant for policy makers. Typically, innovation systems contain three different sets of interactions, all of which influence the dynamism of innovation and the extent of knowledge flows, and hence represent pillars of the system's knowledge distribution power:

- First and most important, constituent elements of the systems interact, like firms and knowledge institutions. The very notion of innovation systems builds on these interactions, as they are necessary to compensate for the inability of markets to ensure sufficient knowledge flows. *Innovation performance relies on the willingness and ability of firms and institutions to interact and hence share and exchange knowledge.*
- Second, there is a high level of inter-dependence and interaction between different markets (e.g. labour markets, capital markets and product markets). These influence knowledge flows and provide powerful economic forces for innovation and growth. In other words, *innovation processes are linked to the way different markets interact*, a fact that is crucial for regulatory reform and the management of diverse policy areas in a coherent policy space.
- Third, knowledge flows occur through interaction between market and non-market mechanisms. This implies that systems oriented innovation policy covers not only the functioning of various markets, but also the stimulation of interaction through networking and collaboration. Typical examples of this are the importance of clusters (representing flows of traded goods and services) and partnerships in R&D activities.

Dimensions of growth in innovation systems

The present report aims at expanding the understanding of systems and derives practical implications for policy makers. In short, it is assumed that innovation systems derive their dynamism from certain dimensions of growth that are typical for viable, purposeful systems (see e.g. Deutsch, 1966):

- Interactions and linkages: These are the key ingredients of the interactive model, and the NIS approach assumes that growth in

interactions lead to improved innovation performance. In line with the above discussion, not only the quantity of these interactions is important, but also their quality. Hence, innovation systems may grow through complementary interactions between innovators and their partners.

- Growth in manpower and population: This dimension points to the very basic item in human systems and how they repose on the population's general quality, including physical and general health. Hence, it is difficult to assume dynamic innovation systems without a minimum level or growth in the welfare of populations.
- Economic growth includes growth in disposable factors of production as well as the supply of skills and scientific and technical knowledge. From a systemic point of view, it may be stated that economic growth should exceed the growth of population and manpower for the system to remain viable.
- Growth in the operational reserves of the system: The environment may suddenly present new challenges, and both material and human resources need to be available for new uses. The existence of such slack resources defines to a great extent the degree of flexibility and responsiveness of innovation systems.
- Growth in autonomy or the ability of systems to develop by self-determination: The growth in autonomy contrasts with the often-overstated notion of inter-dependence in innovation systems being a key feature. This report takes the position that such autonomy of innovation systems or their sub-systems is a key source of dynamism. On the one hand, autonomy rests on social cohesion or social capital to facilitate interactions, networking and communication. On the other hand, autonomy rests on the ability to act in correspondence with this learning.
- Growth by transformation: Innovation systems that are growing in various ways will sooner or later be victims of scale effects. Growing systems tend to become locked in or jammed by inefficient communication and interaction. Systems can therefore only grow in the wide sense of the term if they are regularly transformed through strategic simplifications. An illustrative example is the tendency for political systems to grow in administrative regulations that impede innovation, leading to the need for simplification of these regulations. Another example is growth through de-centralisation and broader use of *e.g.* regional innovation systems. The most important task for

policy makers in the current innovation-driven economy could be to facilitate these strategic simplifications.

- Growth in goal-changing abilities: This includes the capacity for major re-arrangements of both purpose and structure, and for the development of radically new solutions. This ability for the innovation systems to re-invent themselves and develop novelty and creativity rests on advanced learning as well as autonomy, as mentioned above. The well known story of the Finnish firm NOKIA is illustrative and shows that goal-changing abilities facilitate growth through letting even key components go and adapting purposefully to new opportunities and environments.

Implementing the NIS approach

These forms of interactions and growth processes are the basic sources of dynamism in innovation systems. They structure the innovation process and translate into multiple equilibria in the economy. To achieve dynamism, innovation policy needs to address two sets of structural problems:

- An efficient configuration or structuring of the constituent parts of the systems, for example the economic structure or the organisation of universities and public labs.
- The structure of the innovation process itself, or the particular processes by which knowledge flows in innovation systems and leads to improved economic performance.

Hence, implementing the NIS approach is not an issue of deriving a grand design. Further, it is a process that needs to include market-based interactions and not be restricted to non-market linkages between innovators. Further still, policy makers need to include sources and dimensions of systems growth and apply policy instruments to nurture processes of virtuous growth. The NIS approach constitutes a knowledge-based, comprehensive structural policy, and the specific aim of this report is to specify better the mechanisms by which governments can promote dynamism in innovation systems and how the role of governments is affected by this.

PART III: DYNAMISM AND GROWTH IN INNOVATION SYSTEMS

The building block: Innovative firms

The previous report from the NIS project, “Managing National Innovation Systems” (OECD, 1999a) stressed that, while innovating firms generally enjoyed a productivity advantage, there is increasing evidence that the innovation capacities of most firms are limited. There are both market and systemic failures that lead to significant weaknesses, *e.g.* the “low capability trap” in which firms with low capabilities and learning performance have problems in entering virtuous circles of knowledge accumulation and innovation. There are different and distinct levels of learning capability or innovativeness, ranging from the static firm through the innovating and the learning firm to the self-generating firm. An important task of innovation policy is to facilitate firms’ efforts to raise their learning and innovation capacities.

As shown in Figure 1, evidence points to great differences between sectors and countries as regards innovation expenditures.¹ There is even greater variation on the firm level.

Firms grow through transitions

The innovative capacity of firms is linked to their ability to combine knowledge from internal and external sources. Firms have therefore to develop linkages with other firms and organisations to acquire the knowledge needed for the innovation process. They grow through enhanced absorptive capacities for knowledge acquisition and use, and through internal learning processes. A key

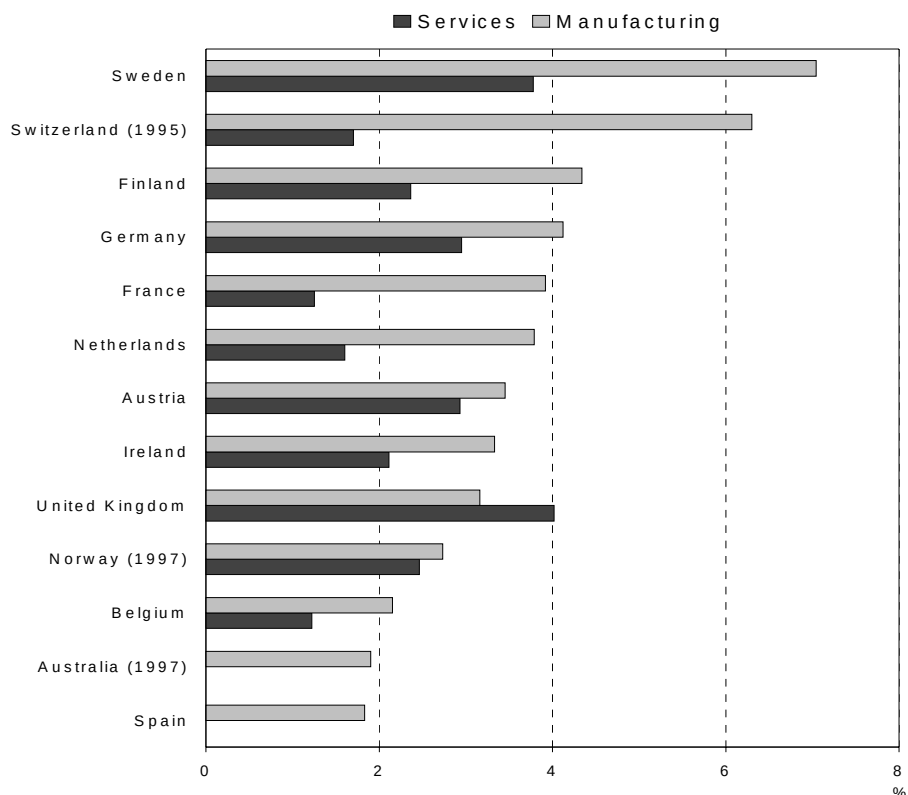
1. Innovation expenditures include “all expenditure related to the scientific, technological, commercial, financial and organisational steps that are meant to lead to the implementation of technologically new or improved products and processes” (OECD, 2001e).

challenge for firms is to manage major transitions as they grow in innovative performance. Strategic simplification that improves learning and knowledge acquisition capacities is needed. There are four levels through which such transition management is vital (A. D. Little, 2001):

- The static firm: The organisation is not involved in systematic innovation, but may have a stable market position while present conditions exist.
- The innovative firm: The organisation operates a linked set of processes involved in concept generation or market identification, product and process development, production, market introduction and feedback. It is able to produce innovations serving known markets efficiently and effectively.
- The learning firm: The organisation adapts to a changing environment, it is able to question existing routines and norms and develop new ones, and thereby engage in so-called double-loop learning.
- The self-generating firm: The organisation has the capacity for strategic re-positioning, it is able to question, change and re-shape the industry it is in, it is able to learn to learn (triple-loop learning) and reinvent itself through advanced learning and adaptation.

A transition of firms through these levels of innovativeness requires the development of key capacities as defined in the NIS project (A. D. Little, 2001). These include vision and strategy, intelligence or knowledge management, managing the competence base, organisation and processes, creativity and idea management, and culture and climate in the firm.

Figure 1. Expenditure on innovation as a share of total sales, 1996



Source: OECD 1999b, based on data from Eurostat.

Firms have degrees of freedom in innovation

Evidence from the Focus Group on Innovative networks suggests that patterns of knowledge management differ according to specific modes of innovation developed by firms. Hollenstein (2001), based on Swiss CIS II data, found for the Swiss services sectors five innovation styles or modes:

- Science-based, network-integrated high-tech firms, endowed with highly qualified staff, high R&D intensity and favourable market and technological opportunities.

- IT-oriented, outward-looking developers with a highly skilled staff, high investments in IT, and favourable market conditions.
- Market-oriented, inward-looking incremental developers, profiting strongly from very favourable market conditions, product and process innovations that have a high IT content, but incremental in nature, where networking is weakly developed.
- Cost-reducing, value chain oriented process innovators, whose innovation inputs are IT and innovation-related follow-up investments, where the networking structure is predominantly value chain based.
- Low-profile, inward-looking innovators, with marginal innovation performance, weak demand, strong price competition, low appropriability and innovation opportunities. The innovation style is based on adoption of innovation generated elsewhere.

Hollenstein finds that there is a clear link between service industries and innovation intensity, but that the innovation modes are widely distributed across industries. Further, there are few significant differences between the innovation modes with respect to economic performance. The results suggest that firms have a range of innovation modes to choose from, and that the important issue is not which mode they use, but that they engage in some particular style that fits their own learning needs. In other words, there is no industry-optimum; the styles are idiosyncratic on the firm level.

These results support a similar study by Arvantis and Hollenstein (2001). They found five distinct innovation styles among manufacturing firms, and four specific knowledge management modes. However, the innovation styles were distributed relatively evenly across industries. Further, the knowledge management modes, labelled as users of *i)* market-oriented knowledge, *ii)* all types of sources with scientific knowledge being important, *iii)* supplier-based knowledge, and *iv)* scientific knowledge only, were not highly correlated with industries, but more so than in the case of innovation styles. By relating the results on innovation styles and knowledge management modes, Arvantis and Hollenstein suggest five general innovation modes that seem well defined: First, process-oriented innovators using primarily supplier-based knowledge; second, incremental product-oriented innovators drawing on market-oriented knowledge; third, incremental product-process innovators drawing primarily on supplier-based and market oriented knowledge; fourth, fundamental product-oriented innovators using scientific and other knowledge; and fifth, high intensity product-process innovators combining scientific knowledge with a

broad range of other sources. Again, as for the services, there is a weak link between choice of innovation style and economic performance. Although the findings for both manufacturing and services suggest that firms may have a variety of modes to choose from, it may still be assumed that successful use of particular styles is linked to particular internal resources or endowments.

Reinventing the firm

Innovation on the firm level may be characterised in terms of process or product innovations, or in terms of innovation styles as above, but the ultimate innovative behaviour implies the reinventing of the firm itself, radical re-arrangements of both its mission and its internal structure. This kind of reinvention ensures future growth through the release of some activities to the benefit of others. The recent reinvention of firms like Nokia (see Box 1) and Siemens to become specialised, high-performance innovators in the telecommunications sector are illustrations of not only a high learning capability, but also of the impact such re-inventions may have on surrounding or emerging clusters of firms.

Such deep transformation or innovation processes are inherent components in the growth and dynamism of innovation systems. But they are hard to measure and understand. They often include outsourcing of activities, start-ups and spin-offs, mergers with other firms, etc. Hence, the innovation process is also about firm demography. Current statistical systems do not capture these systemic changes. In this context, the Focus Group on Human mobility has initiated an important activity on firm demography. In Sweden, a specific project is underway with the aim to develop a new method to study the dynamics of firm creation and destruction, whereby firms are defined by their employees rather than their administrative identification number. For example, if a minimum share of a firm's employees moves to a new formally identified firm, one may consider the firm as the same as the one they left. That is, the firm is the same measured in terms of its competence (Svanfeldt and Ulstrom, 2001). Such methodological developments will improve the understanding of dynamics in innovation systems, including the knowledge flows inherent in deep, firm-level transformations.

Box 1. The transformation of Nokia

The Management strategy was intentional in turning Nokia from a traditional industrial conglomerate to a specialised telecommunications firm, a process that started in the early 1980s and was completed in the mid-1990s. Nokia itself was reinvented several times in a process of major metamorphosis. While Nokia until recently has been a national company operating in global markets (domestic revenues are only 2;5%), it is increasingly establishing operations globally. This process is partly driven by the scarcity of highly-skilled labour in Finland, pushing Nokia to access knowledge elsewhere (Paija, 2001, Ali-Yrkkö *et al*, 2000).

Non-technological innovation is important

Although technological innovation plays a crucial role in firms' performance, evidence from the Focus Groups suggests that non-technological forms of innovation deserve more attention. On the one hand, new forms of organisational models, managerial practices and working methods are more often than before prerequisites for effective use of technology, in particular productivity-enhancing ICT. On the other hand, non-technological innovation plays a greater role in its own right, as a source of value-added and flexibility.

Firms will for example need to link their innovation process to demand. Branding is an increasingly important strategy in this respect, and is aimed at segmenting the market to create the necessary difference to the advantage of the focal firm's products or services. A brand implies a constantly renewed, creative process of innovation and production which guides the development and marketing of a series of products and services.

The work of the Focus Group on Clusters demonstrated the importance of branding in two very different sectors, telecommunications and agro-food. These are also typical cases of companies in consumer mass markets. The agro-food industry, which has often been labelled as supplier-dominated, is increasingly becoming demand-driven. Consumer needs and trends are to a great extent influencing the dynamics of these firms' innovation process. And although equipment from suppliers is still a significant source of knowledge, feedback from and linkages to, as well as inter-locking mechanisms vis-à-vis consumers, today represent crucial components in the overall innovation process. In the case of TINE, the Norwegian dairy co-operative, major resources are deployed on market analysis, product launching and identification mechanisms, often using specialised knowledge suppliers.

A completely different company in a very different sector is Nokia, the Finnish, very much global player in telecommunications. Well known for its capacity in R&D and innovation, Nokia has been one of the greatest performers during the past decade. Huge investments in R&D and innovation, tightly linked to the growth in net sales, have made it possible to stay up front in a rapidly evolving market, where products like mobile phones have very short life cycles. More than in most sectors, the innovation costs need to be recaptured through relating successfully to customers. Hence, advanced branding of Nokia's products has been a significant contribution to the high growth of net sales and profitability. Even being in a relatively new sector, Nokia has been ranked 11th by the American Interbrand in their assessment of brand values, and the Nokia brand is an important risk-reducing innovation. The brand was a notable factor in switching Nokia's marketing strategy in the early 1990s away from high-end to mass market (Ali-Yrkkö *et al.* 2000; Paija 2001).

Clustering of innovative firms

The cluster concept

The cluster concept captures all the important dimensions of modern innovation processes:

- New growth theory stresses the importance of increasing returns to knowledge accumulation, based on investment in new technologies and human capital.
- Evolutionary and industrial economics demonstrates that this accumulation process is path dependent (following “technological trajectories” which show some inertia), non-linear (involving interactions between the different stages of research and innovation) and shaped by the interplay of market and non-market organisations and by various institutions (social norms, regulations, etc.).
- Institutional economics stresses the importance of organisational innovation within firms and government in the design and co-ordination of institutions and procedures involved in handling more complex interdependencies, as growth leads to the increasing specialisation of tasks and productive tools.
- Sociology of innovation stresses the role of “trust” in avoiding the escalation of transaction costs that would result from increased specialisation, the role of institutional and cultural variety in boosting

creativity, and that of non-monetary incentives and barter trade within innovation networks.

Clusters can be defined as networks of interdependent firms, knowledge-producing institutions (universities, research institutes, technology-providing firms), bridging institutions (*e.g.* providers of technical or consultancy services) and customers, linked in a value-added creating production chain (Roelandt and den Hertog, 1999). The concept of cluster goes beyond that of firm networks, as it captures all forms of knowledge sharing and exchange. The analysis of clusters also goes beyond the traditional sectoral analysis, as it accounts for the interconnection of firms outside their traditional sectoral boundaries.

Clusters as sub-systems of the economy are inherently different between countries (or regions), between technological areas, and ultimately between individual clusters themselves. Not only do innovation and innovation processes differ between construction, agro-food and ICT clusters, but the way in which innovation is taking shape in, for example, the Finnish, the British or the Flemish ICT clusters, or in the various ICT sub-clusters within a single country, are inherently different. This reflects differences in historical roots, type of knowledge base, surrounding national conditions, stage in the cluster's life cycle, and networking practices.

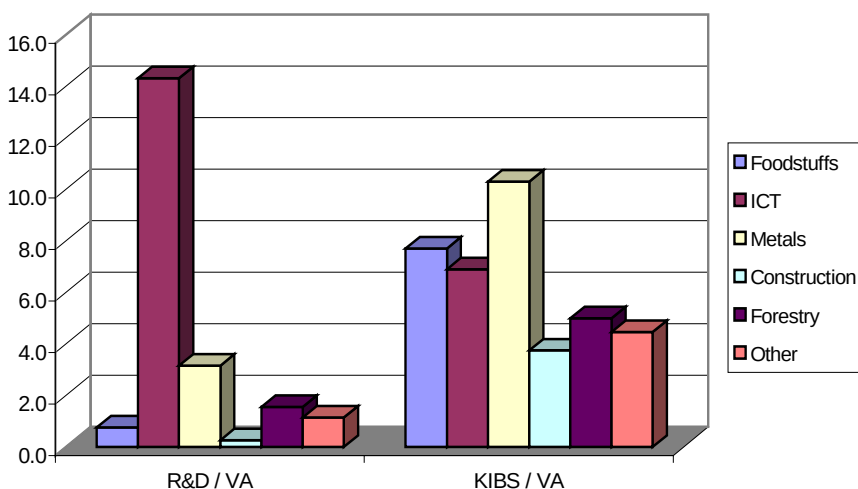
The geography of clusters is generally complex, transcending the various geographic levels of economic regulation. Sometimes very localised (*e.g.* industrial districts) clusters operate on world markets. Localised markets are often served by clusters that are global in terms of production and innovation networks. In most clusters international, national as well as regional elements can be identified.

Different innovation patterns in different clusters

The differences across clusters in how they innovate have been well illustrated in the case of Finland. Figure 2 shows that knowledge is provided very differently to the innovation process in different clusters. While ICT dominates in R&D intensity, more mature clusters have a much higher intensity in the use of knowledge-intensive business services (Luukkainen, 2001). Evidence from the work by the Focus Group on Clusters suggests a multidimensional variability in the innovative behaviour of mature clusters (Dahl and Dalum, 2001a; Peeters *et al.*, 2001; Hauknes 2001; Vock 2001):

- Mature clusters typically have low R&D intensities; in Denmark the R&D intensity of the construction cluster has dropped significantly over the past decade.
- Education levels are often relatively high, but high-skilled jobs concentrate in specific specialised suppliers or core firms, often leaving the bulk of the clusters with lower education levels.
- Product innovations and patenting are variable, but may often be high in specialised suppliers and core firms. However, consumer-oriented clusters like agro-food are often highly innovative. Innovation in mature clusters is often non-technological, *e.g.* focusing on management and organisational practices.
- Many mature clusters collaborate intensely with R&D institutions, most notably in agro-food, but user-producer relationships remain most important.
- Clusters like agro-food and construction are mostly dependent on the domestic market, and innovation performance as well as innovation modes are heavily dependent on the national regulatory framework.

Figure 2. Innovation modes across clusters in Finland (%)



Source: Statistics Finland.

Key factors in cluster development

The work by the Focus Group on Clusters demonstrates the complexity of the interacting factors that determine how innovative clusters emerge and develop. The following factors seem particularly important and some of them are explored further in subsequent sections:

- The development model of a cluster can be defined from a systems or evolutionary perspective as *i)* variation or the creation of novelty, often through random or unforeseen processes, *ii)* accumulation of information and knowledge through learning processes, *iii)* selection through competitive processes. [See Peneder, (2001) for a study of the emergence of the ICT multi-media cluster.]
- Framework conditions are key in providing market-based incentives to the actors involved, and help sustain the evolutionary process of cluster development.
- High levels of interdependency between firms translate into important market-based knowledge flows.
- Outsourcing to existing or new firms is the key determinant in cluster demography. For example, Nokia's first-tier subcontractors are about 300 (Paija, 2001). New entrants are key to this dynamic quality, as they maintain diversity, competition, and rivalry. The particular value of new entrants, as identified in the Norwegian cluster project, is explained in Box 2.
- Innovation-friendly financial systems, in particular venture capital, and more generally a corporate governance that favours innovation and up-grading, are crucial to the development of clusters.
- Supportive education and training systems are necessary to meet the evolving demand for skills.
- A market-oriented technology and innovation policy helps avoid lock-ins and inefficient allocation of resources.
- National clusters often develop through regional specialisation, induced by specific policy environments, as well as through being a part of internationalised value chains, giving rise to "boundary-less clusters" (Green *et al.*, 2001).

Box 2. Reinforcing complementarities

- New entrants in a cluster:
- Enhance rivalry.
- Increase the market for resources that are external inputs to the entrants' activities.
- Help create a critical mass of specialised inputs.
- Increase the efficiency of incumbents because they can outsource the activity to a specialist with higher scale or competence.
- Increase the degree of specialisation in the cluster.
- Make entrance into the market more attractive.
- Increase the total economic activity in the cluster and makes investments in infrastructure more profitable.
- Which increases the performance of all incumbents

(Adapted from Jakobsen 2000.)

Networking in uncertain and rapidly changing environments

The speed of change in international markets and science and technology, along with the greater diversity and specialisation of knowledge, create uncertain and rapidly changing environments for firms. In stable environments it may be sufficient for firms to engage in stable and exclusive relationships with a small number of partners. Hagedoorn and Duysters (2000) argue that firms in dynamic environments need to explore continuously multiple contacts and even accept a certain degree of redundancy in their external linkages, in order to cope with their evolving but largely unpredictable knowledge needs.

Networks are not a generic inter-organisational arrangement, but represent specific institutional forms (Britto, 2000). The structures of industrial networks are to a large extent sector or technology-specific. In other words, specific configurations of technological systems are associated with specific structures of interaction which themselves are shaped by specific institutional

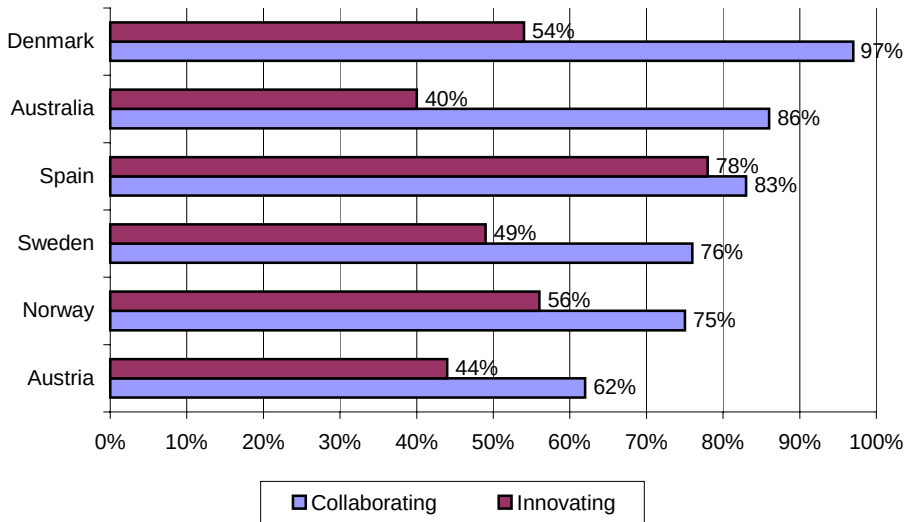
infrastructures for the creation, diffusion and use of technology or knowledge (Carlsson and Stankiewicz, 1991).

Collaboration is pervasive but the intensity and patterns of collaboration patterns are country-specific

There is strong empirical evidence of a link between innovation and collaboration. Work by the Focus Group on Networks has shown that firms which innovate (generally between 40% and 80% of surveyed firms), have a strong tendency to collaborate. But as Figure 3 shows, firms network and collaborate for a variety of reasons many of those having nothing to do with innovation. For example, data from Australia show that most industry sectors have very high rates of collaboration irrespective of their level of innovativeness (Basri, 2001). In addition, collaboration is long lasting, *e.g.* the networking arrangements identified in the DISKO-study had been initiated on average 10 years earlier.

Another consistent finding in research using CIS data, is that the size of firms matters. There is a strong positive relationship between firm size and collaboration in all economic sectors. Larger firms are often nodes in interactive networks. They also tend to use networking more for screening potential sources of knowledge, experimenting with different partners, and monitoring activity in existing networks (Torbett, 2001; Hagedoorn and Duysters, 2000). In a study of collaborative R&D induced by the EU framework programme, the Focus Group on Innovative networks (Luukkonen, 2001) demonstrated that the majority of large firms were technology – or learning-oriented in their collaborative behaviour, while SMEs were typically more market-oriented.

Figure 3. Percentage of firms innovating and collaborating in selected countries (unweighted)



Source: Basri (2001).

A comparative study of collaboration in Austria, Denmark, Norway and Spain (Christensen *et al.*, 2001) shows that the Danish innovation system is characterised by a very high degree of co-operation. Whereas the Danish firms have a product development intensity comparable to that of the Norwegians, above the Austrians but below the Spanish, their propensity to co-operate with one or more partners is higher than that of firms from the other three countries. There are also significant differences as to the relative role of the different partners, especially non-business knowledge institutions.

Domestic and foreign networks reinforce each other

Inter-firm collaboration still takes place predominantly among domestic firms. However, foreign firms, especially suppliers of materials and components and customers, play a significant and growing role within innovation networks. Empirical data indicate a growing frequency of international relationships, going hand-in-hand with a strengthening of domestic networks, especially for firms in small countries.

Table 1. Innovating and collaborating firms in participating countries (Austria)

	Size (number of employees)						
	Total	10-19	20-49	50-99	100-249	250-499	>500
Austria	77.1	81.7	96.0	74.2	55.1	68.2	78.1
EU	62.8	47.0	51.1	65.4	75.8	79.2	85.0
USA	13.2	3.3	14.4	17.9	10.3	16.0	30.3
Japan	2.2	-	-	3.7	4.7	2.2	5.1
Others	21.0	11.5	50.6	19.8	11.9	14.0	13.1

Source: Basri (2001); CIS II (Austria).

Table 1 shows the effect of firm size on the geographical scope of networking in Austria. For firms with more than 100 employees foreign co-operation partners from the EU are more important than domestic partners. Co-operation with partners from the United States or Japan is more probable for bigger firms than for smaller ones. Smaller firms co-operate more with domestic firms although their propensity to co-operate with foreign firms remains high. This points to the importance of networking for small and medium-sized enterprises, as it may enable them to combine advantages of small size at the firm level, such as flexibility, with economies of scale at the level of networks.

A study using DISKO-data from Denmark (Kristensen and Lund Vinding, 2000) sheds another light on the issue by demonstrating that although domestic partners are the most numerous, a larger proportion of them than of foreign partners are considered of minor importance. This suggests that foreign partners have to a greater extent the role of providing critical knowledge inputs. The study also shows that small firms do not distinguish themselves from larger ones in terms of collaboration patterns, except in their lower propensity to link up to knowledge institutions and foreign partners (Kristensen and Thøis Madsen, 2000).

Networking extends to the science system

Industry-science relationships are growing

The previous phase of the OECD NIS project gave clear evidence of the growing importance of links between knowledge institutions and the enterprise sector. These relationships have received ever more attention as the innovation process itself changes and comes to depend more on knowledge flows between

universities and research institutes and enterprises. However, sectors differ greatly in how they rely on inputs from knowledge institutions – pharmaceuticals and biotechnology being examples of areas where the links are especially tight (OECD, 1999a).

Recent OECD work has cast more light on this important relationship in innovation systems (OECD, 2002). Governments are increasingly concerned by the economic impact of the knowledge producing publicly funded organisations. The project on benchmarking industry-science relationships highlights the reasons why the intensity and quality of industry-science relationships are becoming a more important determinant of the efficiency of national innovation systems (*ibid*):

- Technical progress accelerates and the market expands exponentially in areas where innovation is directly rooted in science (biotechnology, IT, but also new materials).
- New information technologies allow easier and cheaper exchange of information between researchers.
- Industry demand for linkages with the science base increases more broadly, as innovation requires more external and multidisciplinary knowledge, tighter corporate governance leads to the downsizing and shorter-term orientation of corporate labs, and more intense competition forces firms to save on R&D costs while seeking privileged and rapid access to new knowledge.
- Financial, regulatory and organisational changes have boosted the development of a market for knowledge, by making possible the financing and management of a wider range of commercialisation activities.
- Restrictions on core public financing have encouraged universities and other publicly funded research organisations to enter this booming market, especially when they can build on already solid linkages with industry.

Patterns of industry-science co-operation are diverse

A study on Denmark, also based on the DISKO-data, confirm intuition in demonstrating that manufacturing firms generally co-operate to a limited extent with research institutions on product development, and that large firms co-

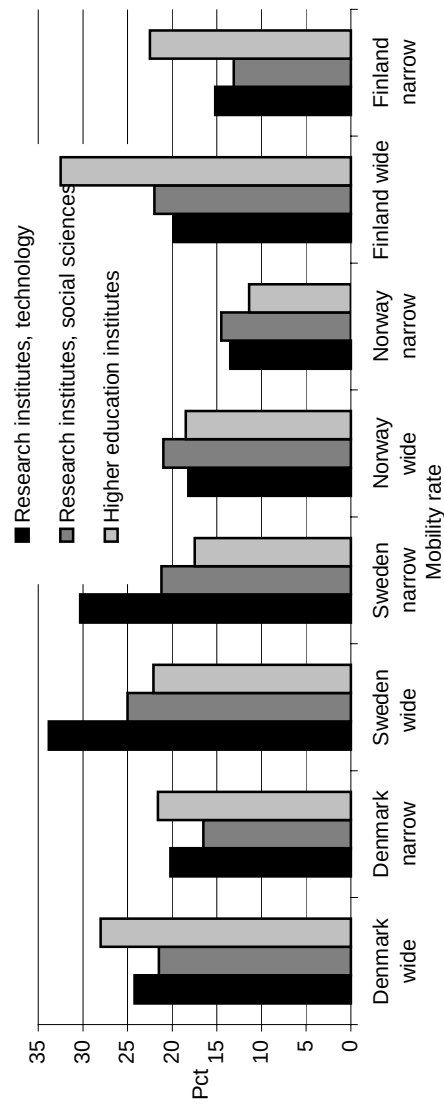
operate more often with R&D institutions than small firms (Christensen *et al.*, 2001). But this study also indicates that:

- *A minority of firms is involved in industry-science relationships.* Whereas some of those not involved have no need for such co-operation, many of them may in fact lack capabilities, especially human resources, to enter into fruitful interaction with non-business research organisations. Kristensen and Thøis Madsen (2000) make the point that to a large extent this reflects a division of labour in the innovation system whereby larger firms specialise in relationships with knowledge institutions, and foreign firms, while smaller, exploit synergies with partners in the value chain that are of a similar culture.
- *High-tech firms co-operate more with R&D institutions than low-tech firms, but the difference is not as high as could be expected (20% and 13% respectively).*
- *Geographic proximity counts.* This is particularly the case for co-operation between firms and R&D institutions, compared to the co-operation with technology advisors. This reflects the fact that technological advisors are geographically more dispersed than R&D institutions, but also the existence of a high degree of tacitness of the knowledge exchanged between firms and R&D institutions.

Labour mobility between science and industry

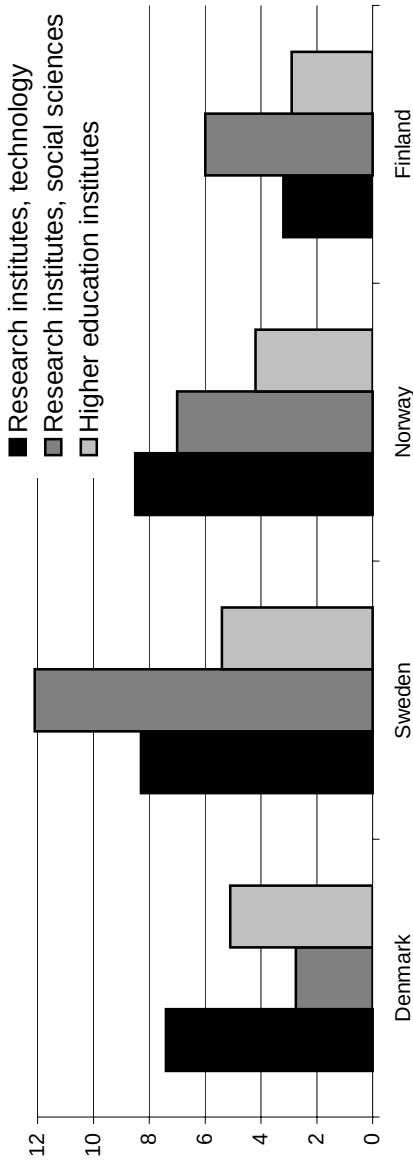
Labour mobility between universities/research institutes and industry facilitates networking between firms and public research. The Focus Group on Mobility has presented further empirical evidence on the national patterns of such mobility, although for a limited sample of countries. Graversen (2001) has shown that in four Nordic countries (Sweden, Denmark, Norway and Finland) the outflow mobility rates are between 15% and 20%, with a maximum in Sweden and a minimum in Norway (Figure 4). However, when the variety of receiving sectors is considered, the study reveals even greater national differences. Figure 5 shows that in Sweden knowledge institutions release human resources to eight sectors, while the corresponding figures are six for Norway, five for Denmark and four for Finland.

Figure 4: Outflow mobility rates for highly educated employees in the R&D and HEI sectors in four Nordic countries



Note: Wide type of mobility includes persons leaving active work force. Narrow type of mobility excludes these.

Figure 5: The number of effective receiving sectors for the R&D and HEI sectors in four Nordic countries



Note: The number of effective receiving sectors is calculated from an inverted Herfindahl index based on a 42 sector input-output matrix for each country.

Government-induced international networking generate national and industry-specific spillovers

Networks usually develop spontaneously but firms may underestimate networking opportunities, especially outside their own country, due to information imperfections and other market failures. This is the rationale behind initiatives such as the European framework programmes for R&D which stimulate networking through financial incentives to collaborative R&D. Work by the Focus Group on Networks revealed that knowledge spillovers through inter-firm linkages in the EU framework programmes have the following patterns (Dumont and Tsakanikas 2001):

- Intra- and intersectoral spillovers are country specific, and more so for user sectors than for supplier.
- Low-tech industries like food and beverages, textiles, iron and steel and non-ferrous metals benefit from considerable spillovers in a number of countries.
- Science-industry spillovers through participation in the Framework programmes are very important for food and beverages in almost all countries and for textiles in some countries.

Competing for skills: Flows of human resources in innovation systems

Labour market aspects have not been seriously integrated into the national innovation systems approach, although it has been long recognised that labour markets and education systems shape innovation processes (Lam and Lundvall, 2000). Labour market conditions affect innovation performance partly through their impact on the allocation of high skilled labour.

In the first phase of its work the Focus Group on Human resource mobility attempted to compare human resource flows across countries. This work was limited to the Nordic countries due to lack of suitable data for most other countries. The main conclusions from this work were that:

- Firm strategies in recruiting highly skilled labour varied greatly across countries.
- The mobility of PhDs represented a weak means of knowledge transfer (based on Swedish data).

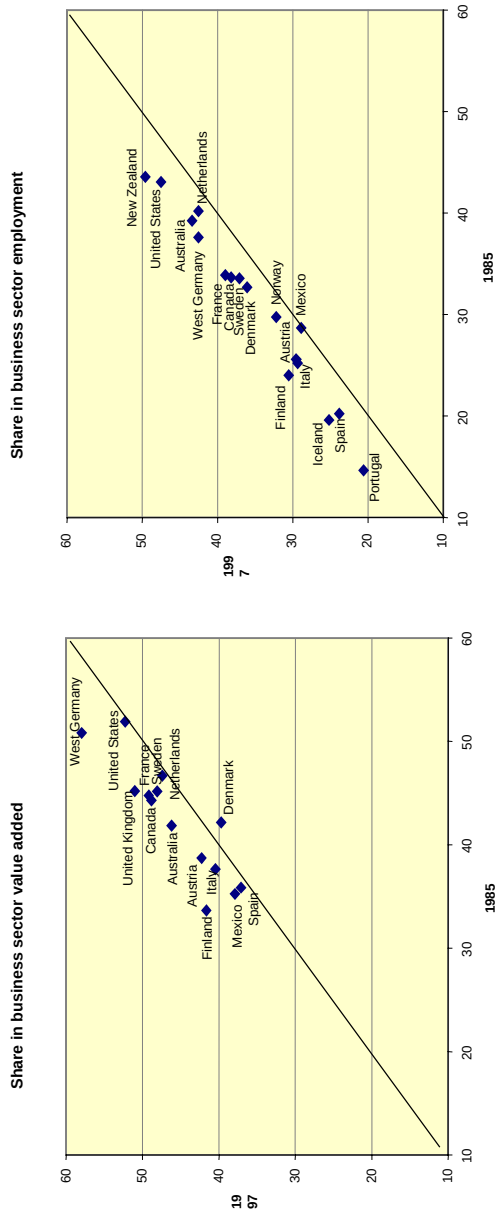
- The Nordic countries experienced a relatively high mobility from one year to the next (20-25% changed jobs), but mobility from knowledge institutions to the private sector was low.
- Flows of human resources between collaborating firms are above than average.

While the concerns of policy makers about the stocks and flows of skills and know-how increase, the availability of relevant data remains problematic. The continued work by the Focus Group on Mobility intends to generate more empirical evidence, exploring data sources such as registry data, national and European Community Labour Force Surveys, work permits and various survey and panel data. In particular, the aim is to cast light on questions concerning the extent and significance of PhD-flows, international flows of highly skilled personnel, the transition of graduates to employment, and the role of the labour market in allocating human resources to innovative and growing sectors in the economy.

The importance of skills and know-how

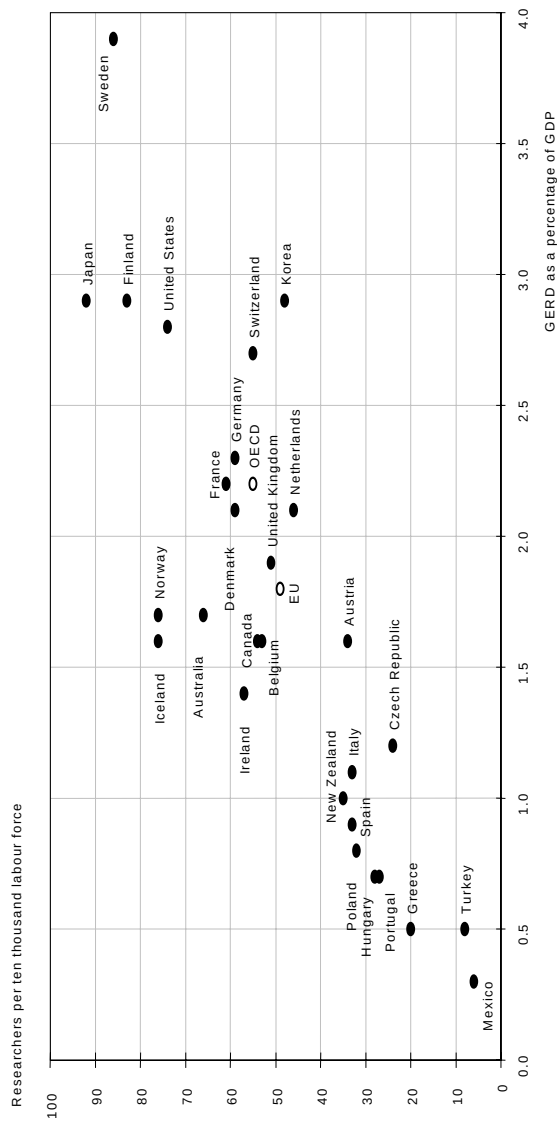
An innovation-led growth is skill-intensive, as illustrated by the increasing share of knowledge-based sectors in business value added (Figure 6). These sectors' share in business sector employment has increased likewise. Over the last two decades most countries have experienced great increases in the stock of R&D personnel (Figure 7). Exceptions are Korea, the United Kingdom and Germany. In general, governments are becoming concerned about the availability of skilled personnel, as the competition for them becomes more global.

Figure 6. Increasing importance of knowledge-based sectors, 1985-97¹



1: Knowledge-based sectors are here understood as those with high R&D intensity.
Source: OECD, Main Industrial Indicators (1999).

Figure 7. Total R&D personnel per thousand labour force, 1981 and 1998



Source: OECD, Main Industrial Indicators (1999).

The mobility of human resources within innovation systems cannot be analysed without consideration of the formation of human capital through increases in labour supply, increased capacities in education systems, and training and re-training of the workforce by industry itself. Countries differ in this respect, *e.g.* as to how they allocate knowledge investments between education, software and R&D. Further, growth of human capital is unevenly distributed within countries; for example, employment growth in the United Kingdom is highest in regions with a high concentration of services rather than manufacturing industries (Tomlinson, 2001*a*). This reinforces the argument that dynamic environments, often regions, shape diverse and often polarised development of human capital. The dynamic role of ICTs is illustrative of the way in which demand for human capital builds up through systemic links in the economy:

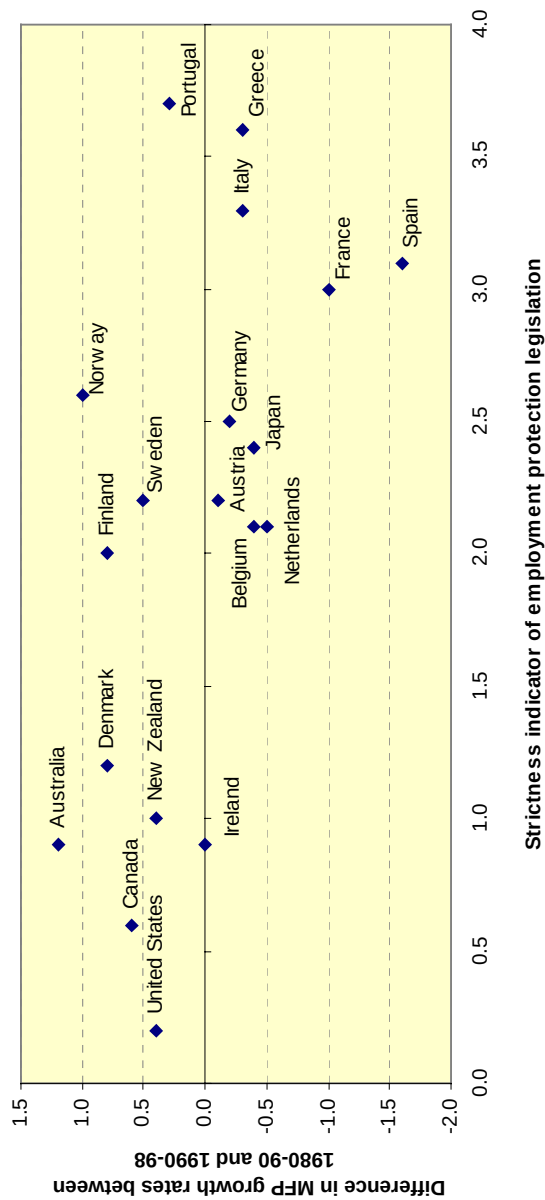
- ICTs development creates a surge for new skills.
- ITCs penetrate deeply throughout the economy, leading to new demand in user sectors, including the public sector.
- The speed of this diffusion process creates skills shortages, and labour markets for these skills have difficulty adjusting.
- The innovation process itself is inhibited, and distribution of incentives in the labour market is skewed.

The link between human capital and mobility on the one hand and economic growth on the other has also a cyclical aspect. Tomlinson (2001*b*) suggests that the relative demand for highly skilled workers tends to increase in economic downturns, and decrease during upturns.

Labour mobility and economic performance

The degree of labour mobility, as influenced by social regulations and other factors, has an impact on economic performance. Recent studies in OECD have established interesting co-relations between differences in multi-factor productivity and the degree of strictness in employment protection regulation (Figure 8).

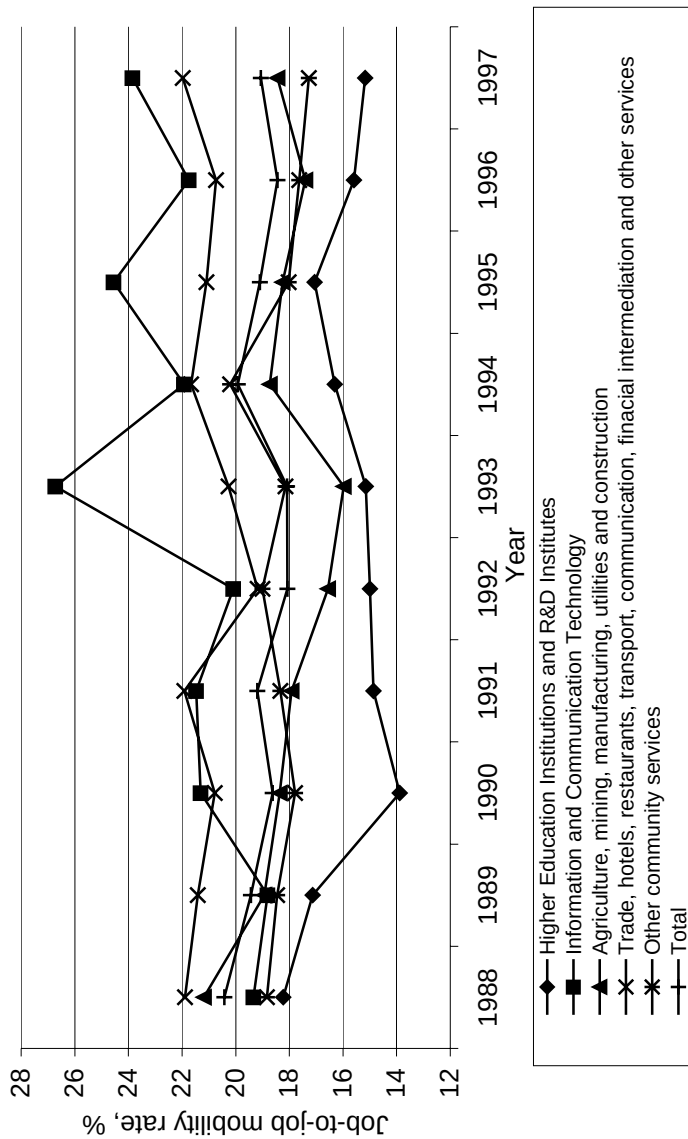
Figure 8. Multi-factor productivity and employment protection legislation



Source: Bassanini et al. (2000).

But evidence from the Focus Group on Mobility suggests a more complex picture regarding the links between social regulations, NIS institutional features, technical change, and labour mobility. The overall mobility rate for the European Union has increased from 6.8% in 1994 to 8% in 1999 for men, and from 7.8% in 1994 to 8.9% in 1999 for women (Laafia and Stimpson, 2001). The Nordic countries show persistently higher mobility rates than most other countries, generally around 23-30% over the past decade (Graversen *et al.*, 2001*b*). At sectoral level, below average mobility is found in the research and the manufacturing sectors (see Figure 9 for Denmark). ICT and services have the highest mobility rates. In addition, mobility rates are inversely related to firm size, with smaller firms receiving the bulk of mobile workers, are highest among the youngest and increase with the educational level.

Figure 9: The inflow job-to-job mobility rates by sectors in Denmark in 1988-97



Note: The job-to-job mobility rate covers inflow mobility of workers employed in year t-1 to employment at a new employer in year t.
Source: Gravensen et al. 2001b.

International mobility of human resources in science and technology

As skills and know-how become more important to the economic performance and innovation capabilities of countries, governments pay more attention to international mobility of tacit or human embodied knowledge. They are concerned about increasing imbalances in migration. The Focus Group on Mobility has highlighted the following issues related to brain drain and gain (Regets, 2001):

- Sending countries may lose productive capacity as well as experience reduced incentives to invest in education, at least in the short term. However, outflows of students of highly skilled labour may represent increased incentives to seek higher education and domestic returns to investments in skills and know-how.
- Outflows may strengthen ties to foreign institutions and firms, improving the integration of the sending country into international innovation and research networks. For example, there is a clear positive correlation between the number of US doctorates received by natives of a country and the percentage of that country's articles co-authored with the US (Regets, 2001). In addition, return migration may revitalise the domestic knowledge base.
- There are obvious positive effects for the receiving country, for example increased R&D and productive and innovative capacity, extended global networks and thus improved knowledge flows and technology export opportunities. Increased enrolment through inflows from abroad may have positive effects on the education system, e.g. the possibility to keep smaller programmes alive and thus maintain a diverse and broad-based education system.
- But receiving countries may also experience negative effects, notably reduced incentives to seek higher education if inflows are perceived to increase competition in the labour market and hence reduce returns to education. High inflows from abroad may crowd out native students from the best schools. The teaching process in the education system may be negatively affected by language and communication problems, in particular when foreign graduate students are teaching.
- Some important global positive effects to be expected are improved ability for researchers to seek work that gives them higher rewards, in economic and/or professional terms, and the formation of borderless

research clusters. Employers may also more easily find rare/unique skills sets.

In sum, greater possibilities for highly skilled labour, students or employees, to seek globally the best employment opportunities may lead to possible detrimental effects in the international distribution of tacit knowledge. International migration of the highly skilled may lead to increased incentives to invest in education and to more efficient international knowledge flows. Hence, a better understanding of migration patterns is needed to determine how best to ensure those benefits exceed costs. However, there are serious shortcomings in data on international migration, and this area of official statistics is regarded as a “story of neglect”¹, indicating a priority area for future international collaboration in policy analysis.

Migration of students: brain drain and gain, and brain gain from brain drain

Flows of students are a central component of international migration of HRST. More than one third of foreign students study in the United States, and more than 70% of all foreign students are located in the four leading countries: France (13.9%), Germany (11.9%), the United Kingdom (10.4%), and the United States (37.1%).

Asian countries are the most important sending countries, accounting for 45% of the total number for OECD countries. The high number of foreign students from countries like China, Korea, Japan, India, Hong Kong China, and Malaysia, is explained by weaknesses of domestic higher education systems and demographic reasons, but also by active policy initiatives in this region to promote the acquisition of skills abroad (ter Weel, 1999). By contrast only a small proportion of US students go abroad and, subsequently, US scientists and engineers are only to a small extent involved in the international flow of HRST. Regets (2001) refers to lower bound estimates of US PhDs abroad which indicate that 3% of native born, 7% of the foreign born who had US citizenship at the time of their degree, and 4% of those who had received permanent visas had taken positions outside the United States.

The empirical evidence also illustrates a regional polarisation of the sources of foreign students in most countries. For example, almost 92% of foreign students in Japan come from other Asian countries. The same pattern is valid for many European countries, especially the smaller ones, but even in

1 . A recent study by the US National Academy of Sciences had the telling title of *Immigration Studies: A Story of Neglect*.

Germany almost half of the foreign students come from other European countries (more than 45%). Countries with a colonial history recruit a large portion of foreign students from their ex-colonies (in France more than 25% come from Algeria). Almost two-thirds of foreign students in the United States come from Asia. For European PhD. students the single most popular destination is the United States, but other European countries meet growing interest. In an Italian survey of PhDs' preferences for study visits abroad, 33.5% reported the United States, but more than 50% reported the United Kingdom, Germany and France (Avveduto, 2001). There are differences between disciplines: while engineers prefer the United States, students in other disciplines, especially social sciences, increasingly prefer Europe.

An Italian survey suggests that there are two main obstacles for students to pursue their PhD. abroad. Lack of funds (34.4%), and conflicting personal commitments (20.9%). Lack of information about opportunities is of less importance. The main problem encountered at the foreign institutions is language, but students appear to adapt well in general (Avveduto, 2001).

The question of brain drain or gain should be seen in a dynamic perspective, so that student circulation may represent a process through which sending countries gain in the longer term through return migration. A key question in this respect is whether and for how long foreign students stay in receiving countries after completion of their studies. According to the National Science Foundation (see Table 2), there are indications of a reduced circulation. While 50% of foreign S&E degree holders had plans to stay in the United States in 1985, the corresponding figure was 67% in 1997. The increase has mainly taken place since 1992. On average, 47% of foreign students stay four years after their PhD. graduation, but there are striking differences. For some countries, the stay rate is very high, suggesting brain drain: China 88%, India 79%, United Kingdom 59%. Other countries have low stay rates, suggesting high circulation and a considerable direct gain from earlier outflows: Japan 13%, Korea 11%, Mexico 30% (Regets, 2001; Finn, 1997). There are also important differences between disciplines. Finn (1997) has found stay rates that varied between 32% in the social sciences, 54% in life sciences and engineering, and 61% in the physical sciences and mathematics.

The role of immigration policy: the US example

Many countries have immigration policies that increase the inflow of highly skilled personnel to meet domestic demand, *e.g.* the United States, while others have been far more restrictive, *e.g.* European countries. There has been a slight increase in the issuance of permanent (INS) visas to the United States in

the past decade. It peaked in 1992-93 for all disciplines, and natural scientists and mathematical/computer scientists are the two groups experiencing the most important increase (from 1 200 in 1988 to 2 500 in 1998 in both cases).

For many highly skilled immigrants, however, temporary stays are often the means to enter a country, with the intention of either a temporary or permanent stay. Figure 10 shows the distribution of inflows to the United States from a number of countries over the past decade. India has had an enormous growth in temporary outflows to the United States, increasing from 2 144 persons in 1989 to more than 55 000 persons in 1999, counting for almost 50% of the temporary inflows into the United States in 1999.

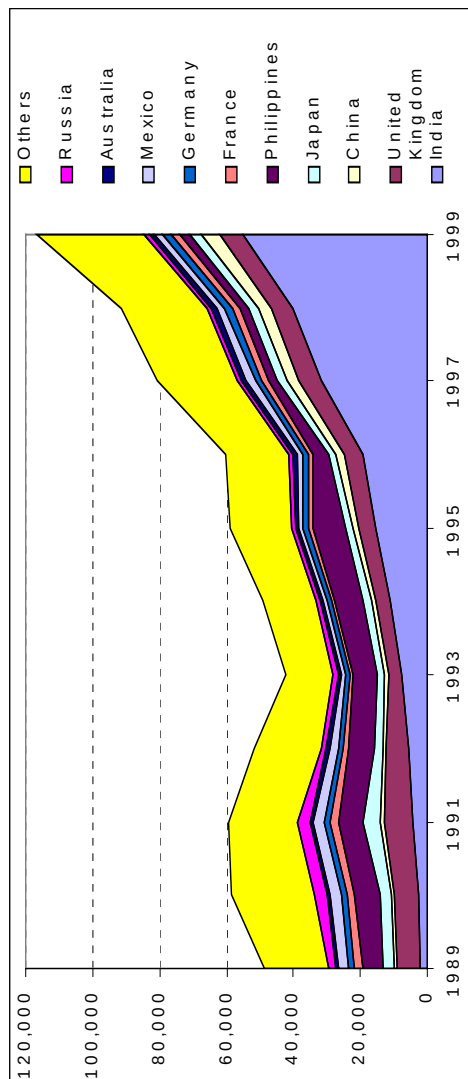
Table 2. Foreign degree holders' plans to stay in the United States

Year	Total S&E Doctoral recipients	Total	Foreign S&E doctoral recipients			
			Plans to stay		Firm plans	
			Number	Percent	Number	Percent
1985	18 113	2 401	1 201	50.0	963	40.1
1986	19 437	2 613	1 322	50.6	1 111	42.5
1987	19 894	3 018	1 479	49.0	1 257	41.7
1988	20 933	3 383	1 729	51.1	1 444	42.7
1989	21 731	3 795	1 873	49.4	1 575	41.5
1990	22 867	5 002	2 449	49.0	1 778	35.5
1991	24 019	6 167	3 690	59.8	2 397	38.9
1992	24 673	6 625	4 274	64.5	2 541	38.4
1993	25 441	7 014	4 480	63.9	2 516	35.9
1994	26 202	7 590	5 108	67.3	2 805	37.0
1995	26 515	7 842	5 533	70.6	3 000	38.3
1996	27 230	8 026	5 781	72.0	3 713	46.3
1997	26 847	7 014	4 815	68.6	3 483	49.7

Note: Foreign doctoral recipients from selected countries of Asia, Europe, and North America. Asia includes China, India, Japan, Korea, and Chinese Taipei. Europe includes all Scandinavian, Western, and Eastern European countries. North America includes Canada and Mexico.

Source: National Science Foundation, Division of Science Resources Studies (NSF/SRS), Survey of Earned Doctorates, special tabulations. Science & Engineering Indicators – 2000.

Figure 10: H-1 visas issued by country of origin, 1989-99



Source: OECD, adapted from Lowell (2000).

Skimming the cream: Interdependencies in the US-Canada relationship

During the 1990s the United States has experienced exceptionally rapid and sustained economic growth in the context of trade liberalisation in the North American continent, leading to the NAFTA agreement. One could have expected that reduced obstacles to movement of people under these conditions would have led to higher migration. This has been only partially the case, as is best illustrated by data from Canada (Zhao *et al.*, 2000; Industry Canada, 1999):

- Statistics on permanent out- and inflows indicate that Canada remained a net recipient of skilled workers, even if Canada at the same time had a significant gross outflow.
- Within the US-Canada relationship, Canada is a net loser of skilled workers, but this net loss is not great. However, 30% of the outflow to the United States are highly skilled immigrants initially attracted to Canada.
- Permanent migration to the United States has not increased much, but the new policy of temporary visas under NAFTA has boosted temporary outflows. For example, 90% of the 1995 graduates who moved to the United States used a temporary visa. The transition from temporary to permanent stay has become easier under NAFTA.
- Canada has been mainly confronted with a “quality issue”. Those leaving were the high-income earners and especially the highly qualified, coming from sectors or occupations with the greatest need for knowledge workers. For example, 42% of the graduates leaving ranked themselves in the top 10% of their class. There are substantial wage differentials for the same types of jobs in the two countries, between 20% and 75% to the US benefit depending on the scientific area.

Complex interactions create resilient, dynamic and adaptive innovation systems

The knowledge distribution power of a national innovation system is the combined efficiency of a complex web of market and non-market interactions between different types of innovation actors, at different geographical levels, for a variety of purposes. *National innovation systems have regional roots and global reach.*

The regional level of interactions receives increasing attention in innovation policy. Regional innovation systems derive their systemic strength from economies of agglomeration and intensive exchanges of tacit knowledge. Evidence from Japan show for example that industries and firms that are highly dependent on access to such knowledge have a propensity to agglomerate in certain regions (Gonda and Kakizaki, 2001).

This regional polarisation of innovation networks is also demonstrated by Edquist *et al.* (2000). Using DISKO data they show that in East Gothia (Sweden), 70% of innovative firms had engaged in collaboration with at least one external partner. Excluding the smallest firms of 1-9 employees, this rises to 76%. The important point they make, however, is that more than half of the collaborating firms had at least one local partner, and 25% had their most important partner located in the region. The most frequent types of collaboration partners were suppliers of material and components, private customers and suppliers of machinery and production equipment.

Multiple modes of interactions complement each other in improving dynamic allocative efficiency in knowledge generation and diffusion

Collaboration between firms in product development was studied in Denmark, revealing the complementary nature of three types of interaction (Kristensen and Lund Viding, 2001): exchange of personnel, use of electronic media, and exchange of prototypes. First, each of the three interactions plays a unique valuable role in transferring knowledge between firms. Second, there is a significant correlation between the use of these media, in particular between: exchange of employees and use of electronic media; the use of electronic media and the exchange of prototypes; exchange of prototypes and exchange of employees.

More generally, clusters result from the interaction between market mechanisms and network relationships among actors of a value or supply chain. Networking between clusters enhances knowledge spillovers throughout the economy. Innovation surveys and the Focus Groups' work show not only that the firms' most important partners in networking are those belonging to the value chains, but also that collaboration with "minor" partners outside clusters plays a major role in the adaptability of clusters and in the economy-wide diffusion of knowledge.

Networking and clustering stimulate human resource mobility and shape its patterns at the regional, national and international levels. For example in Australia 38% of firms exchange employees during the collaboration process,

with a length of stay of 15-20 days (Basri, 2001). Immigrants, mainly Asians, are at the origin of more than a third of the technology-based start-ups in Silicon Valley (see OECD, 2000b). In the United Kingdom areas of international renown in clinical medicine and bio-sciences attract the bulk of foreign academics (Mahroum, 2001).

Summing up

An analysis of new trends in knowledge generation and diffusion reveals complex, dynamic and differentiated developments in innovation systems. The following findings are of particular importance:

- Clusters provide a powerful market-based economic structure for innovation, generating market-based linkages for technology-embodied knowledge flows, as well as additional connectivity through networking and human resource flows.
- Increasingly fluid and decentralised knowledge production structures require those firms to use networking and collaboration to create broad and flexible interfaces with the knowledge environment.
- Market forces, networking and human resource mobility combine to produce dynamic and innovative environments. These complex interactions increase inter-dependencies within and across innovation systems.
- Innovation systems are usually understood as national, but evidence from the Focus Groups on Clusters, Networking and Human resource mobility confirms the increasing importance of their international dimension.
- Non-technological innovation is key in its own right but also as a condition for effective technology diffusion and adoption.

PART IV: DYNAMISING INNOVATION SYSTEMS THROUGH COMPREHENSIVE POLICY

The need for coherent and comprehensive policy-making

OECD countries have gone through major changes in innovation policy in the past decade. The traditional focus on direct support to R&D has been reduced and more attention has been given to improving market and systems mechanisms for sustained innovation performance.

The previous phase of the NIS project suggested that, in addition to setting up conducive overall framework conditions, governments need to adapt their role in innovation policy to become catalysts and organisers, in particular in the framework of cluster policies. One key argument was that cluster policy provides instructive lessons for developing NIS policy frameworks in general, as these clusters can be seen as reduced-form innovation systems (OECD, 1999a). The present report expands this previous work by exploring further what can be learned from cluster policies and policies facilitating networking in designing and implementing the overall technology and innovation policy. This section presents the policy implications from the preceding analysis from this perspective and focuses on three main dimensions of a comprehensive policy approach:

- Structuring the innovation process.
- Managing policy spaces.
- Innovation governance and policy learning.

Structuring and dynamising the innovation process

Enhancing firms' innovative capacities

The Focus Group on Innovative firms and networks examined how governments could contribute to enhancing the capacities of firms. Its main conclusions are (A. D. Little, 2001):

- The strategic capacity of firms, a prerequisite for innovative performance, can be developed through targeted support programmes aiming at raising the firms' ability to place innovation decisions in their strategic context and better integrate technologies and competencies to strategic ends. This has been done in many countries using external advisors, *e.g.* the MINT programme of EU, Norway's BUNT programme, Syntens in the Netherlands, and New Zealand's Current Position Analysis Programme.
- Advanced firms may benefit from a richer information environment, and governments may improve this environment through foresight technology programmes, scenario studies and other initiatives to reduce uncertainty and generate learning platforms for innovative firms.
- As firms rely increasingly on external knowledge sources, they need excellent capacities in managing external relations. Governments can facilitate the relevant knowledge flows, building on existing networks and clusters.
- Specific initiatives to increase the mobility of human resources within and between firms and knowledge institutions include: secondments, staff exchanges, job rotation within firms, placements of young professional staff trained in technology or business disciplines.

Exploiting further the power of markets

Markets have a dual role in the innovation-driven economy. On the one hand they play a vital role in generating incentives for innovation. On the other, they provide valuation mechanisms for knowledge and efficient channels for knowledge flows. Markets for knowledge have gained in breath and depth (see Box 3), increasing the need for and potential pay-offs of the following government actions:

- Removing trade and other barriers to technology-embodied knowledge flows.
- Providing appropriate infrastructure (*e.g.* ICTs) and regulatory frameworks (*e.g.* IPRs) for the development of “non-embodied” and codified knowledge market-based transactions (*e.g.* patenting/licensing).

- Exploiting labour markets in allocating high skilled labour and in providing signals for investment in education and skills by individuals, firms and governments. In many countries there is for example a need for more rewarding career prospects for academic labour, a wider distribution of the highly skilled throughout the economy, more flexible regulation of employment contracts for faculty, and better use of highly skilled immigrants. More generally, the findings of the Focus Group suggest that mobility rates are important indicators of the efficiency of labour markets. Mobility rates below 5% should be seen as an indication that they are too rigid, whereas very high rates (as high as 30% in some countries surveyed) might be detrimental to the learning capacities of firms and suggest the existence of distorted incentives in the labour market (Ekeland and Smith, 2001).

Box 3. Fast growing markets for knowledge

Increased patenting activity is one aspect of the rapid expansion of markets for knowledge, some of which have unusual properties, *e.g.* due to the existence of increasing returns in the production, or decreasing appropriability of what is transacted. In particular, some knowledge markets exhibit network externalities whereby the value of what is traded increases with the number of transactions. A typical example is software.

The economics of knowledge production and distribution have changed radically. Knowledge is increasingly being codified, transmitted and accessed globally at a reduced cost, thanks to the development of ICTs. For example, Nordhaus (2000), refers to the reduction in search time for a document in the Library of Congress. The search time halved every 34 years in the period from 1800 to approximately 1990. In the past decade, the search time has halved in 0.6 years. For example, consulting firms rely on an accumulated stock of collective knowledge and experience which can be cumulatively enriched through constant addition, retrieval and re-use. This development is revolutionising the innovation process in many areas, notably in high-skilled areas like research, knowledge-intensive business services, and many others.

But the expansion of the market-based transaction of knowledge is also explained by changing business R&D strategies which lead to spin-outs, and outsourcing of R&D to other firms and to knowledge institutions.

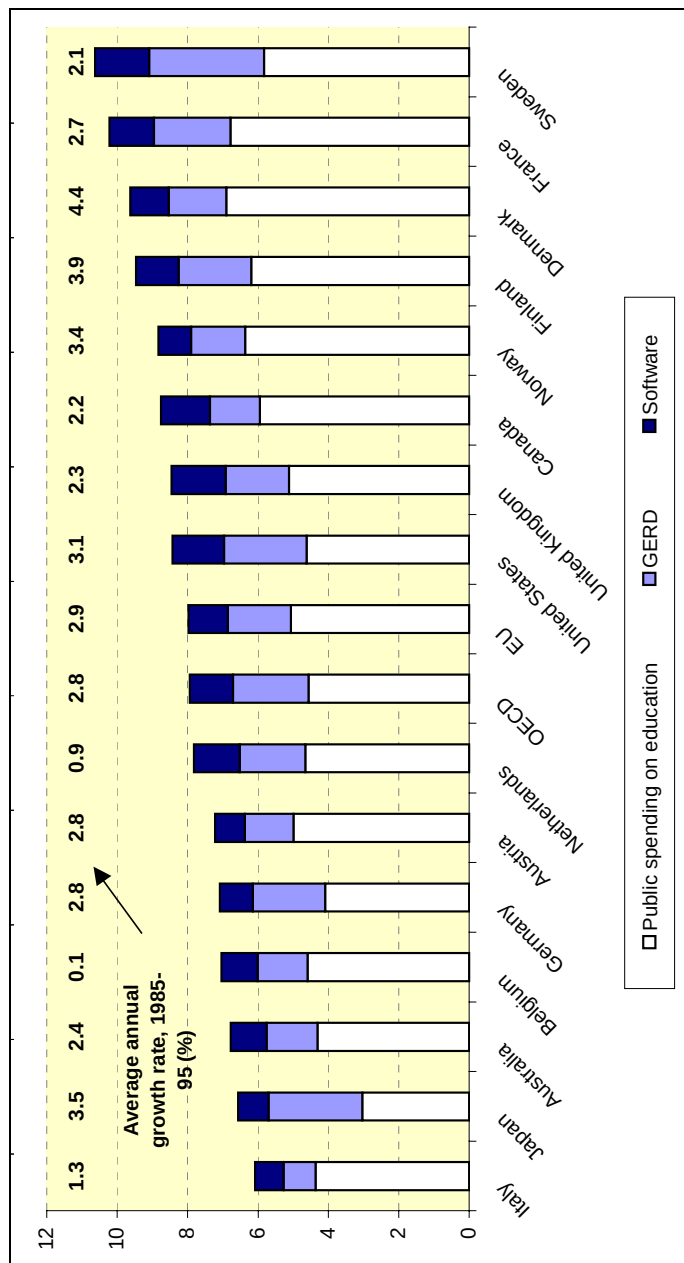
Securing investment in knowledge

The increased policy focus on improving interactions within innovation systems should not lead to a neglect of more traditional R&D and innovation policy goals, especially the need to ensure an appropriate level of investment in knowledge by both the public and private sectors. For example promoting interactions between firms with low endowments of human capital will soon lead to stagnation. The recent OECD growth study highlights this as a major factor explaining differentials in economic growth (OECD, 2001*d*). Figure 11 shows that countries differ greatly in investments in knowledge.

Promoting the commercialisation of publicly funded research

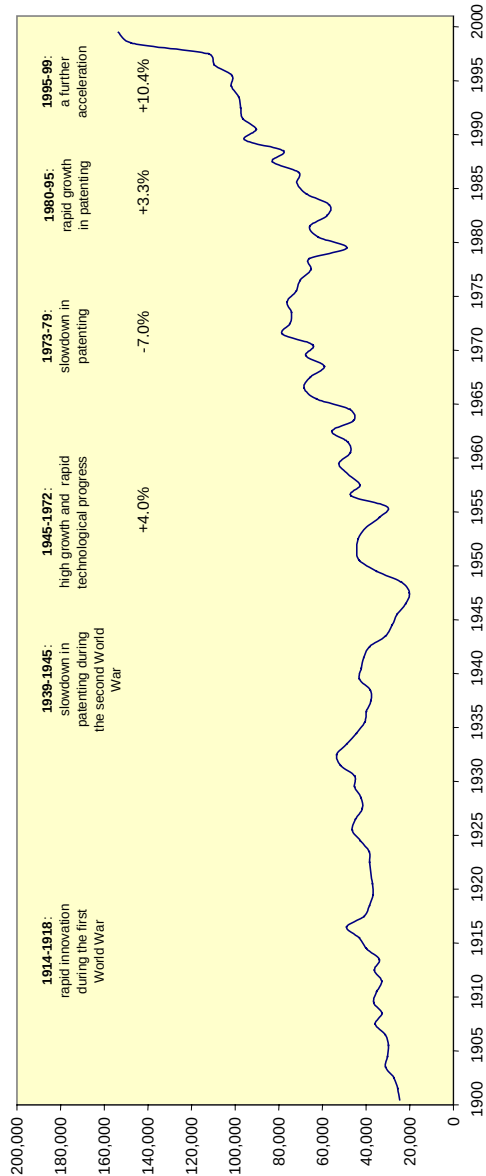
Figure 12 shows the growth of patenting over the last century. The sharp increase in the last decade, which is due to many factors including the increasing scope of what is patentable, points to a change not only in the way commercial innovation is protected but also in the way knowledge is distributed.

Figure 11. Intangible investment as a percentage of GDP, 1995



Source: OECD.

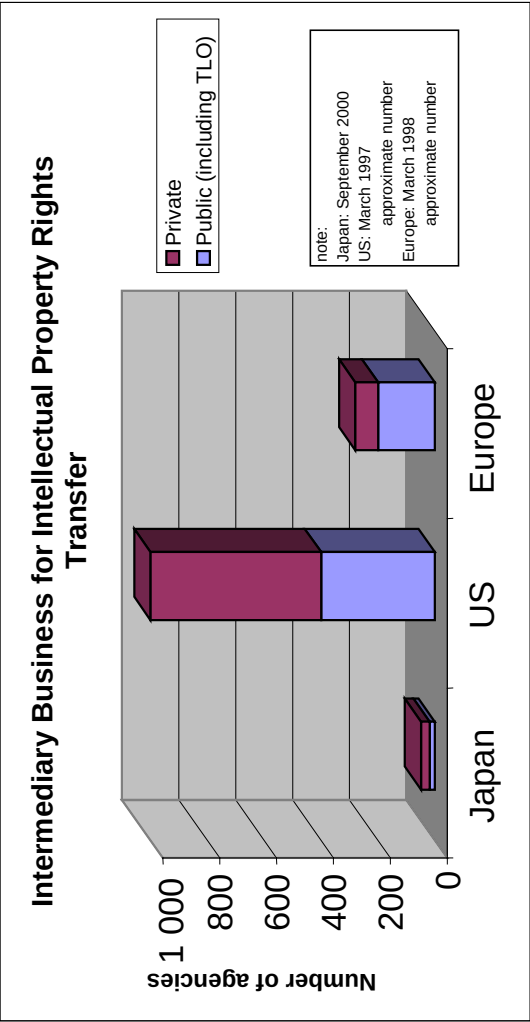
Figure 12. Patents granted in the United States, 1900-99



Source: US Patent and Trademark Office.

This development is of great significance to innovation policy. In particular, publicly funded research organisations must adapt accordingly their knowledge diffusion strategies. In this new context an effective dissemination of knowledge between public knowledge institutions and the private sector depends on certain regulatory factors (*e.g.* IPR policy in the public sector) and on the existence and efficacy of mediating institutions. Regarding the latter, Figure 13 shows that there are great differences between the United States, Europe and Japan

Figure 13. Intermediate transfer institutions



Source: MITI, Patent Office.

Promoting cluster development

Clusters are engines of innovation, and represent a manageable system for governments to implement the NIS framework by complementing horizontal policies by more targeted and customised policies. The Focus Group on Clusters has provided ample insights on how cluster policy should be part of a wider innovation policy. Its main policy recommendations are the following:

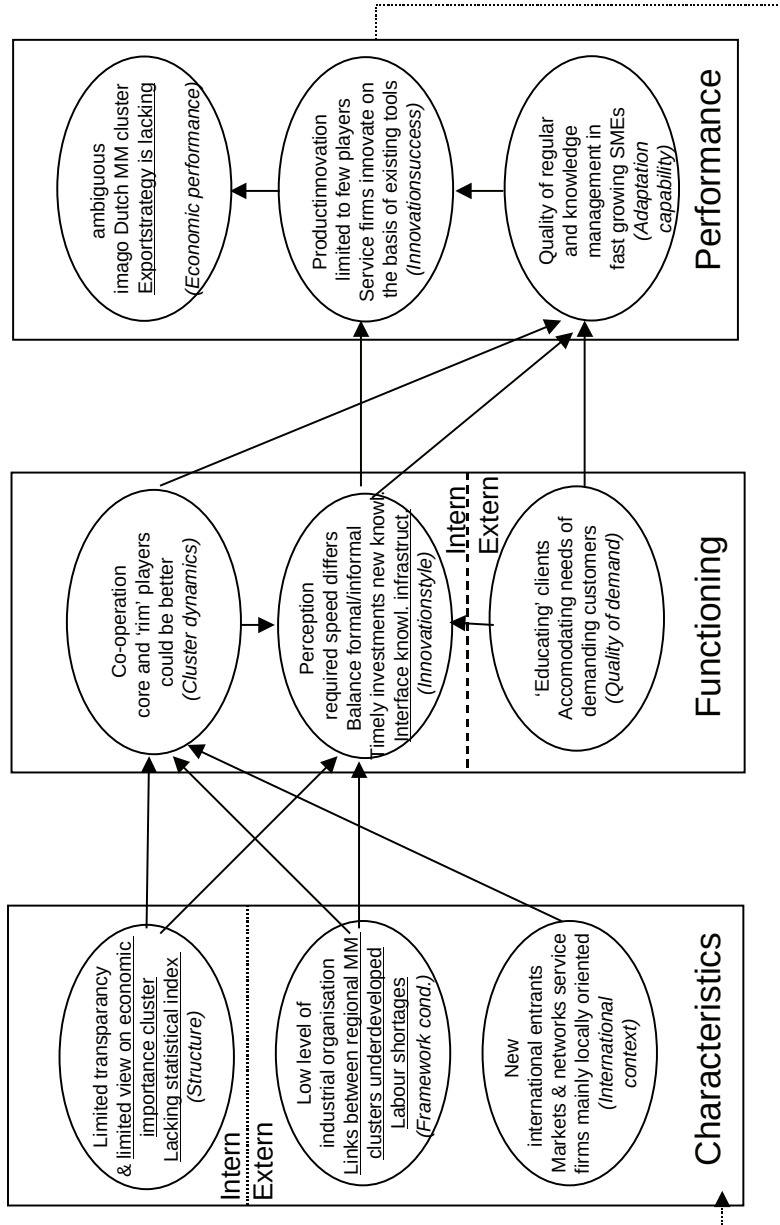
- Support emerging/existing clusters. Clusters emerge from traditional strengths in the economy or from more random events. The task for governments is to support clusters in their formation and further development. A cluster-based approach to innovation policy is particularly well suited to respond to shocks like major downsizing of large firms and closure of government operations.
- Both macro-level input-output analysis and more micro-level analysis help policy makers identify innovation bottlenecks and missing links in the clusters.
- Avoid high-tech myopia by considering both “low-tech” and “high-tech” clusters.
- Assess from a cluster perspective the impact on innovation of a wide range of policies. Evidence shows that defence policy and land-use planning are often driving forces in the formation of clusters.
- Emerging clusters may often benefit from catalytic programmes to stimulate networking, including links with capital markets and business angels.
- The lack of advanced demand is a common bottleneck to cluster development and can justify, for example, specific export programmes and government technology procurement.

The Focus Group on Clusters reviewed national experiences with cluster-based policies. It found a great variety of approaches reflecting a common feature: pragmatism. In Scotland, weight is given to growth prospects, a Scottish capability, willingness or demand from industrial partners, and a visible role for the Scottish agency. In Denmark, cluster policies and programmes are implemented after careful dialogue with all stakeholders, with the aim to agree on tailor-made policy packages. In the Netherlands the government plays several roles in cluster policy, including being chairman of collaborative efforts

with the private sector, being catalyst or initiator of activities, being process manager to stimulate self-organisation of the cluster, being a broker between parties, and connecting networks (Dalsgaard, 2001, Gilsing, 2001). Another common feature of the otherwise very diverse national cluster policies is the importance given to what in the Danish context is termed “specific framework conditions” (Dalsgaard, 2001).

The Dutch Cluster Monitor is an example of a pragmatic, but highly structured approach to policy diagnosis. The core of the methodology is a relational model covering the basic characteristics, the functioning and the performance of a given cluster. There are three dimensions in each of these, suggesting altogether nine dimensions for which quantitative or qualitative information can be collected. Applied to the emerging multimedia cluster, this methodology helps highlight the bottlenecks and the role of government policy in removing them (Figure 14).

Figure 14. The main bottlenecks in the multimedia cluster and their interrelations



Note: the items underlined indicate a possible role for government.

Source: Den Hertog et al. 2001.

The country specificity of cluster policies can to some extent be explained by the fact that characteristics of clusters vary and national cluster endowments differ. Benneworth and Charles (2001) argue for example that clusters can be characterised along two dimensions, intensity of interactions and geographical scope. The corresponding variation in “cluster policy style” is illustrated in Table 3.

Table 3. Variations in policy style with the geographical scope and intensity of interaction of the cluster

	Tight Interaction	Loose Interaction
National	Strategic Interventionary	Enabling, facilitating Foresighting/programming
Local	Daily work & Group involvement	Dealing with specific issues (<i>e.g.</i> planning regulations)

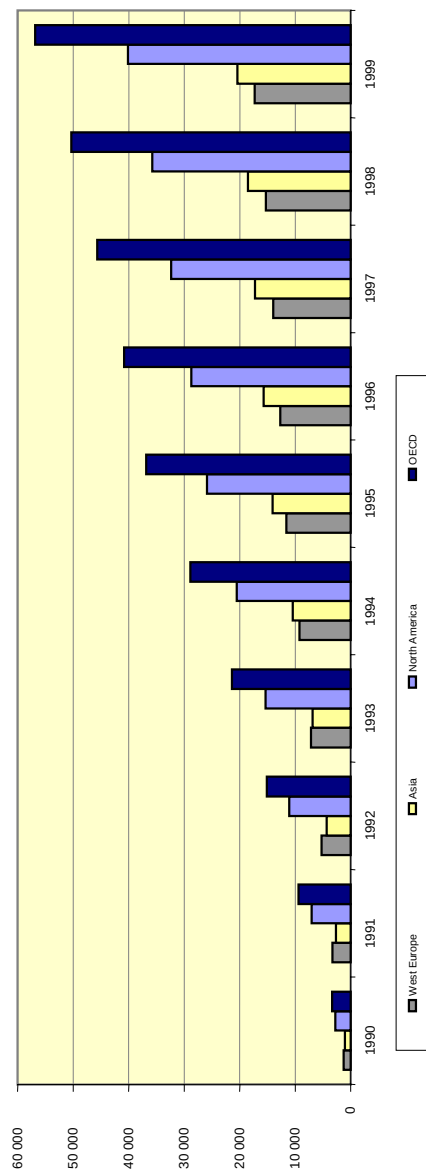
Source: Benneworth and Charles (2001).

Promoting internationally-open networks

As the costs and risks of R&D and innovation grow, and as knowledge is more widely distributed, firms have to enter into various forms of alliances or networks that are more and more often global in scope with the increasing openness of economies (Figures 15 and 16). This is well illustrated by the rapid growth of international strategic alliances (joint ventures, equity positions, collaborative research and development and other joint activities). Although market access and the search for economies of scale are the main motivation of many of these alliances, alliances are also formed to combine and/or access intangible assets (OECD, 2000*b*).

Figure 15. Strategic alliances across the OECD between 1990 and 1999

Cumulative number of deals by zones



Source: OECD calculations on the basis of data from Thomson Financial Securities Data.

Figure 16a. Technological alliances between firms

Change in the number of national and international technological alliances, 1994-96

1988-90 = 100

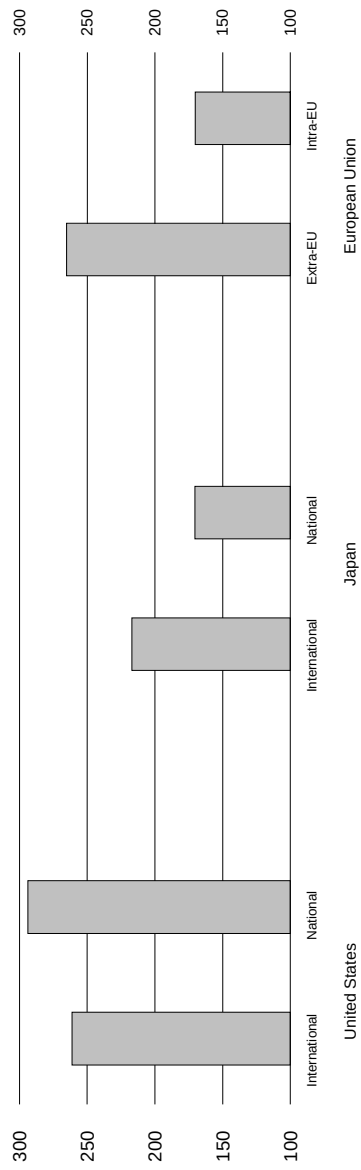
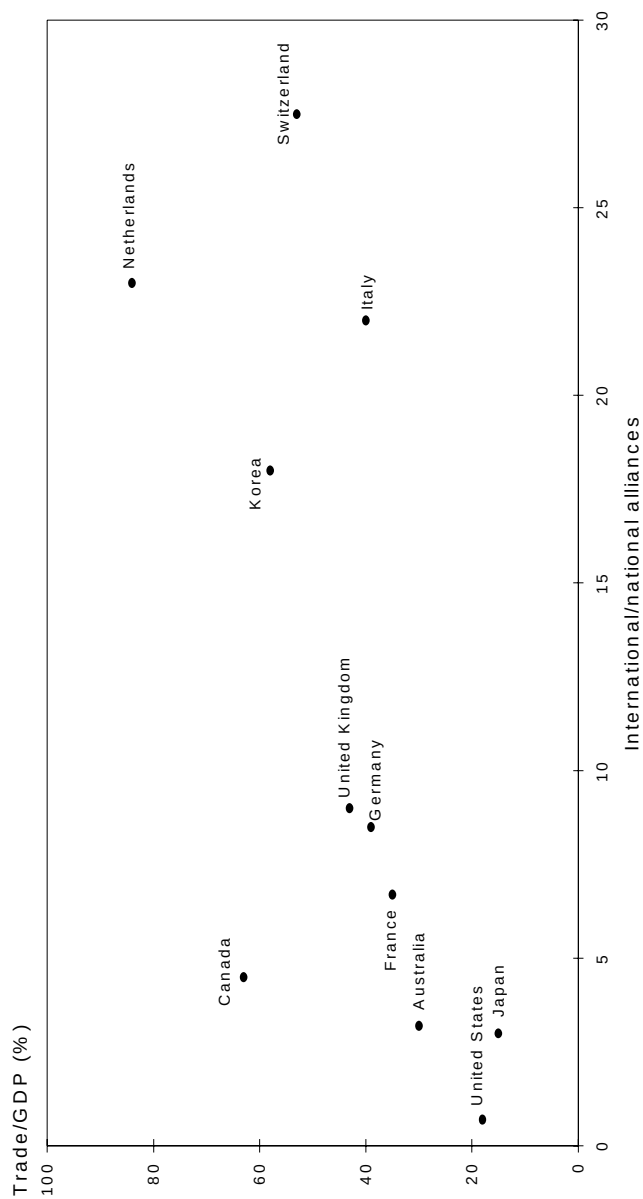


Figure 16b. Ratio of international to national technological alliances and of trade to GDP 1992-95



Source: IFR/SDC, European Commission and MERIT.

Against this background, the Focus Group on Innovative networks has reviewed network-oriented policies in many OECD countries and drawn the following main lessons:

- Governments should not attempt to be the main architects of networks but could play an important role in helping their self-organisation. The new generation of programmes to support self-organisation of participants is “incentive-compatible” in that these programmes are often organised as competitions and provide mainly management, administrative and organisational support.
- Successful networking rests on trust between partners and trust requires time. Policies to promote networks should therefore be implemented and evaluated in a medium-term perspective (minimum 3-5 years), which implies stable funding and institutional settings. Frequent changes in policy goals, competing or poorly co-ordinated initiatives and unstable financing of programmes are even more detrimental to network-oriented policies than they are to technology and innovation policy in general.
- Network programmes need to be context-sensitive, *i.e.* adapted to the needs and capabilities of participants, as well as to the types of networks that are being promoted (*e.g.* R&D collaboration or cluster formation).
- SMES deserve special attention since they have generally a low propensity to network or face obstacles to doing so.
- Success requires co-ordination: *i)* between *different programmes* addressing networking in one country *at the same time*, *ii)* between these national programmes and policies at the *international* (*e.g.* EU FPs and structural funds), or the *regional level*, and *iii)* between cluster/network oriented policies and other technology policy measures (*e.g.* general SME oriented policies, institutional reforms in universities and public laboratories, etc).

From public support to system management

Innovation systems are open, interdependent and evolutionary systems that are structured by a very complex web of market and non-market interactions. Implementing the NIS framework in policy making cannot be through “a grand design” by an “enlightened architect”. Governments must adopt a more

pragmatic approach, using various instruments, and learning through experimentation and institutional adaptation.

Comprehensive, coherent and customised innovation policies

System management requires comprehensive and coherent policies that are characterised by a good match between individual instruments and objectives as well as by compatible instruments and objectives in different policy areas. Achieving coherence is a difficult challenge for governments which are generally not well organised to deal with crosscutting policy issues (OECD, 1996). It involves not only co-ordination of simultaneous policy actions, but also an evaluation of their possible interaction with policies pursuing other primary objectives. This concerns first of all the core set of innovation policies such as S/T and education, but there are a number of other policies whose impacts must also be taken into account. For example, governments will often need to analyse how land-use or infrastructure interferes with cluster development, or how taxation policies interact with R&D policy.

Coherence does not mean undifferentiated approaches. For example, as clusters need different specific framework conditions, the systemic failures that should be corrected are different as well. Whether these failures are limited interaction, information problems, mismatch between knowledge infrastructures and business needs, or lack of demanding customers (see Gilsing, 2001), governments need to adapt their roles accordingly.

Prioritising and sequencing policies

Governments must give priority to measures that have the greatest leverage effect on innovation processes. These policy areas in the innovation policy space may be elevated to a government innovation strategy. A strategic approach makes it easier to generate long term commitments for funding, remove inconsistencies in the incentive system, and formulate and communicate the government's vision.

Managing innovation systems also requires sequencing and periodic streamlining:

- Timing and sequencing of policies are important as effects from one may build foundations for others. For example, the initial competitive regulation of the Finnish telecom sector provided a valuable framework for innovation and growth and for subsequent R&D and

education policies. Programmes to stimulate spin-off from universities should often be preceded by reforms concerning employment contracts and IPRs. Sequencing also allows a step-wise implementation of policy to better correct for unintended impacts that are hardly predictable at the start of the process. It helps also build gradually a broad-based political support to reforms. But the most important advantage is the role that sequencing may have in enhancing policy learning (see below).

- It is a common problem that policies are often introduced without removing or adapting existing programmes with congruent objectives. Congested policy packages full of otherwise well-intended initiatives will often increase transaction costs and the risk of incompatible instruments. Careful attention should be paid to the additionality of new initiatives (Box 4).

Box 4. The Additionality Principle in Finnish Cluster Policy

The additionality principle was applied during the planning phase to ensure that the new programmes targeted areas where no similar policy action existed at that time. For example, the Ministry of Transport and Communications did not select the ICT cluster, since several large technology and research programmes had already been implemented by Tekes and the Academy of Finland in that sector. Instead, the new programme targeted transport, where the development of new logistics systems required extensive collaboration among private and public actors. The ICT sector was targeted with a small, focused programme which aimed to facilitate access of small firms to the Internet and e-commerce (Romanainen, 2001).

Policy co-ordination to improve governance of the NIS

Policy co-ordination is not a top-down process since “the components of co-ordination capacity are cumulative in the sense that higher level co-ordination functions depend on the existence and reliability of the lower ones” (Metcalf 1994, see Box 5). Implementing an integrated innovation policy requires concerted efforts at many levels in many different organisations, including interfaces with the business sector and society at large, which together constitute the governance structure of the national innovation system.

Box 5. The policy co-ordination scale

9. Government strategy
8. Establishing central priorities
7. Setting limits on ministerial action
6. Arbitration of policy differences
5. Search for agreement among ministries
4. Avoiding divergences among ministries
3. Consultation with other ministries (feedback)
2. Communication to other ministries
1. Independent decision-making by ministries

Box 6. Co-ordination in Finnish Technology and Innovation Policy

The 1996 Science and Technology Policy Review identified the need for increased collaboration among the policies in the following fields: economic, financial, industrial, education and science, employment, regional, social and health, environmental and cultural policies. It noted that the work that had already been initiated within industrial clusters, particularly in the sectors of well being and telecommunications, should be extended to other sectors.

To implement this collaboration, the Council suggested additional funding for the Ministries of Trade and Industry, Education and Science, Agriculture, Transport and Communications, Social Affairs and Health, Labour and of Environment. The additional funds were to be used for research and development, in collaboration with Tekes, the Academy of Finland, universities, research institutes and industry (Romanainen, 2001).

The Focus Groups' work on institutional mapping has shown great differences between countries. Innovation governance structures reflect national specificities of the overall political, economic and social systems. Whereas this rules out the search for a single best practice, some lessons which can be generalised can be drawn from the Focus Groups' work.

The first is that reforms of the institutional set-up of ministries or agencies will often create a basis for more efficiently linked policies and delivery systems. In Finland the Science Policy Council has helped give momentum and direction to a comprehensive innovation policy, and in the Netherlands an

increased policy focus on systemic failures has led to a continuous search for institutional adaptation. Another example is Norway which merged five research councils with the aim to generate more comprehensive and integrated R&D and innovation policies.

The second is that improved co-ordination does not mean more centralised government. While many smaller countries have successfully achieved more integration between various agencies and ministries, other, and especially larger countries, may opt for a more decentralised model with more weight given to market-based and regional governance. In particular, a sufficient degree of autonomy for universities and research organisations has proved important to allow flexibility in responding to business needs in regional clusters.

The third is that globalisation increases the impact of regional innovation governance structures on national innovation performance, even if of course one must take account of the fact that the political role and economic weight of regions differ from one country to another. It is often easier to define context-sensitive policies on a regional level.

The fourth is that public policy needs to be made compatible with corporate governance. For example, achieving a proper articulation between private and public governance structures may require greater use of public/private partnerships as a tool to promote innovation.

Lastly, international co-operation becomes more important as an integral part of the national and global innovation governance structures. International co-operation is needed to share the costs of providing public goods, provide a fair reciprocal access to national knowledge institutions and R&D programmes, improve channels for international knowledge flows and even to pursue more specific innovation policy goals. For example, ICT clusters are often “borderless” and fragmented across countries. International collaboration may be needed to remove obstacles to flows of human capital, services and investments that are key to the development of the overall cluster.

Policy learning

One of the key implications of a systemic approach to innovation policy is that governments need to learn more about intended and unintended effects of interacting policies. Governments themselves should be seen from a systemic and evolutionary perspective, as learning organisations (Van der Steen, 1999, 2000).

Policy learning through cycles of experimentation, evaluation and adaptation of objectives and instruments is key to long term success. It allows greater efficiency in achieving a given policy objective but it may also provide broader policy lessons, as illustrated by Table 4 in the case of UK ICT cluster development.

Policy learning rests on three pillars: participatory and non-bureaucratic policy processes; evaluation; and “economic intelligence”. Governments need to engage in continuous interactions in knowledge networks, building on complementary institutions and private partners. Innovation policies and their combined effects should be both monitored to provide real time learning, and evaluated to secure learning and reflection for ministries, agencies and private sector organisations concerned. An example is the Dutch cluster policy which institutionalises learning by providing for evaluation at given stages in the process, to ensure that learning does not only occur *ex post* (Gilsing, 2001). Evaluation itself requires that governments can rely on appropriate policy analysis and data which allow international benchmarking. As the work by the Focus Groups has shown, indicators are often poorly suited to inform policy makers on knowledge flows and connectivity. For example, labour force surveys have not been developed with the aim to study mobility; data on the commercialisation activities of publicly funded research organisations cannot be easily compared internationally. Improvements would require efforts at both national and international levels.

Table 4. Clusters, driving forces and policy environments, the UK ICT case

Clusters	Driving forces and policies	Policy learning
Silicon Glen, Scotland	a) WWII location of electronics industries b) Tradition for investments in high-skilled labour c) British and foreign inward investments d) Ferranti as a key firm: gave priority to competence and diversification e) Recently backed by regional development efforts (Scottish Enterprise), part. in enhancing and maintaining skills f) Mismatch between science and industry: Innovation based on segmented but high performances	a) Best practice case for policies for inward investments b) Policy should support high-skill capacity in generic products and knowledge c) Support needed for firms to locate in the region, which is underpinning upgrading
Thames Valley	a) Post-war planning policy to develop area west of Heathrow b) Military procurement ensuring profitable development projects c) Industrial policy in the 60s promoted big firms and led to R&D capacity around strong locations d) Science policy crucial in establishing government labs and funding civil R&D in a defence dominated environment e) Deregulation of the telecommunications market spurred defence based electronics firms to diversify into commercial technologies f) Government policy has encouraged a shift to services g) One firm, Racal, led the way to endogenous innovation/growth	a) The cluster helped shape government conceptions of competitiveness, recently demonstrated by the Vodafone take over of Mannesmann b) The success of the cluster was based on proximity to advanced science and labour pools, and Government came to accept the need to concentrate scarce science resources in science and prioritise science and technology expenditure c) Lessons from Thames Valley influenced the organisation of planning, and gave legitimate basis for land use planning to accommodate growing clusters, e.g. housing

**Table 4. Clusters, driving forces and policy environments, the UK
ICT case
(cont'd)**

Clusters	Driving forces and policies	Policy learning
Cambridge	a) Strict planning regime in the region leading to a selection and concentration of high-tech firms. The university contributed to this with a science park b) Science policy favoured the development of bioscience firms in the area. Research in this area was revolutionised through ICT, creating a demanding market for electronics firms c) Competitive advantage of cluster derives from dynamism and innovation in emerging activities d) The Cambridge environment is supported by patient venture capital and incubators e) The Cambridge system of innovation was underpinned by a culture of high integration between academic work and entrepreneurship	a) The Cambridge phenomenon becomes incorporated in national industrial policy: Development and modernisation can be organised instead of paid for by financial support b) The Cambridge success informed science and technology policy that national competitiveness does not need spatial consideration, but support according to capability

Source: (Based upon Charles and Benneworth, 2001).

CONCLUDING REMARKS: NIS AS A BENCHMARKING TOOL

The OECD NIS project has shown that the NIS approach is not a “quick fix” to innovation policy or a recipe for leveraging the “metrics” of the system. Rather, the NIS framework should be seen as an approach to conceptualise and implement policy with the aim to take explicitly into account the systemic and other features of the innovation process (Box 7) and the interaction between the different policies that influence this process.

The NIS approach can add value to the general toolbox of innovation policies by helping refocus policy attention:

- From optimum/equilibrium to real problems/effectiveness. Market failures cannot be the sole rationale for technology and innovation policy. Consideration of systemic and government failures focuses the attention on how the economy works in practice.
- From “universal” to “context-specific” determinants of economic performance.
- From stocks to flows of knowledge as drivers of innovation performance.

Box 7. Properties of innovation systems

Types of systems: The key systemic properties of the innovation process and innovation systems are based on the idea that such systems are both open, adjusting through interactions with other systems or the environment, and loosely coupled, referring to variable degrees of interdependencies in the system.

Diversity and growth: Acquiring and using knowledge is the core process in innovation. As firms' knowledge bases become more widely dispersed through increasing technological specialisation and un-bundling of knowledge structures, they become more dependent on other firms and organisations. The diversity includes knowledge sources as well as types, challenging innovators to cross boundaries and search for new combinations. The resulting pressure for openness, networking and complementarity is great, as are the needs to furnish growth through knowledge endowments.

Complex interactions: While the previous dominant model of innovation prescribed a linear relationship between the components, focussing attention on investing in R&D and securing the flow from the R&D end to the marketplace, the new model redirects attention to interaction:

- Knowledge accumulates and leads to increasing returns. Innovators investing in knowledge reinforce their learning capabilities and accumulate more knowledge.
- Non-market relations like networking reinforce market relations in value chains. Clusters contain inherent systemic properties that facilitate knowledge flows: The highest propensity of inter-firm networking is found between firms trading goods and services. Complex clusters with long and internationally linked value chains have a greater potential for generating innovations.
- Interactions between different markets tend to produce dynamic innovative environments, as is the case in the combined forces of labour, capital and product markets in areas like Silicon Valley (US) and Cambridge (UK).
- Innovators engage in multiple, complex networking, co-operation and collaboration to share and acquire knowledge, and rely less on single partners.

Non-linear processes and multiple equilibria: Multiple interactions cumulate in virtuous or vicious circles of growth and stagnation. These innovation processes are geographically distinct, and any national economy may include dynamic environments along with stagnant ones.

Adaptation through experimentation and learning: Effective innovation systems are dynamic and generate capacities for adaptation through learning. The learning process includes typically searching for knowledge internal and external to the firm, experimentation with products, services and strategies, and evaluation. Governments need to continuously adapt through policy experimentation and learning. Experimentation and learning is a partly self-steered process of configuration of the system towards a better alignment between its various components.

Systems failures: Economies or systems with poor innovation performance typically suffer from systems failures, *i.e.* failures of these systems to provide the negative, corrective feedback and adaptability associated with high performance, effective systems. The most prominent are failures in infrastructure provision, transition failures, lock-in failures, and institutional failures.

This report has stressed the importance of horizontal approaches to implementing the NIS framework. The need to engage in effective learning processes suggests that governments may benefit from intensified international benchmarking of policy practices in this respect. For example, the Nordic European countries have recently initiated a process through which policy makers identify relative strengths and weaknesses of their policies in all the dimensions suggested by the NIS framework (see Box 8).

Box 8. Comprehensive recommendations in the Nordic innovation policy benchmarking project

1) A structural policy for the innovation process

Enhancing firm-level capacities for entrepreneurship, innovation and transformation

- The absorptive capacity of firms
- Entrepreneurship, creativity and knowledge-based start-ups
- Firm transition and transformation, private spin-offs

Exploiting markets for innovation

- Intellectual property rights and institutions for commercialisation and technology and knowledge diffusion
- Dynamic labor markets and labor market institutions
- High quality regulation of product markets
- Competitive markets for innovation
- Effective financial systems for innovation
- Advanced demand

Ensuring systems growth through knowledge endowments

- Investments in R&D
- Investments in education and human capital
- Investments in and diffusion of ICT and software

Promoting cluster development

- Cluster-specific framework conditions (R&D, education, infrastructure etc)
- Leveraging missing cluster components
- Encouraging cluster-based global links
- Mixed support to emerging/existing clusters

Box 8. (cont'd)

Encouraging non-market interactions

- Stimulate networking and co-operation
- Development of science-industry relations
- Public-private partnerships
- Complementary interactions to reinforce dynamism
- Information and foresight

2) The role of governments

Managing the innovation policy space

- Defining the appropriate innovation policy space
- Strategic integration of innovation policy areas at the government level
- Analyse interactive effects between policies
- Co-ordination between sectoral ministries through financing, incentives and negotiation
- Sequencing and packaging of policies

Governance of innovation and systems innovation

- Institutional set-up and strategic change
- Regulatory systems
- Adapting the role of regions
- Desentralised governance innovations
- Autonomy and adaptability for knowledge institutions

Institutionalising policy learning

- Learning from good practice
- Policy experimentation
- Evaluation, indicators and policy reviews
- Policy learning along policy life cycles and across policy areas
- Assess policy lock-ins and cognitive models
- International co-operation and benchmarking

ANNEX

THE NIS PROJECT

The OECD project on National Innovation Systems

Exploring the task of how governments can strengthen their national innovation systems has been a major interest of the Committee for Scientific and Technology Policy (CSTP) during recent years. The Committee's Working Party on Technology and Innovation Policy (TIP) has been the key body to organise this work.

The NIS project has evolved through several phases since it began in 1994. The project set out to explore the "distribution power" of national innovation systems. It elaborated a framework for comparative analysis of Member countries' innovation systems, and the distribution power of these systems, meaning their capability to ensure timely access by innovators to the relevant stocks of knowledge. The first phase of the NIS project laid down the foundations for subsequent empirical and analytical work, linking it to the emerging interests in the knowledge-based economy as the general term for economic development of the 1990s.

In its second phase, the NIS-project evolved along two tracks: *i*) general analysis involving all countries; and *ii*) more in-depth analysis of specific aspects within Focus Groups. The work of the first two phases is summarised in the report *Managing National Innovation Systems* (OECD, 1999a).

During the second phase, six Focus Groups were established, involving countries with advanced methodologies, data sets, or special research or policy interests. These were: Innovative firms, Innovative firm networks, Clusters, Mobility of human resources, Organisational mapping, and Catching-up economies.

When reviewing the results of the second phase, the TIP Group favoured follow-up work, but suggested some streamlining of the project content and

organisation to sharpen policy focus and avoid dispersion of scarce resources. It decided that the two first groups should be merged into one, covering both innovative firms and networks, and that the issues identified by the groups on organisational mapping and catching-up economies should now be tackled as horizontal issues by the three remaining groups. Thus, for the third phase, three Focus Groups would continue their work on:

- Innovative firms and networks (lead countries Austria and Australia).
- Clusters (lead country the Netherlands).
- Mobility of human resources (lead country Norway).

The Focus Groups

The NIS Focus Groups represent the bottom-up model of organising the analytical work of the third phase. The groups reached a broad participation across OECD countries, and were able to build upon a variety of resources and research activities in individual countries. The objectives of the Focus Groups for the third phase were endorsed by the TIP group in December 1999 (Box 9).

Box 9. The objectives of the NIS focus groups

- *Focus Group on Clusters:* to explore to what extent and in which respects clusters differ in their innovation performance and mechanisms of knowledge sharing and transfer, with a view to derive concrete implications for cluster-based innovation policy. In this phase, the Focus Group concentrated its work on:
 - Improving and applying the common methodology for macro clustering.
 - Comparing selected individual clusters internationally.
 - Developing and applying a typology of clusters based on their innovation patterns.
- *Focus Group on Innovative firms and networks:* to define characteristics of firms and networks of firms that hamper or promote innovative activities, with a view to determining how government policy can directly or indirectly help increase the stock of innovative firms. The work devoted special attention to three themes:
 - The dynamics of networks, including in the service sector.
 - Policies to enhance innovative capacities of firms.
 - The role of policy in stimulating co-operation and networking.
- *Focus Group on Mobility of human resources:* to analyse the role of mobility of human resources in the circulation of knowledge within a NIS. The work went along three lines:
 - Benchmarking of internal mobility rates across the participating countries.
 - A study of international mobility in terms of brain drain and gain.
 - Recommendations for the development of relevant indicators.

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OECD PUBLICATIONS, 2, rue André-Pascal, 75775 PARIS CEDEX 16
PRINTED IN FRANCE
(92 2002 07 1 P) ISBN 92-64-19783-4 – No. 52513 2002